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Causal Regularities of Effect of Urban Systems on Condition of Hydro Ecosystem of Dnieper River

Vitalii Pichura, Larisa Potravka, Svetlana Skok and Nataliia Vdovenko[1]

Kherson State Agrarian University, Ukraine, 73006, Kherson, Stritens'ka str. 23,
[1]National University of Life and Environmental Sciences of Ukraine, Ukraine, 03041, Kiev, Heroiv Oborony str. 15
E-mail: pichuravitalii@gmail.com

Abstract: Under conditions of uncontrolled increase of anthropogenic impact in use of water resources and intensity of contamination, it becomes necessary to develop and comply with water conservation measures, use environmentally friendly technologies and introduce adapted conservation measures. Emphasis was made on the fact that the influence of urban systems lead to the transformation of floodplains, destruction of river hydro ecosystem and significant deterioration of the water management and recreational values. The situation is aggravated by the operation of outdated and inefficient water discharge and water treatment systems. It leads to systematic contamination of the urban system of suburban river basin with sewage surface runoff and distribution of pollutants outside/upriver. The results of the study of process of the impact of sewage surface runoff from the urban system Kherson city on the condition of the lower Dnieper hydro ecosystems in the suburban area of the river and outside/upriver were shown. The model of the system research of causal relation “coming of water (stage I) → surface sewage runoff (stage II) → condition of the hydro ecosystem (stage III)” was offered. The seasonal nature of intensity of precipitation effects, which causes acceleration of hazardous erosion in territory of urban systems, which is a consequence of systemic diffuse pollution in suburban basin of the Dnieper River, was determinted. The hydrochemical properties of sewage runoff, which have significant seasonal dynamics, were determined. It was justified by the change in volume of water use in economic and domestic purposes. The intensity of the impact of surface runoff of the urban system of Kherson city on the hydro ecosystem of the Dnieper River at 100- and 300-meter area upriver was determined: the 100-meter area is “very polluted” (class VI) – “extremely polluted” (class VII); the 300-meter area is “polluted” (class V) – “very polluted” (class VI). It was found that the main pollutant that leads to deterioration in the quality of the water in the Dnieper River is the significant excess of petroleum products. Hydrochemical values of sewage discharges in accordance with needs for fishery exceed the MPC values 4 times. It proved the unsatisfactory ecological condition of the hydro ecosystem of the lower Dnieper river in the urban system and outside/upriver. It was proved that reusing of treated sewage surface water of Kherson city can provide irrigation for growing crops at the area of 9468 ha. The application of the suggested complex model of research and the establishment of causality of the impact of the urban system on the ecological condition of the hydrosystem of the rivers shall allow to carry out spatial differentiation of protection measures regarding reduction of the negative impact of sewage surface runoff on surface water condition and it shall improve obtaining of crop yields on irrigated land due to the reuse of sewage surface water.

Key words*:* Urban system, Surface runoff, Sewage runoff, Water quality, Hydro ecosystems, Dnieper river

The most important component of the environment and the essential factor of satisfaction of existence of living organisms, health of population, social and economic development, environmental security and sustainable development of society as a whole is the availability and condition of water resources. According to the assessment of the International Bank, about 1.5 billion people lack access to clean drinking water, more than 40% of the world's population experience water shortage, 25% of population are at risk of consumption of poor quality water. About 3 billion people live in unsanitary conditions. More than 80% of all diseases related to consumption of poor quality water (Chorna et al 2019). Surface water bodies take about 4% of the total territory of Ukraine with a resource of about 209.8 $km^3 year^{-1}$. Groundwater resources are estimated at 22.5 $km^3 year^{-1}$. Its reserves are up to 25%. According to the volume of water reserves, Ukraine belongs to the resource-poor countries since water resources do not exceed 1.5 thousand m^3 per person per year. Main consumers of water are industries (51.5%), in particular, ferrous metallurgy, energy, pulp, paper and food industries, agricultural (28.1%) and utility (18.1%) companies that cover more than 90% of the total water intake.

The majority of surface water resources in Ukraine is classified as “polluted” and “dirty” (Pichura et al 2017). Systematic accumulation and exceeding of values of maximum permissible concentrations of heavy metals (copper, manganese, zinc) and biogenic substances (nitrogen, phosphate) (Lisetskii et al 2014, Pichura et al 2019) in surface waters makes it impossible to provide favorable conditions for water use. Thus, the negative consequences of anthropogenic impact on the basin of the rivers take place. It leads to a change of the natural condition, disbalance of the integrity of the functioning of hydro ecosystem and destruction of the synergetic process of self-regulation, self-purification and self-restoration of rivers

(Lisetskii et al 2015, Pichura et al 2018). The main causes of pollution of surface water are: discharge of polluted communal, domestic and industrial wastewater, emission of pollutants together with surface runoff from city systems and erosion-cumulative processes in agricultural land (Dudiak et al 2019). Anthropogenic transformation of ecosystems as a result of urbanization is one of the most pressing problems associated with the intensification of the impact on natural ecosystems of the Dnieper basin. The basin covers more than 48% of the territory of Ukraine and accumulates about 80% of its water resources. It meets food and drinking needs of more than 30 million Ukrainians. Such scientists as Mostepan (2010), Yurchenko (2012), Rychak (2016), Bytkova (2018) emphasized that the main causes of impact on water bodies is unorganized control of surface runoff of urbanized areas and insufficient capacity of drainage networks for rainwater. Pollution of rivers from city systems is caused by the lack of effective engineering systems for diversion of surface runoff, low level of provision of residential areas with sewerage system (95% for cities, 61% for urban-type settlements, 2.5% for villages), operation of outdated water treatment facilities with low level of treatment of communal, domestic and industrial wastewater. Mahas (2013) noted in his studies that comprehensive planning for rehabilitation of rivers should be based on possible models of consequences of adverse effects of economic activities for establishing the pollution sources and degradation of river ecosystems. Therefore, the problem of river pollution, especially in lower parts of the flow, where natural and man-made components of surface and underground runoff are accumulated, is urgent. The purpose of the research is to establish the causal regularities of the impact of urban systems on the condition of hydro ecosystem of the Dnieper River.

MATERIAL AND METHODS

The object of the study is the process of the impact of sewage surface runoff from the urban system of Kherson city on the condition of the lower Dnieper hydro ecosystems in the suburban area of the river and outside/upriver (Fig. 1). The study was conducted in the system causal relation "coming of water (stage I) → surface sewage runoff (stage II) → condition of the hydro ecosystem (stage III)". The condition of water quality was determined at three stages during 2012-2019 according to the indicators of changes in its hydrochemical properties in line with generally accepted methods in certified laboratories of the communal utility company "Production Office of Water and Sewage Utilities of Kherson city" and the State Environmental Inspectorate in Kherson Region. There were studied 60 wastewater

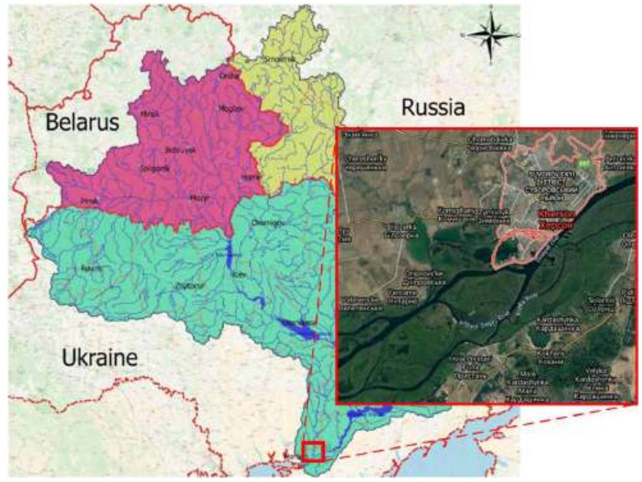

Fig. 1. Location of the of Kherson city in the Dnieper basin

samples, 30 of which were taken from the collectors at the places of primary collection of the city's runoff, and 30 samples were taken at the places where the runoff collectors were opened, immediately before this water entered the river waterways.

Underground artesian water and precipitation are the main sources of water supply for Kherson city. Artesian water from 137 wells is used for drinking water supply of Kherson city. Its volume is 50-55 thousand m^3 per day. After use, it enters sewers and treatment facilities. After passing the biological ponds it is subject to discharge through Virovchyna River into the right branch of the Dnieper River – Koshova River. Rainwater forms a surface runoff that enters the suburban basin of the Dnieper River without treatment (Fig. 2). The comprehensive assessment of the quality of surface water, suburban water in the direction of the Dnieper River at the 100- and 300-meter zone was carried out according to different methods, in line with the current water quality standards for surface water bodies in Ukraine according to the maximum permissible concentration (*MPC*) of cultural, recreational, fishery purposes using the modified water pollution index (*MWPI*) (Klimenko et al 2012).

In accordance with the applicable rules, water that is least affected by anthropogenic pressure belongs to class I. The values of its hydrochemical and hydrobiological indicators are close to the natural values for the region. Water of class II is characterized by certain changes in comparison with natural values; however, these fluctuations do not violate the ecological balance. Water that is under considerable anthropogenic influence, the level of which is close to the limit of stability of ecosystems, belongs to class III. Water of classes IV-VII has disturbed environmental parameters and its ecological condition is considered as ecological regression. The effectiveness of sewage treatment (E_q) in treatment plants is determined by comparing of its quality before incoming and after discharge from a sewage treatment plant in accordance with the method of runoff quality control (Sheludchenko 2001):

$$E_q = \frac{C_{in} - C_{out}}{C_{in}} \times 100\% \qquad (1)$$

where C_{in} is the concentration of pollutants in discharge water before purification, C_{out} is concentration of pollutants in discharge water after discharge from the treatment plant.

The suitability of sewage runoff for irrigation of agricultural crops was determinted in accordance with GOST 2730:2015, Protection of the environment. Quality of natural water for irrigation. Agronomic criteria (2015), which gives the possibility for expanding of irrigated area. The size of the area was determined by the method of calculation of resource-saving irrigation regimes for agricultural crops. The use of cartographic methods for the spatio - temporal establishment of hydrological patterns of water runoff distribution in urban system and suburban basin of the Dnieper river was suggested. The copyrighted method of the operational recording of the distribution of discharge water in the bed of the Dnieper River was used. The method is based on the use of multi-colored balls of foam materials. The following licensed software was used for processing and analyzing input data: STATISTICA Advanced + QC for Windows v. 10 Ru, Automated Neural Networks STATISTICA for Windows v. EN 10 and ArcGis 10.1.

RESULTS AND DISCUSSION

Water balance of Kherson city is to be determined by the total amount of surface runoff, seepage loss and evaporation. In particular, the volume of surface runoff was calculated on the basis of the total income of the natural moisture in 1961-2019 per area of the urban system. This value is 179.8±44.7 million m^3. The level of variation is 11.9% due to cycles of climatic conditions. SO^{2-}, HCO_3^- , Ca^+, Na^+ prevail in chemical composition of precipitation. The variation of salinity is within 50-60 mg dm^{-3}. The maximum surface runoff is recorded in the spring and summer. The seasonal nature of intensity of precipitation effects causes acceleration of hazardous erosion in territory of urban systems, which is a consequence of systemic diffuse pollution in suburban basin of the Dnieper River. In addition, redistribution of surface runoff depends on the terrain of urban system, which has form of slope in the northern, western and southern part of Kherson city. At the same time, it forms surface runoff that contains hazardous pollutants in the direction of the Virovchyna, Koshova and Dnieper Rivers. Urbanized elimination of the natural drainage network resulted in violation of the hydrological regime of local area and restructuring of the system of unloading of underground waters, which occurred mainly on the slopes of gills. At the same time a significant increase in surface runoff was found in the Kherson area bottom that absorbs most of the moisture from the inner part of the city. Artificial regulation of redistribution of surface runoff in most dangerous parts of urban system is carried out through the storm drainage network with total length 71.4 km. Storm water is discharged through the 14 sewers. Water is discharged through 6 sewers directly to Dnieper river, through 6 sewers to the Koshova river, through 2 sewers to the Virovchyna river.

It was determined that over the past 20 years the engineering support of storm drainage network was not available because it was not included in the public sewerage, had no jurisdiction (except several departmental sites on the territory of companies). Today, the entire network has only a few highways in the city along the slope of Dnieper River, which is 30% of the network. The remaining 70% are under soil and sludge contamination, therefore the surface runoff from the territory of the city is not subject to purification and filtration. The lack of the sewage network leads to direct and indirect contact with surface water of the Dnieper river. The

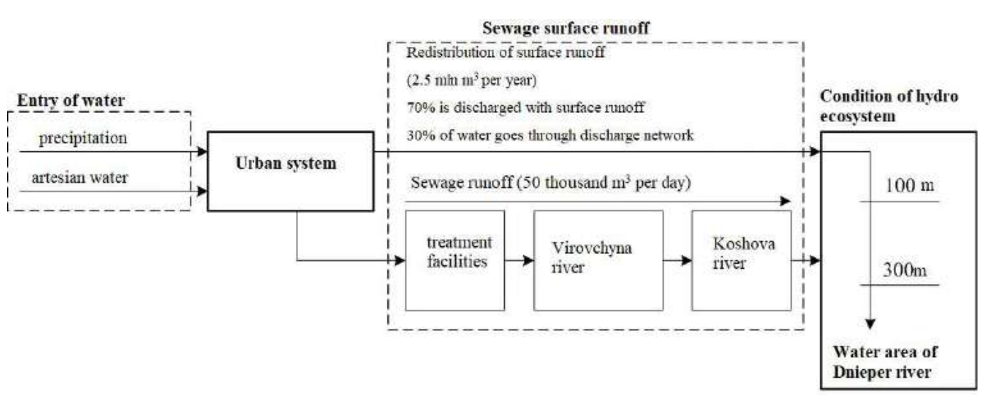

Fig. 2. Causal relation of urban system and hydrosystem

total area of land provided with storm drainage is 4240 ha or 32% of the entire city (13570 ha). 12% of rainfall evaporates, 56% of rainwater from the territory of the urban system comes with surface runoff to the waters of the Dnieper River. In 2012-2019, the average hydrochemical properties of stormwater discharges (Table 1) from areas with different landscape of the city territory for fishery exceeded the *MPC* value in certain indicators: the content of suspended solids – 97.8-163.8 times, solids –1.54-1.70 times, sulfates – 1.31-1.65 times, calcium – 1.84-2.06 times, magnesium – 2.04-3.10 times, sodium + potassium –3.13-4.05 times, petroleum products – 20-102 times. Content of ammoniacal nitrogen 1.12 times exceeds the standard value. It directly enters the Virovchyna River through storm water of the collector system of the northern part of the city.

Distribution of influence of surface runoff of the urban system of Kherson city on the water area of the Dnieper was determined by a series of interseasonal inspections of river water. The samples were taken at the lower 100 and 300-meter areas upriver from the place of discharge of most stormwater (Kherson city, Dniprovskyi district, Park of Glory, coordinates – latitude: 46° 63.5064' 0", longitude: 32° 63. 3692' 0"E). According to seasonal observations, the water quality of the coastal area of the Dnieper River for fishery according to the values of *MWPI* corresponds to the classes (Table 2). The 100-meter area is “very polluted” (class VI, *MWPI* = 7.7-8.7) – “extremely polluted” (class VII, *MWPI* = 12.46-13.32); the 300-meter area is “polluted” (class V, *MWPI* = 4.1-4.4) – “very polluted ” (class VI, *MWPI* = 7.4). The main pollutant, which leads to deterioration in the quality of the Dnieper water, is a significant excess of the content of petroleum products that enter the suburban area of the Dnieper River with untreated discharge water.

Together with surface runoff, sewage runoff also significantly affects the pollution of the rivers. Domestic and industrial wastewater is drained from the territory of Kherson city by gravity by sewerage system of the city. Its capacity is 250 thousand m^3 per day.

About 60% of the sewerage system of Kherson city is in poor technical condition. It leads to systematic breakthrough, leakage and redistribution of discharge water to the groundwater that is hydraulically connected with neogene horizons. To maintain satisfactory status of the network it was proposed to annually update at least 5% (45 km $year^{-1}$) of its length. According to the actual data in 2012-2019 about 0.8% of the sewerage network was annually updated. In addition, in 2012-2019 the daily volume of discharge water for the treatment plant of the city (urban-type settlement Komyshany) is 45-50 thousand m^3. It is discharged into the right distributary channel of the Dnieper River with conventionally cleaned water via biological ponds. Four secondary aeration sediment basins have capacity for tertiary treatment of sewage discharges up to 250 thousand m^3 with a total area 17.2 ha. The area of mirror is 105.0 thousand m^3.

Increasing negative impact of discharges on deterioration of hydro ecosystem of the lower Dnieper was determined. It is intensified by the deterioration of technical conditions of treatment facilities, in particular, untimely cleaning of sediments basins. It leads to discharge of significant amount of contaminated silt that enters the river together with about 400 tons of surface-active substances, oxides of nitrogen, sulphur, phosphorus, petroleum products, etc. During some periods, the volume of these substances is up to 1500 tons per day. In 2012-2019, the average value of individual indicators of the hydrochemical properties of sewage discharges (Table 3) that enter directly the water of Virovchyna River and are redistributed to the Koshova and Dnieper Rivers according to the fishery criteria exceeded *MPC*: suspended solids – 4.2 times; dry residue –1.3 times; sulphates –1.7 times; chlorides –1.2 times; sodium+potassium –2.6 times; ammoniacal nitrogen –3.8 times; petroleum products – 2.0 times. The change in hydrochemical properties of discharge water is reasonably justified by signified seasonal dynamics. It is characterized by change of volume of water used in household activities of population. The removal of dry residues to the treatment system in the autumn (salt, soil and sand components and biogenic and detrital substances) is 1.4 times less than in the summer. Therefore, the effectiveness of treatment systems in Kherson city accoding to the difference between indicators of the hydrochemical properties for entering and discharge of the sewage is 50.0-97.0%.

The dependence of the efficiency of treatment from pollutants that come from treatment plants was determined. The results of the study of hydrochemical properties of the condition of treated discharge water at discharge point show significant reduction of pollutants that come to treatment system from sewage water. However, the hydrochemical properties of the discharge water at the discharge point in the river according to individual indicators exceed the *MPC* values for fishery 4 times. This is due to the absence of local treatment facilities at most companies of Kherson city. It causes entering of highly concentrated industrial discharge water to communal treatment plants, which accelerates deterioration of the technical condition of city sewer networks, violation of the technological regulations of treatment. In 2019, a significant number of unauthorized discharges of polluted discharge water by industrial companies into the Dnieper river was recorded (Table 4). The

Table 1. Average annual values of hydrochemical indicators of storm water in Kherson for 2012-2019

Location of sample collection from collector		Suspended substance, mg dm^3	pH	Dry residue, mg dm^{-3}	Sulphates, mg dm^{-3}	Chlorides, mg dm^{-3}	Phosphates, mg dm^{-3}	Calcium, mg dm^{-3}	Magnesiu, mg dm^{-3}	Sodium + Potassium, mg dm^{-3}	Ammoniacal nitrogen, mg dm^{-3}	Nitrate nitrogen, mg dm^{-3}	Petroleum products, mg dm^{-3}
MPC according to fishery criteria													
MPC value	20	6.5–8.5	1000	100	300	3.5	180	50	120	0.50	40		0.05
Old city													
Beginning	X	1875.0	7.35	1526.0	131.0	227.5	2.15	326.0	156.5	369.0	0.34	22.0	0.9
	σ	223	0.9	185.0	15.5	29.6	0.30	45.2	18.6	44.2	0.04	2.62	0.10
End	X	2475.0	7.32	1544.0	132.0	230.0	2.6	331.0	154.5	375.0	0.36	23.0	1.0
	σ	345	0.75	214.0	15.3	27.5	0.40	39.7	18.3	45.1	0.05	2.59	0.12
+/-		+60.0	-0.03	+18.0	+1.0	+3.5	+0.45	+5.0	-2.0	+6.0	+0.2	+1.0	+0.1
MPC exceedance		123.8	–	1.54	1.32	–	–	1.84	3.10	3.13	–	–	20.0
Southeastern part of the city (zone of the coastal slope of the Dnieper River)													
Beginning	X	1879.0	7.45	1674.0	160.0	290.0	3.9	377.5	143.5	404.5	0.38	20.0	6.6
	σ	225.0	0.90	198.0	19.2	34.8	0.47	45.2	17.2	48.2	0.05	2.40	0.80
End	X	1955.0	7.5	1698.0	165.0	287.0	3.5	371.2	142.0	406.3	0.37	22.0	5.1
	σ	230	0.92	200.0	20.2	36.4	0.42	42.6	16.8	50.1	0.05	2.32	0.61
+/-		+76.0	+0.05	+24.0	+5.0	-3.0	-0.4	-6.3	-1.5	+1.8	-0.1	+2.0	-1.2
MPC exceedance		97.8	–	1.70	1.65	–	–	2.06	2.84	3.40	–	–	102.0
Northern part of the city (with a slope of the area to the left slope of the top of the Virovchyna river)													
Beginning	X	3200.0	7.1	1671.0	130.0	219.0	4.5	342.0	105.0	479.5	0.58	36.0	3.6
	σ	384	0.85	195.0	15.6	26.3	0.54	41.0	12.6	62.3	0.07	4.32	0.43
End	X	3275.0	6.9	1664.0	131.0	215.0	4.4	364.0	102.0	485.7	0.56	34.0	3.7
	σ	375.0	0.74	193.0	15.7	25.6	0.53	45.1	11.8	65.4	0.06	3.85	0.49
+/-		+75.0	-0.2	-5	+1.0	-4	-0.1	+22	-3	+7.2	-0.2	-2	+0.01
MPC exceedance		163.8	–	1.66	1.31	–	1.26	2.02	2.04	4.05	1.12	–	74.0

deterioration of ecological condition of hydro ecosystem of the lower Dnieper in the area of urban system was determined. It was caused by the absence of surface water treatment facilities of surface waters and its unsatisfactory technical condition for sewage treatment, spatial and seasonal distribution of precipitation and water use, which determines the rate and volume of removal of pollutants of urban system by sewage runoff, its spatial redistribution in the deltoid and reed bed hydro network upriver and partial self-purification of water in the lake and reed bed ecosystems of Dnieper River. Downstream water of the river complies with the needs of the fishery, but the *MPC* values of water are not satisfactory and correspond to the class "moderately polluted" (class III) – "polluted" (class IV)".

To reduce the impact of urban system on the hydro ecosystem of the lower Dnieper, the water protection measures were developed for the purification and reuse of sewage runoff of Kherson city for underground irrigation of urban and suburban areas. For additional biological treatment of sewage surface runoff and prevention of an emergency discharge of untreated sewage to the suburban area of the Dnieper River, the construction of the emergency waste stabilization pond was proposed. With minor daily volumes of sewage (45-50 thousand m^3), it is to be capable of holding a 5-7 days discharge, which shall allow avoid emergency situation and repair the city sewage system. Afterwards, water of waste pond shall be redirected for post-treatment using highly modified strains of microorganisms, *Clostridium, Peptococcus, Butyrivibrio, Bacillus,* which increase the efficiency of extraction of pollutants from sewage and break down complex polymeric molecules of proteins, carbohydrates, nucleic acids and lipids to simple chemical compounds. The construction of local treatment facilities for the implementation of mechanical treatment with subsequent post-treatment of surface waters at public wastewater treatment plants was proposed. It was established that the annual volume of untreated and conventionally purified sewage surface runoff that enter the Dnieper river is 20.5 million m^3, including sewage runoff 18.0 million m^3 and surface sewage runoff 2.5 million m^3. The use of this water after treatment for irrigation was recommended as it has improvement value due to the content of nitrogen, phosphorous and potassium compounds. According to the qualitative assessment of sewage drains in line with

Table 2. Assessment of water quality in different parts of the lower Dnieper river

Location of sampling		Quality assessment					
		For fishery			For amenity needs		
		WPI value	Quality class	Characteristic	WPI value	Quality class	Characteristic
Spring	River water 100 m	13.32	7	Extremely polluted	1.9	3	Moderately polluted
	River water 300 m	4.4	5	Polluted	1.02	3	Moderately polluted
Summer	River water 100 m	12.46	7	Extremely Polluted	2.02	3	Moderately polluted
	River water 300 m	7.43	6	Extremely polluted	1.55	3	Moderately polluted
Autumn	River water 100 m	8.7	6	Extremely polluted	1.77	3	Moderately polluted
	River water 300 m	7.44	6	Extremely polluted	1.56	3	Moderately polluted
Winter	River water 100 m	7.7	6	Extremely polluted	1.57	3	Moderately polluted
	River water 300 m	4.1	5	Polluted	0.96	2	Clean

Table 3. Hydrochemical characteristics of the sewage at the discharge point for 2012-2019

Season and years		Suspended substance, mg dm^{-3}	pH	Dry residue, mg dm^{-3}	Sulphate, mg dm^{-3}	Chloride, mg dm^{-3}	Phosphates, mg dm^{-3}	Calcium, mg dm^{-3}	Magnesium, mg dm^{-3}	Sodium + Potassium, mg dm^{-3}	Ammonia cal nitrogen, mg dm^{-3}	Nitrate nitrogen, mg dm^{-3}	Petroleum product, mg dm^{-3}
MPC according to fishery criteria													
MPC value		20	6.5-8.5	1000	100	300	3.5	180	50	120	0.50	40	0.05
Before treatment	2327	8.2	32568	5733	6236	51.7	151.2	32.3	1226.7	49.2	186.7	0.12	0,12
	441.3	0.24	4501	529	350	6.8	70.5	14.8	271.8	10.8	41.3	0.04	0,04
After treatment	84.0	8.5	1300	168	365.7	1.8	150.3	4.4	313.9	1.9	25.7	0.10	0,10
	12.5	0.3	207.0	20.8	43.6	0.6	47.9	1.4	69.6	0.8	12.3	0.04	0,04
+/-		-2243	0.35	-31268	-5565	-5870	-49.9	-0.87	-27.9	-912.8	-47.3	-161	-0.02
MPC exceedance		4.2	–	1.3	1.7	1.2	–	–	–	2.6	3.8	–	2.0

agronomic criteria, it was determined that the water is suitable for irrigation upon conditions of preliminary improvement. Total irrigation norm was calculated for typical crop rotation (forage crops – 33 %, grain crops – 67 %) (Table 5).

According to the annual volume of sewage surface runoff of Kherson city, its reusing can provide irrigation for growing crops at the area of 9468 ha, with a weighted average irrigation rates gross 2165 $m^3 ha^{-1}$, with the rate of water loss net 2079 $m^3 ha^{-1}$. The energy conversion efficiency of underground irrigation system was also considered (η = 0.96). It is possible to irrigate one million hectares of agricultural land due to the formation of the total volume of sewage surface runoff on the territory of Ukraine. The adoption of the proposed measures shall reduce the level of negative impact of sewage runoff in hydro ecosystem of the lower Dnieper River. It shall reduce the consumption of water for irrigation and provide production of agricultural crop yields due to reuse of sewage runoff.

Table 4. Number of recorded MPC exceedances in sewage runoff of companies in Kherson city in 2019

Wastewater quality indicators	Number of found violations
Suspended substances	50
Ammoniacal nitrogen	90
Phosphates	103
Biochemical oxygen demand (BOD_5)	18
Chlorides	7
Fats	64
Synthetic Surfactants (SS)	47
Sulfates	1
Iron	26
Zinc	1
Sulfides	12
Chemical oxygen demand	20
Nitrates	1
Nitrites	50
Petroleum products	12
Dry residues	10

Table 5. Grain and fodder crop rotation and the value of irrigation norms of agricultural crops

Rotation of agriculture crops	Irrigation norm, $m^3 ha^{-1}$
Alfalfa	3000
Alfalfa	2700
Winter wheat	1050
Cereal and bean mixture	1150
Corn for grain	1250
Corn for grain	1250
Spring wheat	1150
Alfalfa seeding	900

CONCLUSIONS

The influence of urban systems leads to the transformation of floodplains and braids, destruction of the river hydro ecosystem and significant deterioration of the water management and recreational values. The situation is aggravated by the operation of outdated and inefficient water discharge and water treatment systems. It leads to systematic contamination of the urban system of suburban river basin with sewage surface runoff and distribution of pollutants upriver. The dependence of the amount of sewage surface runoff from preceptation and the volume of drinking water in Kherson city was established. The effectiveness of treatment systems in Kherson city accoding to the difference between indicators of the hydrochemical properties for entering and discharge of the sewage is 50-97%. The negative impact of surface runoff of the urban system of Kherson city at 100- and 300-meter area of the water basin upriver was determined: the 100-meter area is “very polluted” (class VI) – “extremely polluted” (class VII); the 300-meter area is “polluted” (class V) – “very polluted” (class VI). It was found that the main pollutant that leads to deterioration in the quality of the water in the Dnieper River is a significant excess of petroleum products. Hydrochemical values of sewage discharges for fishery exceed the MPC values 4 times. It leads to unsatisfactory ecological condition of the hydro ecosystem of the lower Dnieper River in the urban system and outside/ upriver. It was determined that the application of the suggested integrated model of research and the establishment of causality of the impact of urban system on the ecological condition of the hydrosystem of the rivers allowed to carry out spatial differentiation of protection measures regarding reduction of the negative impact of sewage runoff on surface water condition and it shall improve obtaining of crop yields on irrigated land due to the reuse of sewage rainfall.

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Hydrological Appraisal of Nariganipalli Watershed (India) using Spatial Information Technology

Mahesh Palakuru, Venkat Reddy K, Sirisha Adamala[1] and Harish Babu Bachina[2]

Civil Engineering Department, National Institute of Technology (NIT), Warangal-506 004, India
[1]Natural Resources Management Division, Central Island Agricultural Research Institute (CIARI), Port Blair-744 101, India
[2]Department of Applied Engineering, Vignan's Foundation for Science, Technology and Research (VFSTR) University, Vadlamudi -522 213, India
E-mail: bachina.harish@gmail.com

Abstract: The basic intent of the present study is to derive the parameters required for runoff modeling using the geospatial database and estimate the runoff of Nariganipalli watershed. During the basic data preparation stage of the study, the land use map and the digital elevation model covering the study area were derived with the help of remotely sensed information. Shuttle Radar Topographic Mission data have been imported into soil and water assessment tool (SWAT) project to start watershed delineation. By providing all the inputs for the model set up, SWAT model was simulated for the period of two years (2012-13). Results of streamflow were validated with the observed data of Nariganipalli watershed. Though the rainfall in the watershed is 72.5 mm annually there is a deficiency in water in the watershed. Total requirement of water in the watershed is 93.01 ha m and available water is 68.5737 ha m. This statistics tells that there is huge difference between available water and required water. These types of models will help to reduce the water deficiency and can be utilized as a potential tool for water resource management at Nariganipalli watershed.

***Keywords*:** Digital elevation model, India, Nariganipalli, SWAT, Watershed

Environmentally, socially and financially sound management of water resources requires long-term and reliable hydrologic information. Poor availability of comprehensive and good quality hydrologic data leads to unsound planning and inadequate design and operation of water resources projects. Use of mathematical models for the hydrologic evaluation of watersheds is the current trend and extraction of watershed parameters using remote sensing (RS) and geographical information system (GIS) in high speed computers are the aiding tools and techniques for it. Surface runoff is one of the major causes of erosion of the earth's surface and the location of high runoff generating areas is very important for making better land management practices. The location of runoff production in a watershed depends on the mechanism by which runoff is generated. Infiltration excess occurs when the rainfall intensities exceed the soil infiltration rate or any depression storage has been already filled. Soil infiltration rates are controlled by soil characteristics, vegetation cover and land use practices. Mathematical models are much more popular for runoff assessment as these are fewer data driven, simpler and cheaper.

Soil and Water Assessment Tool (SWAT) is a river basin scale model developed to quantify the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time (Singh et al 2014, Niraula et al 2015, Briak et al 2016, Muenich et al 2016, Tuo et al 2016, Woldesenbet et al 2016, Zhang et al 2016). To test the capability of the model in determining the runoff of the watershed, SWAT 2012 with ArcGIS 10.1 interface was selected for the present study. The Epicollect is a free open source software application for collecting, storing, and exporting real-time data from remote rural areas across the globe for Epidemio surveillance of human/livestock/wildlife diseases as well as resource mapping (Aanensen et al 2009). The main objective of the present study is to derive the parameters required for runoff modeling using the geospatial database and estimate the runoff of the Nariganipalli watershed (India). In this case study, a new approach 'Epicollect mobile application' was used for data collection about structures in the watershed.

MATERIAL AND METHODS

For the present study, Nariganipalli watershed was selected (Fig. 1). Nariganipalli watershed is located in Nariganipalli Grama Panchayat of Ramasamudram Mandal in Punganur Block, Chittoor district. The watershed is located between the latitudes 13°13'30'' and13°14'23''to longitude 78°39'0'' and78°43'04'' at valley point. It is at a distance of 5 km from its Mandal headquarters and 15 km from the district headquarters. This watershed is located at an elevation of

964 m above the mean sea level. The total area of the watershed is 287 ha. The average annual rainfall (10 years) in the area is 738 mm.

Working of epicollect: The first thing to do in EpiCollect is to create own project website with a name through the link (http://www.epicollect.net/create1.html) that is free hosting on EpiCollect server. Once after creating the own project, users have to login using Google mail desktop/laptop computer with internet connection. Users can design a form/questionnaire for data collection as per research interest. EpiCollect entries usually include the GPS location and a photo, however in order to collect text data. When EpiCollect is launched on the mobile phone three options are initially available, 'New Entry', 'List Entries' and 'Display Map'. By selecting 'New Entry' users can create a new data record within the phone's on-board database and assigns a unique ID to the record. After successful entry of necessary data, one can amend the look and feel of his/her homepage by adding some explanatory text about your project and upload an image through login the project website (http://www. epicollect.net/project.html?name=nitwproject).

Digital Elevation Model (DEM) was extracted from the Shuttle Radar Topographic Mission (SRTM) Global. This has

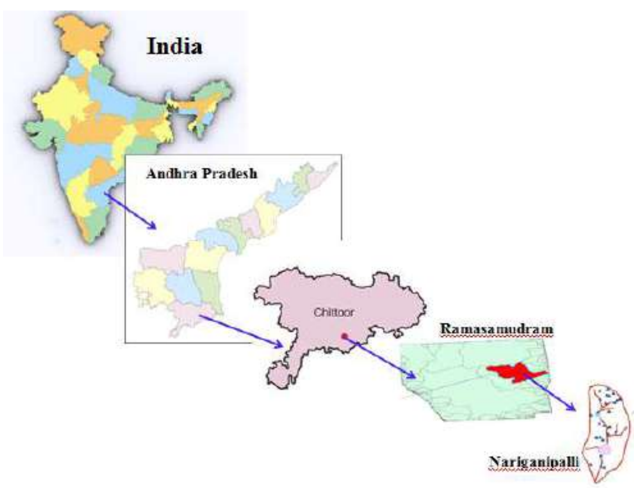

Fig. 1. Location of Nariganipalli study area

a spatial resolution of 30 m. The DEM was used to delineate the watershed and sub-basins as the drainage surfaces, stream network, and longest reaches. The topographic parameters such as terrain slope, channel slope or reach length were also derived from the DEM.

The movement of water depends on the soil type and vegetation cover. The amount of rain lost due to interception storage on the plants depends on the type of vegetation and has a significant effect on the infiltration capacity of the soil. For each of the delineated sub-basins, land use and soil data were defined for modeling of various hydrological and other physical processes.The land use map was extracted from processing of Landsat Thematic Mapper (TM) satellite image of the year 2012 and 2013 that has a spatial resolution of 30 m. The supervised classification and the photo interpretation techniques were used to derive and distinguish the most present land use classes in Nariganipalli basin. Six major classes were identified. The dominant land use classesare irrigated agriculture (90%) and irrigated intensive agriculture (10%).

Soil physical attributes were initially stored to the SWAT's soil database through an Edit database interface and relevant information required for hydrological modeling was provided to the model. The database was linked to the soil map through the look up table which was again linked to the soil map. Later, it was given as input to the SWAT model. The soil map was obtained mainly from the Harmonized World Soil Database developed by the Food and Agriculture Organization of the United Nations.

SWAT2012 model was set up using the threshold of 287 ha as the drainage area for delineating the watershed. This resulted in the subdivision of the watershed into 16 sub basins. Thereafter, the 52 Hydrologic Response Units (HRUs) were generated firstly by a combination of sub-basins, land use, soil and slope layers with 5%, 10% and 10% as thresholds, respectively. The urban and water classes were exempted from this simplification due to their low areas. The water balance parameters were calculated using the curve number method for the surface runoff.

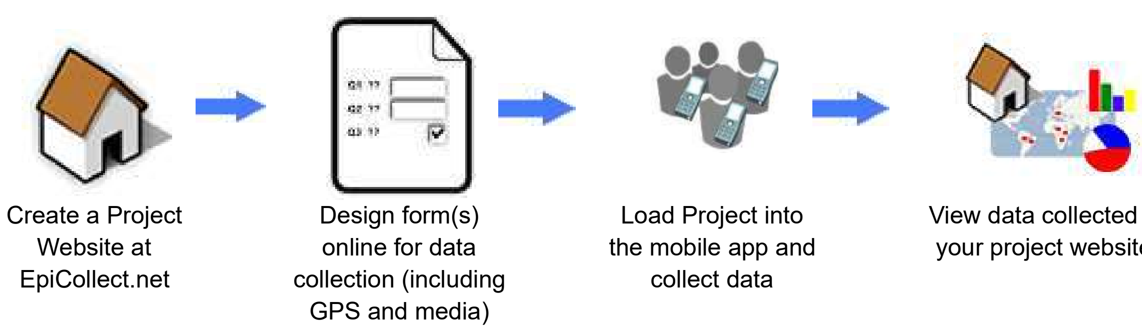

Fig. 2. Overview of the Epi Collect workflow

Evaluation of model: The calibration was carried out using the average monthly observed flow at the hydrometric station. The validation was done thereafter to evaluate the performance of the model with calibrated parameters to simulate the hydrological functioning of the watershed over another time period that has not been used in the calibration phase. The validation was carried out using the coefficient of determination (R^2), Nash-Sutcliff Efficiency (NSE), Percent BIAS (PBIAS)and Root mean squared error (RMSE) observations Standard Deviation Ratio (RSR).

$$R^2 = \frac{\left[\sum_{i=1}^{n}\left(O_i - \overline{O}\right)\left(T_i - \overline{T}\right)\right]^2}{\sum_{i=1}^{n}\left(O_i - \overline{O}\right)^2 \sum_{i=1}^{n}\left(T_i - \overline{T}\right)^2} \qquad (1)$$

$$NSE = \left[1 - \frac{\sum_{i=1}^{n}\left(T_i - O_i\right)^2}{\sum_{i=1}^{n}\left(T_i - \overline{T}\right)^2}\right] * 100 \qquad (2)$$

$$PBIAS = 100 \times \left[\frac{\sum_{i=1}^{n}\left(O_i - T_i\right)}{\sum_{i=1}^{n}\left(T_i\right)}\right] \qquad (3)$$

$$RSR = \frac{RMSE}{STDEV_{obs}} = \left[\frac{\sqrt{\sum_{i=1}^{n}\left(T_i - O_i\right)^2}}{\sqrt{\sum_{i=1}^{n}\left(T_i - \overline{O}\right)^2}}\right] \qquad (4)$$

Where T_i and O_i = target (observed) and output (simulated) values at the i^{th} step, respectively; n = number of data points; $_T$ and O= average of target and output values, respectively; TO= average of target and output values.

RESULTS AND DISCUSSION

Running SWAT model with the specified optimal values allow measuring the performance of the model. This is done by comparing the observed and simulated flow for both the calibration and validation periods. This comparison is summarized in Table 1 with the mentioned statistic coefficients and showed graphically in Figure 3 for calibration and Figure 4 for validation period. The statistic evaluators showed a acceptable correlation between the monthly observed and simulated river discharge with R^2 of 0.44, PBIAS of 73.4 and RSR of 1.11 (Table 1) for the calibration period. The validation period revealed good values for R^2 (0.52), and RSR (0.74) but less accurate value for PBIAS (28.9). According to Moriasi et al (2007), the model

Table 1. Statistic evaluation of simulated versus observed streamflow data

Coefficient	Calibration (2012)	Validation (2013)
R^2	0.44	0.52
PBIAS	73.4	28.9
RSR	1.11	0.74
NSE	0.22	0.74

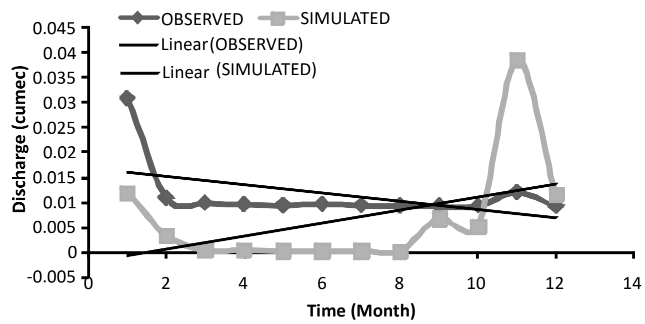

Fig. 3. Comparison of monthly observed and simulated flow for calibration period (2012)

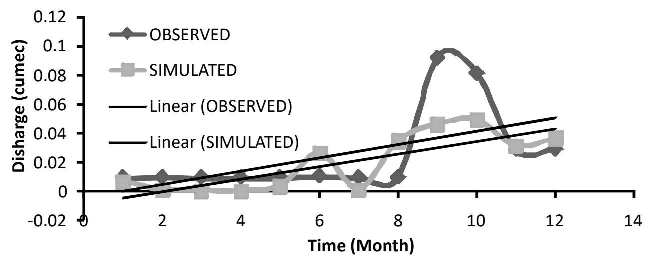

Fig. 4. Comparison of monthly observed and simulated flow for validation period (2013)

performance for both the calibration and validation periods was evaluated as 'very good performance rating': 0 to 0.5 for RSR and –10 to 10 for PBIAS. The values of PBIAS indicate that the model had slightly overestimated the streamflow during the calibration period and had underestimated it for the validation period 2013. In the other hand, the lower value of RSR indicates the lower of the root mean square error normalized by the observations standard deviation which indicates the rightness of the model simulation.

Hydrological response unit (HRU): The threshold value in HRU delineation was calibrated and adjusted appropriately to account for various land use types covering a significant area in the watershed. A threshold of 10% for land use and 10% for soil was used, which deducted any land use that occupied less than 10% of the land in the sub-basin and any soil that represented less than 10% of the land use in the sub-basin. As per the final HRU report, 52 HRUs are being created within the Nariganipalli watershed and sub basin wise HRU report was generated.

Development of a suitable model for the hydrological process for a river basin is the most important aspect of water resource management. SWAT hydrological model was applied to Nariganipalli watershed to assess runoff of the basin. Input data generated through geospatial techniques are quite applicable to run the SWAT model for the Nariganipalli watershed. The performance and applicability of SWAT model were successfully evaluated through model calibration and validation. Streamflow is the most important element simulated in this model. Average annual prediction of streamflow is 72.95 mm. From the (Fig. 5) discharge of water throughthe outlet is maximum at the year 2013, from the year 2012 to 2013 the discharge rate is increased periodically. When we observed the Figure 6 the observed runoff and simulated runoff curve varies approximately 10% to 20% this variation is acceptable by observing the runoff curve. Therefore, we can suggest constructing water harvesting structures to reduce runoff to increase ground water table, reduce soil erosion and mineral transportation from the watershed.

Water budget: Data pertaining to water budget in the Nariganipalli watershed area is shown in Table 2.

The detailed calculations to describe the whether there is any deficiency of water in the Nariganipalli watershed area is shown in below calculations.

- Village area = 287 ha, Average rainfall = 738 mm
- Village rain water =287 ×
- 0.738 = 211.806 ha-m = 2118060 cumec = Total rain water
- Ground water (9%) = 211.806 x (9/100) = 19.062 ha-m
- Total runoff (40%) =211.806 x (40/100) = 84.7224 ha-m
- Evapotranspiration (41%) = 211.806 x (41/100) = 86.840 ha-m
- Soil moisture (10%) = 211.806 x (10/100) =21.180 ha-m
- Water storage (Water stored in all water harvesting structures in area: 7.15 ha-m)
- Net runoff = Total runoff – Water storage = 84.7224 –7.15 = 77.572 ha-m
- Water available for ground water storage (20%) = 211.806 x (20/100) =44.361 ha-m
- Total available water = 19.062 + 44.361+7.15 = 68.5737 ha-m
- Water budget = Available water – Required water= 68.5737–93.01

  = – 24.4363 ha-m = 244363m^3

The negative value of water budget shows the deficiency of water in the Nariganipalliwatershed area.

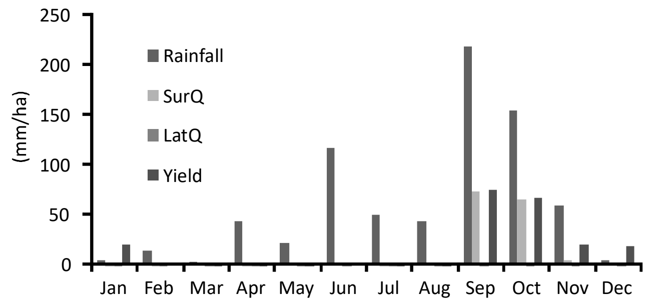

Fig. 5. Average monthly basin values Q-Discharge

Table 2. Water budget data of Nariganipalli watershed

Particulars	Quantity	Unit (ha-m)	Required water (cumec)
Human beings (No.)	850	3.2/1000	27200
Livestock (No.)	250	4.8/1000	11910
Goats/sheep (No.)	700	0.4/1000	2800
Poultry (No.)	650	0.2/1000	1300
Paddy (ha)	43	12/10	516000
Dry crops (ha)	50	2/10	100000
Horticulture (ha)	71	2.8/10	198799
Vegetables (ha)	30	2.4/10	72000
Total			930100

CONCLUSIONS

In the present study, GIS based hydrological modelling was utilized for the assessment of total amount of the water available in the study area. This study showed the utility of GIS to create, combine and generate the necessary data to set up and run the hydrological models especially for the distributed and continuous. This study was also demonstrated that the SWAT model works well in the Nariganipalli watershed. SWAT hydrologic model was calibrated for monthly simulated streamflow by using observed streamflow data from the gauging station in the catchment. The calibration and validation results of SWAT model were satisfactory, as indicated by good values of R^2 and NSE. Obtained R^2 and NSE were 0.44 and 0.22 and 0.52 and 0.45 for the calibration and validation, respectively. This performance indicates the model goodness. Overall water budget results indicated that there is huge difference between available water (685737m^3) and required water (930100 m^3).

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Effect of Slum on Water Quality in Abakaliki Southeastern Nigeria

C. Njoku, C.N. Mbah, J.N. Nwite, J.O. Agwu, O. Elom[1], T.S. Igwe and J.U. Ndem[2]

Department of Soil Science and Environmental Management, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki-Nigeria
[1]Department of Agriculture Education, Ebonyi State College of Education, Ikwo, Nigeria
[2]Department of Technology and Vocational Education, Faculty of Education, Ebonyi State University, Abakaliki-Nigeria
E-mail: chimarco2001@yahoo.com

Abstract: This research was carried out in 2016 and 2017 to determine the effects of slum on water qualities in Abakaliki Southeastern Nigeria at slums of Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba. Water samples were analysed for colour, conductivity, total suspended solid, total dissolved solids, total solids, pH, NO3-, Cl-, Ca hardness, Mg hardness, total hardness, Pb, Cd, Cu and Zn. Apart from total solids and Cl-, which were above the recommended standards, all the other parameters were within the acceptable standard for safe use. Furthermore, parameters were significantly higher in 2017 than 2016 indicating the possibility of these parameters to be hazardous in future. It is therefore, recommended that water sourced from tube wells under slum settlements should be treated before usage to prevent health risks.

***Keywords*:** Degraded, Dirt, Indiscriminate, Overcrowded, Slum, Water quality

The various slums located around and within urban centres in developing countries are experiencing greater rates of urbanization compared to developed countries (Mahabir et al 2016). Increased urbanization is a major concern for developing countries such as Nigeria since it often lacks the infrastructure and basic services such as water, sanitation and healthcare necessary to support decent living of large number of people (Cohen 2006, Montgomery 2008). For urban areas not to have problems, urban growth and economic development must grow at equal rates. However, history has shown that, this could not always be the case as many less developed countries are unable to support the increased urban population (Mahabir et al 2016). Thus, slums have emerged and continue to grow and persist in many Nigerian cities such as Abakaliki, Ebonyi State. According to Uwejamomere (2008), since 1990 urban coverage for water and sanitation has failed to keep pace with population growth. The nature of settlement in these slums can best be described as informal or random. There are no plans, rules and rationales as houses are often built without proper planning with too many people living in one small structure. Most of the dwellers get their water from small scale private suppliers, such as water trucks, street vendors, and other water sellers. It is common for families in these colonies to purchase water that has been trucked in from a borehole well that is outside the city or from a neighbour who has water piped to their home. Similarly, borehole well owners may sell water to these truckers, who, in turn, would sell the water in the slum colonies and slum neighborhoods in an unregulated manner. Thus quality of the water sold is highly questionable. It is estimated that one-third of deaths in developing countries are caused by the consumption of contaminated water and on average as much as one-tenth of each person's productive time is sacrificed to water-related diseases. The commonly used guideline is that the well should be located in a higher area and at least 15 m away from the pit latrines and should be at least 2 m above the water table (Wambui et al 2007). The increase of shanty dwellings, informal and random settlements in Nigerian cities in which Abakaliki the study area is not an exception necessitated this study. Therefore, the objective of the study is to determine the effect of slum on water qualities in Abakaliki Southeastern Nigeria.

MATERIAL AND METHODS

The study was conducted in Abakaliki Southeastern Nigeria. Abakaliki lies in latitude 06°14' and 06° 30' N with longitude 08°0' and 08°15' E. The rainfall pattern is bimodal (April to July and September to November), with a quick dry spell in August normally referred to as “August Break”. It has annual rainfall of 1700 to 2000mm and annual mean of 1800mm. The area has minimum temperature of 27°C and maximum mean daily temperature of 31°C. Humidity is high (80%) during rainy season and low (60%) during dry season. Geologically, the soil of the research site is derived from sedimentary rock which is obtained from straight seawater retainer of the cretaceous periods and quaternary periods. Abakaliki remain within 'Asu River group' and made up of olive brown sandy shale, small particles of mudstones and sandstone. The soil is not very deep with unconsolidated parent substances within 1 m of the sand uppermost layer. Reconnaissance survey of the study area was conducted and the following water sources were chosen were tube well at countryside (control), slums of Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba.

Water sample collection: Cleaned and sterilized Ivy bottle water was used to collect five replicate water samples in five tube wells in control and each slum in 2016 and 2017 years of the study.

Physical parameters: Bhagure and Mirgane (2010) methods were used to determine total suspended solids, total solids and total dissolved solids. The colour of the samples was determined in terms of percentage transmittance of light. The conductivity of the sample was determined using SANXIN SX723 conductivity meter (Hossain et al 2001).

Chemical parameters: The pH of water was determined using pH meter (Jung 2001) nitrate (NO_3^-) by using turbidimetric method (Stavrianou 2007). Chloride was determined using argentometric titrimetric method (Jung 2001) and Calcium, Magnesium and total hardness were determined using estimation method described by Jung (2001).

Determination of heavy metals: Heavy metals (Pb, Cd, Cu and Zn) were determined by digesting the sample in a fume cupboard and reading transmittance of light using Atomic Absorption Spectrophotometer model (American Public Health Association 1998).

RESULTS AND DISCUSSION

Effect of slum on physical parameters: The water colour, conductivity, total suspended solids, total dissolved solids and total solids showed significant changes among the different tube wells. The order of increase in colour was Control <Ogbeawusa <Amaikeaba <Orokeonuoha <Mgbukobe for the 2016 while the order of colour increase in the 2017 was Control <Amaikeaba <Orokeonuoha <Ogbeawusa <Mgbukobe. Control recorded conductivity values of 0.04 and 0.06 μScm^{-1} for 2016 and 2017, respectively while conductivity values in tube wells sited in the slums ranged between 0.42-0.47 and 0.44-0.48 $\mu S\ cm^{-1}$ for 2016 and 2017. Control had the lowest total suspended solids of 31.02 $\mu S\ cm^{-1}$ in 2016. This observed suspended solid in control was lower than suspended solids in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 326, 323, 299 and 241%, respectively. Similarly, the lowest total suspended solids of 28.17 $\mu S\ cm^{-1}$was observed in control in 2017.The observed total suspended solids in control were lower than total suspended solids in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 372, 337, 341 and 376%, respectively. The order of increase in total dissolved solid in the 2016 was Control <Ogbeawusa <Mgbukobe = Amaikeaba <Orokeonuoha, whereas, the order of increase in total dissolved solid in 2017 was Control <Ogbeawusa <Orokeonuoha <Amaikeaba <Mgbukobe. Control recorded the lowest total solid of 66.11 and 64.44 $\mu S\ cm^{-1}$ in 2016 and 2017, respectively, whereas, tube well sited in slums ranged between 219.34-245.74 and 239.53-250.48 $\mu Scm^{-1}$for the corresponding years of the study.

Effect of slum on water pH, NO_3^- and Cl^-: There was a significant change in water pH, $NO_3^-$and Cl^-(Table 2). In 2016, control recorded the lowest pH of 6.83 and was lower than pH in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 6, 12, 9 and 7%, respectively. Similarly, the lowest pH value of

Table 2. Effect of slum on water pH, NO_3^- and Cl^-

Tube well	pH		NO_3^-(mg l^{-1})		Cl^- (mg l^{-1})	
	2016	2017	2016	2017	2016	2017
Control	6.83	6.92	2.36	2.32	68.96	77.83
Ogbeawusa	7.23	7.21	6.21	6.47	252.01	263.76
Orokeonuoha	7.63	7.61	6.15	6.28	261.23	267.17
Mgbukobe	7.41	7.36	6.17	6.20	265.45	268.91
Amaikeaba	7.28	7.15	6.24	6.27	278.21	277.54
CD (p<0.05)	0.28	0.16	0.29	0.16	16.23	20.39
Standard	6.5 – 8.5		10		250	

Standards according to Alloways (1996)

Table 1. Effect of slum on water colour (% transmittance), conductivity, total suspended solids, total dissolved solids and total solids

Tube well	Colour (%)		Conductivity ($\mu S\ cm^{-1}$)		Total suspended solids (mg l^{-1})		Total dissolved solids (mg l^{-1})		Total solids (mg l^{-1})	
	2016	2017	2016	2017	2016	2017	2017	2017	2016	2017
Control	4	5	0.04	0.06	31.02	28.17	35.09	36.27	66.11	64.44
Ogbeawusa	13	16	0.42	0.44	132.14	133.06	103.16	113.42	235.30	246.48
Orokeonuoha	14	15	0.43	0.47	131.17	123.08	114.57	116.45	245.74	239.53
Mgbukobe	16	17	0.47	0.48	123.77	124.25	113.23	123.26	237.00	247.51
Amaikeaba	12	14	0.44	0.46	105.89	134.17	113.45	116.31	219.34	250.48
CD (p=0.05)	0.98	1.01	0.08	0.07	11.02	12.57	15.78	16.21	10.51	14.38
Standard	50		500		500		500		150	

Standards according to Alloways (1996)

6.92 observed in control in 2017 was lower than pH observed in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 4, 10, 6 and 3%, respectively. The order of increase in NO_3^- in 2016 was control <Orokeonuoha <Mgbukobe <Ogbeawusa <Amaikeaba while the order of NO_3^- increase in 2017 was control <Mgbukobe< Amaikeaba <Orokeonuoha <Ogbeawusa. In the 2016, control recorded the lowest Cl^- value of 68.96 mg l^{-1} whereas Cl^- ranged in tube wells sited in slums ranged between 252.01-278.21 mg l^{-1}. In the 2017 Cl^- was 77.83 mg l^{-1} in control whereas Cl^- in tube wells sited in slums ranged between 263.76-277.54 mg l^{-1}.

Effect of slum on Water Ca, Mg and total hardness: There were significant changes among the different tube wells studied with respect to Ca, Mg and total hardness (Table 3). The order of Ca hardness for 2016 and 2017 was Control <Orokeonuoha <Amaikeaba <Mgbukobe <Ogbeawusa and Control <Amaikeaba <Mgbuokbe <Ogbeawusa <Orokeonuoha, respectively. Control recorded the lowest Mg hardness value of 36.14 mg l^{-1} in 2016. This observed Mg hardness in 2016 was higher than that of Mg hardness in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 153, 125, 173 and 139%, respectively. Similarly, in 2017, Mg hardness value of 48.09 mg l^{-1} was observed in control. This lowest value of Mg hardness observed in control was lower than Mg hardness observed in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 92, 74, 106 and 89%, respectively. In 2016 and 2017 control recorded total hardness values of 101.28 mg l^{-1} and 99.37 mg l^{-1}, respectively, whereas total hardness in tube wells sited in slum ranged between 190.02-211.13 mg l^{-1} and 203.79-213.89 mg l^{-1} for the corresponding periods of studies.

Effect of slum on Water Pb, Cd, Cu and Zn: There were significant) changes in Pb, Cu and Zn among the different tube wells studied (Table 4). On the other hand, Cd recorded non-significant changes among the different tube wells studied. The order of increase in Pb for both periods was Control <Ogbeawusa <Orokeonuoha <Mgbukobe <Amaikeaba. Control recorded the lowest Cu values of 0.11 mg l^{-1} and 0.12 mg l^{-1} in 2016 and 2017, respectively whereas Cu in tube wells sited in slums ranged between 2.24-2.61 mg l^{-1} and 3.71-3.98 mg l^{-1} for the corresponding years. The lowest Zn value of 1.26 mg l^{-1} was observed in control. This observed Zn in control in the 2016 was lower than Zn in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 157, 198, 187 and 202%, respectively. Also, in 2017 control recorded the lowest Zn value of 1.17 mg l^{-1}. This lowest Zn value in control was lower than Zn in Ogbeawusa, Orokeonuoha, Mgbukobe and Amaikeaba by 226, 227, 217 and 240%, respectively.

Increase in colour, conductivity total suspended solids, total dissolved solids and total solids in tube wells sited in slums may be attributed to the presence of impurities in tube wells sited in slums than that of control. Impurities such as faeces, particulate matter, debris, metals, woods, microorganisms, dirt, fuel, smokes and excreta are transferred to underground water as a result of improper disposal. According to Wambui et al (2007) quality of water which slum dwellers use in Kenya showed that in overcrowded slums the distance between tube wells and pit latrines are short, thus, causing micro-organisms, faeces and other substances to be easily transferred to tube wells. Similarly, Njoku et al (2017) in their study of water properties as influenced by abattoir wastes in Abakaliki and Ezzamgbo Southeastern Nigeria also discovered the higher values of colour, conductivity total suspended solids, dissolved solids and total solids in water sources in abattoir sites than the water source in non-abattoir site. total solid which the values in slum were above the standard (Table 1), the values observed for colour, conductivity total suspended solids and total dissolved solids were within the recommended standards (Alloways 1996). Higher pH in tube wells in slums than tube well in non-slum mighty be as a result of pollution of underground water by alkaline slum wastes. The particulate matter such as ash and wastes generated in this dirty and

Table 3. Effect of slum on water Ca, Mg and total hardness

Tube well	Ca (mg l^{-1})		Mg (mg l^{-1})		Total hardness (mg l^{-1})	
	2016	2017	2016	2017	2016	2017
Control	65.14	51.28	36.14	48.09	101.28	99.37
Ogbeawusa	119.32	120.17	91.41	92.17	210.73	212.34
Orokeonuoha	108.55	121.88	81.47	83.51	190.02	205.39
Mgbukobe	112.35	114.91	98.78	98.98	211.13	213.89
Amaikeaba	110.46	112.78	86.46	91.01	196.92	203.79
CD (p=0.05)	10.34	12.81	5.29	7.18	16.01	18.46
Standard	200		250		500	

Table 4. Effect of slum on water Pb, Cd, Cu and Zn

Tube well	Pb (mg l^{-1})		Cd (mg l^{-1})		Cu (mg l^{-1})		Zn (mg l^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017
Control	0.001	0.002	0.000	0.000	0.11	0.12	1.26	1.17
Ogbeawusa	0.026	0.028	0.002	0.001	2.24	2.36	3.24	3.81
Orokeonuoha	0.035	0.038	0.001	0.002	2.41	2.43	3.76	3.83
Mgbukobe	0.039	0.037	0.002	0.001	2.37	2.40	3.61	3.71
Amaikeaba	0.041	0.042	0.000	0.000	2.61	2.51	3.81	3.98
CD (p=0.05)	0.004	0.003	NS	NS	0.025	0.028	0.66	0.83
Standard	0.01		0.003		2.0		3.0	

overcrowded environment might have contributed to increase in pH of the underground water in the slum. However, the observed values were within the stipulated standard limit of 6.5-8.5 (Alloways 1996). The higher NO_3^- in slums could be attributed to prevention of sunlight and oxygen from entering the water which makes it difficult for fish to breathe and for photosynthesis to take place in aquatic plants. The higher Cl^- in these tube wells sited in slums mighty be attributed to large amounts of chloride that are transferred from slum wastes to the underground water.

Tube wells sited in slums recorded higher Ca, Mg and total hardness than the tube well sited in non-slum environment. The higher concentrations of Ca, Mg and total hardness in tube wells sited in slum than tube well sited in non-slum area may be as a result of non-coordination of disposal of wastes in slums. Zitte et al (2016) observed that used-oil disposal along East-West Road, Port Harcourt Nigeria, showed that metals may be retained in soils in the form of oxides, hydroxides, carbonates, exchangeable cations, and/or bound to organic matter in the soil which became gradually released to underground water thereby causing hardness of water.

Higher concentration of heavy metals (Pb, Cd, Cu and Zn) in tube wells sited in slums than the tube well sited in non-slum environment could be as a result of wastes that are not properly disposed in the slums. Zitte et al (2016) showed that wastes contain iron, steel, copper, lead, zinc, barium, cadmium, sulphur and water and these could easily decay and release heavy metals to the water bodies.

CONCLUSION

The water from tube wells in slums is not fit for usage. Most of the parameters such as NO_3^-, Cl^-, Ca, Mg, total hardness, Pb, Cu and Zn were higher in the second year of the study than the first year. Hence, the need to encourage people to treat water from slums before usage to avoid health problems associated with using such water.

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Effect of Land Reclamation on Water Using Remote Sensing Techniques, Penang Island

Kazeem Olukunle Rauff, Ismail Ahmad Abir[1] and Abdul Qadir[1]

Department of Physics, Faculty of Science, Federal University of Kashere, PMB 0180, Gombe, Nigeria
[1]School of Physics, University of Science Malaysia, 11800, Pulau Pinang
E-mail: rauffkazeem@yahoo.com

Abstract: Land reclamation plays an important role in urban development by creating new landmass from the oceans for various purposes. This study aimed at combining remote sensing technique and ground instrumentation measurement for the identification of effects of land reclamation on water. Geocoded Landsat 8 and SPOT-6 satellite data were acquired and processed with ENVI and *ACOLITE* software. A supervised classification was performed to select sample pixels with specific classes of interest in the image. The results showed a great deterioration of water quality around reclaimed land areas. Higher values of turbidity were equally observed in the eastern and western parts on the coastal area where land had been reclaimed as compared to the northern and southern parts that were free of land reclamation.

***Keywords*:** Land reclamation, Population density, Remote sensing, Water turbidity.

Coastal areas are often densely populated areas worldwide as they serve as the boundary between the sea and the land where humans build cities and settle therein (Gao et al 2018). Many countries such as Singapore; Hong Kong; Japan and Malaysia notably surrounded by water practice land reclamation on water bodies extensively and this has impacted their respective developments (Nadzir et al 2014). According to the World Bank (2016), Malaysia has been classified among the top ten most densely populated countries in the world with Penang having a population density of 1663 per km^2. Land reclamation in Penang Island has been playing important roles in terms of development by creating new landmass from the ocean for industrial, agricultural and residential purposes (Gao et al 2018). The extent of reclaimed land is dramatically expected to increase between 2017 and 2030 with the construction of five new artificial islands on the northeast and south coasts of Penang (Chee et al 2017). The importance of water cannot be overemphasized in the history of human development and survival of the ecosystem. However, since the second half of the 20th century, the challenges seem to have worsened as the quality of water is being affected everyday around the coastal areas (Christirani et al 2015). This is as a result of high turbidity which causes water pollution, loss of the original marine ecosystems and difficulty in the survival of marine species (Chee et al 2017). It is therefore important to study the effect of reclamation on the marine environment and provide means of mitigating the effects. Remote sensing, a cost-effective technique, is used in combination with in-situ measurement to calibrate the relationship between the reflectance data of satellite imageries and the field measurement. This study has been carried out between 2017 and 2019 at TanjungTokong beach and National Park, Penang Island, Malaysia to identify the effects of land reclamation and estimate the turbidity around the coastal area using remote sensing technique and in situ methods.

MATERIAL AND METHODS

This study was carried out at TanjungTokong and National Park with geographical coordinate (05° 26' 51” N, 100° 18' 24” E) and 05° 27' 42'' N, 100° 11' 24” E) respectively. TanjungTokong is one of the coastal areas in Malaysia where the reclamation project is on-going. This area is categorized as a moderately exposed sandy beach with medium to fine sand (Kaffashi et al 2015). The area is good for the nursery and production of marine species which makes fishing activities easy. The National Park is the only considerable natural forested area left in Penang Island (Kaffashi et al 2015).

Methodology: The method of Secchi disk (SD) created by Pietro Angelo Secchi SJ in 1865 was used to measure the clarity of natural water for this research as it is a convenient and inexpensive limnological and oceanographical tool (Brezonik 2011). It has a circular white and black disk that was lowered into a natural body of water by observers until the pattern on the disk was no longer visible to obtain the Secchi depth value. According to Holmes (1970), the Duntley-Preisendorf (1963) equation, which describes the attenuation of contrast of submerged objects using Eq. 1.

$$C_R = C_O e^{-(\infty + k)R} \qquad (1)$$

Where C_R is the apparent contrast of an object at the depth at which the Secchi Disk disappears; C_o inherent contrast of the object against its background; ∞ and k are the attenuation coefficients for collimated and diffuse light respectively and R is the depth at which the Secchi Disk disappears. The parameter R has the value of 0.0066 according to (Tyler 1968). Taking the In of both sides of Eq. 1, it gives:

$$\frac{1}{R}\,\text{In}\,\frac{C_O}{C_R} = -(\alpha + k) \qquad (2)$$

The value C_O was estimated to be of 40 and In C_O/C_R was 8.69 (Tyler1968). The attenuation coefficients ∞ and k can be related to color and turbidity levels respectively and assumed in terms of Eq. 3 to be constant.

$$\frac{1}{R} = -\{\infty\,(\text{colo}) + k\,(\text{turbidit y})\} \qquad (3)$$

A total number of 14 soil samples were collected at TanjungTokong using a grab sampler dropped into the bottom of the sea. A water sampler was also submerged into the sea at the same depth with secchi depth for water sample collection. These procedures were repeated at different locations. Twenty-five secchi depth readings were taken around the reclaimed land mass 1 km^2 interval. Inverse Distance Weighting (IDW) interpolation tool in Arc Map was used to produce a Secchi depth distribution map of the study area and a linear regression method to test for relationships between the Secchi disk depth and the reflectance from the Landsat 8 image. To better understand the effect of reclaimed land on coastal areas and compare the results, ten secchi depth measurements were obtained at Penang National Park where there is no reclamation. The first satellite data that was used for this study was acquired on 20^{th} December 2017 from Landsat 8 imagery at the United States Geological Survey (USGS) with Path Type WRS 128, Row 56 and contains 11 bands. The projection of the imagery is UTM WGS84 Zone 47 with the spatial resolution is 30 m x 30 m, although only the visible-near infrared bands with bands 1, 2, 3, 4, 5, 6 and 7 were chosen. The other satellite data was acquired from SPOT-6 through the Agensi Remote Sensing Malaysia (ARSM). SPOT-6 satellite sensor is an optical imaging satellite with ability to image the Earth with a resolution of 15 m panchromatic and 6 m multispectral (4 bands: blue, green, red, near- Infra-red IR) built by AIRBUS Defence and Space, launched on September 9, 2012, by the Polar Satellite Launch Vehicle (PSLV), Satish Dhawan Space Centre in India.

Satellite data processing: The data was processed and corrected using ENVI5.3 software. The regression function for the single band was implemented and the best fitted linear regression method was calculated. Supervised classification was used to automatically separate pixels of images into groups of like spectral characters. The maximum likelihood classification method was selected to process the supervised classification. A confusion matrix was used with ground truth ROIs to determine the percentage of pixels contained in the image classification and the overall accuracy was calculated by summing the number of correctly classified values and dividing by the total number of values.

RESULTS AND DISCUSSION

The concentration of SD transparency was found very low at point numbers of 23 and 24 with a value of around 0.2 m, indicating the cloudiness of water (Fig. 1). The reduction in coastal water transparency depends on the number of suspended particles in the water which could be algae, organic material or loose sediments originating from reclaimed land. As the clarity of water decreases, these suspended particles make it more difficult for the sunlight to penetrate deeply into the water column. The southern part of reclaimed land showed a higher value of water column depth of about 1 m which maybe because of the effect of the tidal current at a different time of Secchi disk readings.

Some water samples collected at TunjungTonkong when the water level started rising with high speed (northwest to southeast) having sediment suspension due to the presence of tidal current thereby causing some errors in the SD readings (Fig. 2). The green box in the chart shows the water level during the survey. At the beginning of the conducted survey (10 am), the water level was about 1 m but later increased to 2.2 m around (12.30 pm).

Chee et al (2017) recommended that the measurement of SD should be taken whenever the sea is relatively calm as the sea motion introduces a source of error in the visibility of SD readings. To better understand the effect of reclamation of land, the results obtained from TunjungTonkong were compared with those obtained from a control area, Penang National Park. SD measurements were found higher (approximately 2 m) at the control area than the area of land reclamation, indicating high water clarity at Penang National Park as shown in Figure 3(a). A general seafloor sediment distribution depicting an increase in the grain size towards the northwest with fine sediment (mud) being located near the reclaimed land was observed as depicted in Figure 3(b). This mud distribution could be the result of loose material from the reclaimed land that had settled down.

Turbidity is higher in the western and eastern parts which may be due to the introduction of wastes into the water because of agricultural activities such as paddy plantation, urbanization and industrialization in the regions as compared to northern and southern regions where there are low turbidity results (Fig. 4a). The northern region has the lowest turbidity because it is a state government reserve area. The coastal area in the west region of Penang Island is covered by the mangrove forest which has created sediment along the west coastal area. Results obtained from Secchi disk (Fig. 1) and ACOLITE software (Fig. 4b) was the same way. An important factor to consider in the estimation of turbidity is the tidal effect, as there is an inverse relationship between turbidity and tides.

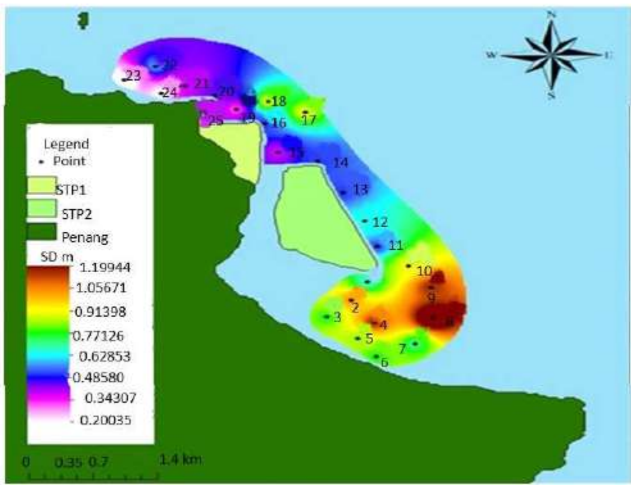

Fig. 1. Map of SD distribution along with reclamation land with IDW interpolation method

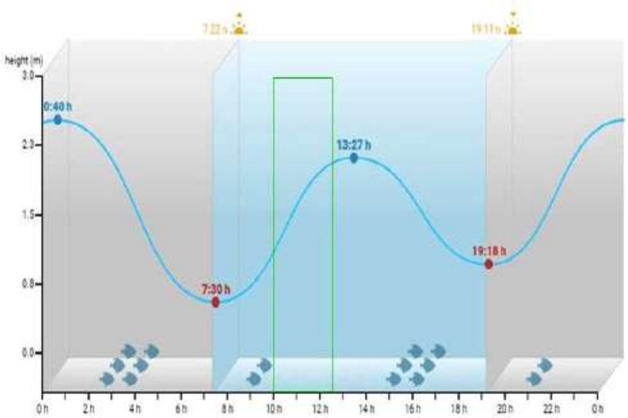

Fig. 2. Tidal chart, Tunjung Tonkong

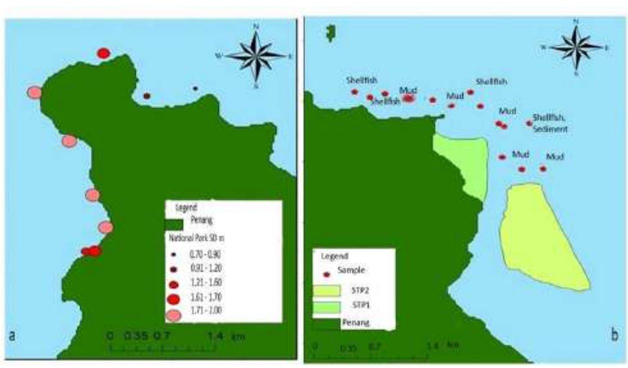

Fig. 3. SD measurement at Penang National Park (a) and distribution of seafloor sediment (b)

Image captured at low tides gives high turbidity because sediments are carried by water into the sea; however, at high tides, turbidity is low near the coastal area as the sea level is at its peak and covers all the sediments at the seabed.

Regression analysis was used to test the relationship between the secchi disk depth within the study area and the reflectance from the Landsat 8 and presented in Figure 5. The results ranging from 0.5 to 0.7 show a strong linear relationship between ground data and remote sensing at the TanjungTokong site with R^2 value of 0.705.

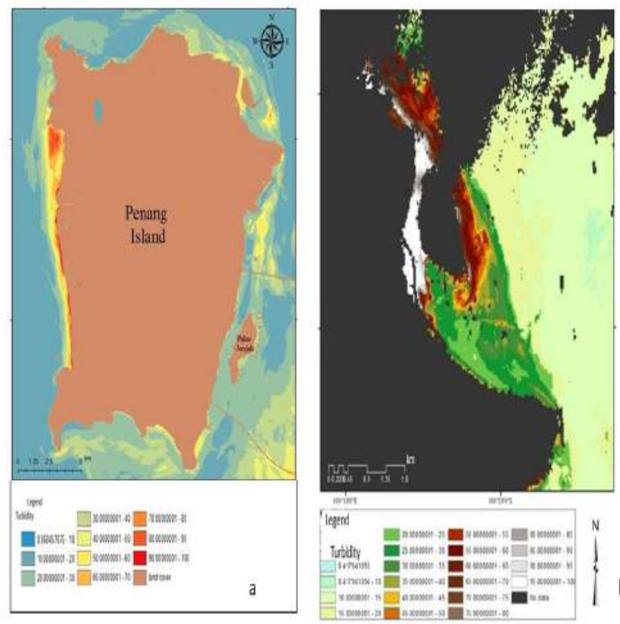

Fig. 4. Turbidity estimation map (a) and Turbidity estimation using ACOLITE software (b)

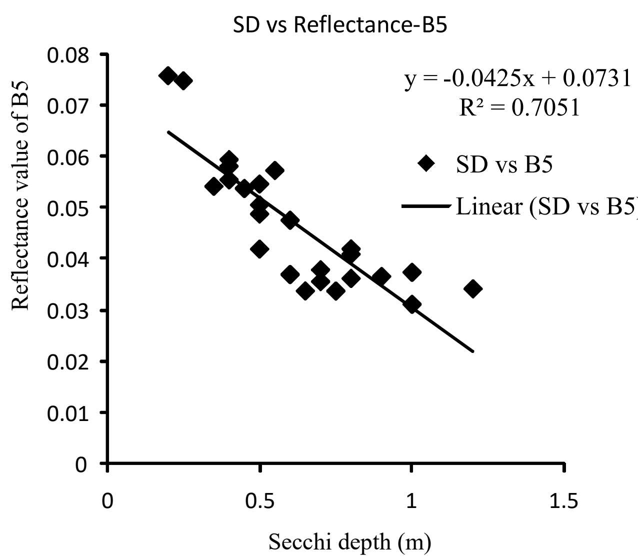

Fig. 5. The linear regression between secchi depth and reflectance of band 5 (near-infrared) located in reclamation land in TanjungTokong

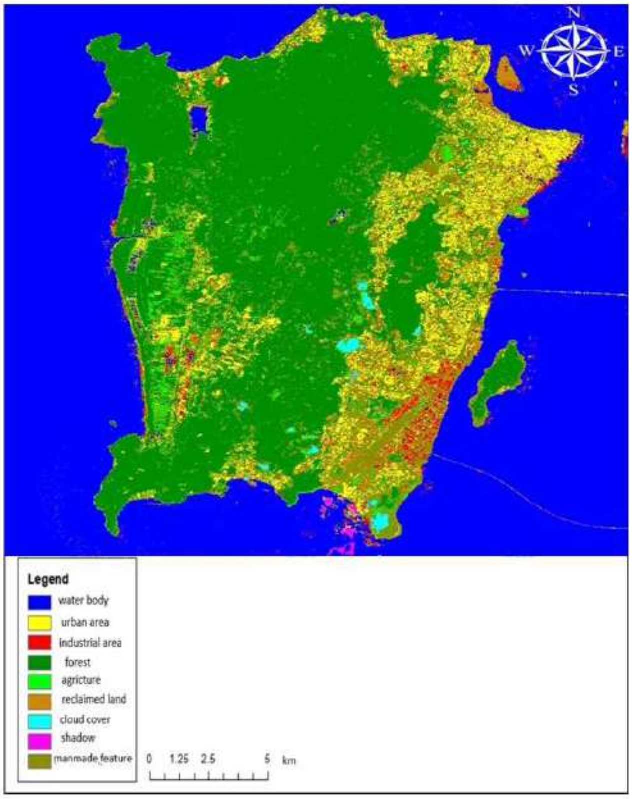

Fig. 6. Land use land cover of Penang Island

The prepared lulc map of Penang Island with the application of the supervised classification method in ENVI software and SPOT-6 image is given in Figure 6. The objective of preparing the map is to highlight the developed areas of Penang Island. The map shows that there is high development in the eastern region of Penang Island due to urbanization and industrialization around the area coupled with proximity to the port. Comparing Figure 4a and Figure 6, turbidity in the eastern region is lower than the western of Penang Island despite the fact that the eastern part is the most developed region in the state, and one of the most developed places in Malaysia as a whole. Based on the analysis of the final output, the turbidity is higher on the western part of Penang Island due to agricultural activities such as Paddy plantation than the eastern which is covered with the urban and industrial activities. This means that agricultural activities have more impacts on water clarity than urbanization and industrialization. Water clarity on both the northern and southern regions show low turbidity in Penang Island.

CONCLUSION

Remote sensing technologies have moved to the forefront of geotechnical science, largely due to their ability to measure deformations of the earth's surface over a wide area with great accuracy without being in contact with the earth's surface. In this study, there was a careful application of remote sensing in the identification of effects of land reclamation on water. The constant reality of any community is to have good water for existence, however, land reclamation plays a vital role in terms of fishery damage and water pollution via deposition of sediments and discarding of rock into water bodies. In Penang, the reclamation of land is common where it causes disability of the natural system of water. In particular, the land reclamation project in TanjungTokong has been shown to have negative effects on water clarity. There is a good linear correlation between SD and reflectance of Band 5 (Near-Infrared). There is also a correlation between the SD method and the ACOLITE software. Thus, it is evident that ACOLITE software is suitable for water studies. The applications of remote sensing, GIS techniques, and traditional in-situ sampling are effective, inexpensive and reliable in the estimation of water clarity. The concept of integrating remote sensing techniques and in situ measurements would be taking place for the first time to the best of our knowledge in Tanjung Tokong, Penang Island, Malaysia.

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Drought Assessment in Tiruchirapalli District using Varied Time Scales

S. Rathinavel, A. Mani, Jithendrakumar, P. Anbarasan, P. Soundharya and S. Soundharya

TNAU, Agricultural Engineering College and Research Institute, Kumulur–621 712, India
E-mail: rathinavelesr@gmail.com

Abstract: Drought analysis was carried out in Tiruchirapalli district of Tamil Nadu State of India using standardized precipitation index (SPI) with 35 years of rainfall data and drought affected years were identified, months, which receive maximum rainfall and average precipitation of the district were estimated. The analysis was carried out in 1, 2, 3, 6, 12 and 24 month time intervals on SPI scale. The district was not a severe drought affected region but some mild to moderate drought occurred in the past 35 years and no severe or extreme droughts. The years 1980, 1989 and 2002 were observed most deficit years. The average rainfall was 862 mm. Some of the mitigation measures may provide relief at the existing drought incident scenarios were discussed.

Keywords: Rainfall, Drought, Standardized precipitation index

Drought occurrence is inevitable but can be predicted or preventive activities can be done in order to avoid losses. A drought can last for months or years, or may be declared after as few as 15 days. Monitoring drought, declaration of drought, mitigating the drought are the important phases of drought handling. Monitoring drought is crucial to continuously plan preparedness activities and also mitigate the drought impacts. India is one of the highly drought prone countries in the world. Studies on drought occurrence and prediction were carried out in Iraq, New Zealand, Serbia Nile basin, and Parambikulam-Azhiyar basin and Manjalar basins of Tamil Nadu, Surat district of Gujarat, Maharashtra state in India (Manikandan et al 2016, Janapriya et al 2016, Chavadekar et al 2016, Awchi et al 2017,Caloiero et al 2017, Gocic et al 2020). The climate change projections indicate high probability for frequent and prolonged droughts in India. Tamilnadu state of India has several drought events and Tiruchirapalli district also subjected to several droughts. Earlier researches reveal the status of drought in many parts of the world. Another study evaluated different drought indices and also generated a synthetic data of future 58 years using the rainfall data of Trichirapalli district (Sathya et al 2019). Meteorological drought occurrences in Tiruchirapalli district of Tamil Nadu state is analysed and in the present study.

MATERIAL AND METHODS

The study area Tiruchirapalli district of Tamilnadu occupying 4403.83 square kilometres and average annual precipitation is 862 mm. The district is the central region of Tamilnadu, southern part of Indian subcontinent. The stations under study for computation of SPI are 14 stations totally available in Tiruchirapalli district. Vast tracts of district's land are irrigated by Kaveri and Kollidam rivers which forms Kaveri delta. Rice and Sugarcane are the major crops. Banana, coconut, cotton, betel, groundnut has also cultivated. The Central location of the study area is 10°47′N 78°41′E. The study area consists of the following blocks, Lalgudi, Pullambadi, Marungapuri, Thurayur, Uppiliapuram, Musiri, Thottiam, Thathayangarpet, Vaiyampatti, Manikandam.

There are several indices which are used to monitor and assess drought, as they simplify the complex inter-relationships between many climatic parameters. Palmer Drought Severity Index (PDSI) and Standardized Precipitation Index (SPI) are the commonly used indices. Based on the data available and in correlation with climatic parameters involved in the indices, SPI index was chosen. The daily meteorological data of selected station was collected from TNAU meteorological department from 1980 to 2014 i.e., of 35 years and used as input for the SPI computation. The monthly data were arranged into monthly sets for further analysis of meteorological drought and wet events. The study was carried out through Standardized Precipitation Index by the following procedure. The precipitation value has to be transferred into standardized precipitation index.

The transformation of the precipitation value in to standardized precipitation index has the purpose of

1. Transforming the mean of the precipitation value adjusted to 0
2. Standard deviation of the precipitation is adjusted to 1.0

3. Skewness of the existing data has to be readjusted to zero

When these goals have been achieved the standardized precipitation index can be interpreted as mean 0 and standard deviation of 1.0

Mean and standard deviation of the 35 years (1980 to 2014) was found out using MS Excel software. And skewness is found out by using the formula,

$$Skew = \frac{N}{(N-1)(N-2)} \sum \left(\frac{X - \bar{X}}{s} \right)^3$$

The precipitation is converted to lognormal values and the statistics U,

$$Log\ mean = \overline{X_{in}} = In\ (\overline{X})$$

$$U = \overline{X_{in}} = \frac{\Sigma In(X)}{N}$$

Shape and scale parameters of Gamma distribution are computed,

$$\text{Shape parameter} = \beta\ \frac{1 + \sqrt{1 + \frac{4U}{3}}}{4U}$$

$$\text{Scale parameter} = \alpha\ \frac{\overline{X}}{\beta}$$

The cumulative probability is estimated as:

$$G(x) = \frac{\int_0^x x^{a-1} e^{\frac{-x}{\beta}} dx}{\beta^{\alpha} \Gamma(\alpha)}$$

The gamma function is undefined for x=0 and a precipitation distribution may contain zeros, the cumulative probability becomes:

H(x) = q + (1-q)G (x) (q is the probability of zero)

The H(x) (cumulative probability) is then transformed to the standard normal random variable Z with variance of one and mean zero, which is the SPI value following Edwards and McKee (1997); employing the approximate conversion provided by Abromowitz and Stegun (1965) as an alternative,

$$Z = SPI = -\left\{ t - \frac{c_0 + c_1 + c_2 + t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right\} 0 < H(x) \le 0.5$$

$$Z = SPI = +\left\{ t - \frac{c_0 + c_1 + c_2 + t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right\} 0 < H(x) \le 1$$

$$t = \sqrt{In\left(\frac{1}{H(x)^2}\right)}\ 0 < H(x) \le 0.5$$

$$t = \sqrt{In\left(\frac{1}{(1 - H(x))^2}\right)}\ 0 < H(x) \le 1$$

c_0 = 2.515517 c_1 = 0.802583 c_2 = 0.010328

d_1 = 1.432788 d_2 = 0.189269 d_3 = 0.001308

From the resulting SPI value and using the Table.1, the degree of drought can be found out.

RESULTS AND DISCUSSION

The mean annual rainfall of the study area was 862 mm similar to the existing data. The September receives the most

Table 1. SPI values and drought category

SPI values	Classification
2.00 or more	Extreme wet
1.50 to 1.99	Severe wet
1.00 to 1.49	Moderate wet
0 to 0.99	Mild wet
0 to -0.99	Mild drought
-1.00 to -1.49	Moderate drought
-1.50 to -1.99	Severe drought
-2.00 or less	Extreme drought

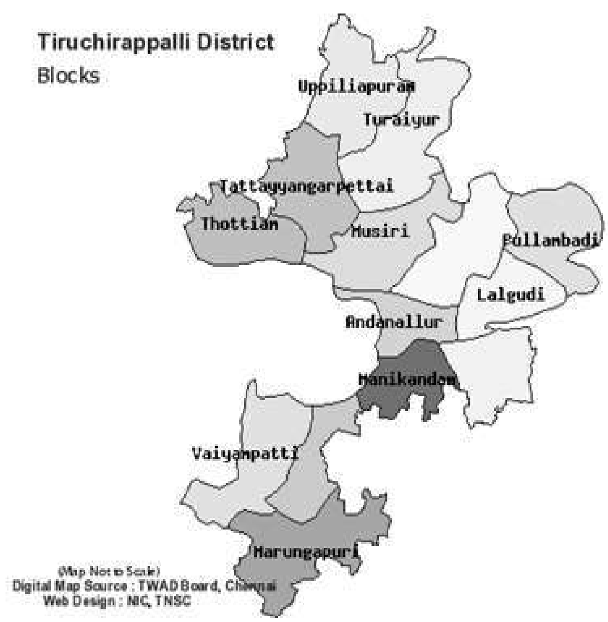

Fig. 1. Outline map of the study area

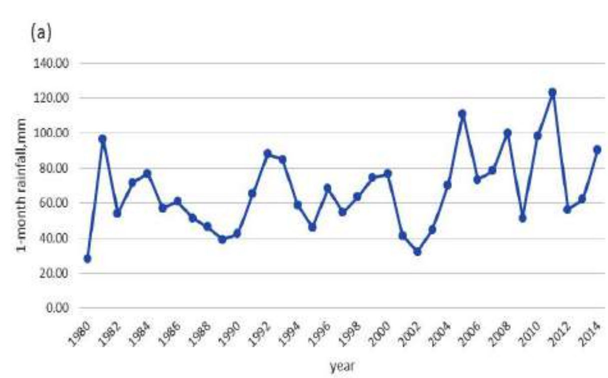

Fig. 2. Rainfall yearly using 1 month time scale computation

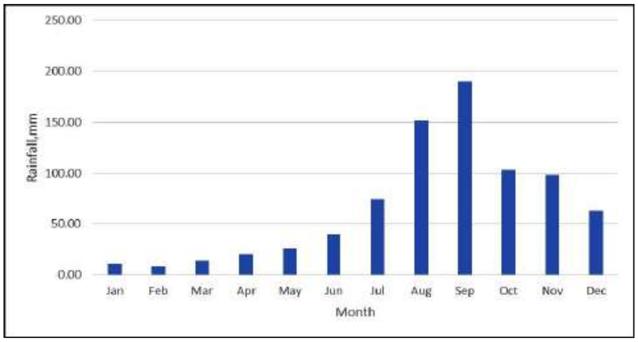

Fig. 3. Monthly mean distribution of rainfall

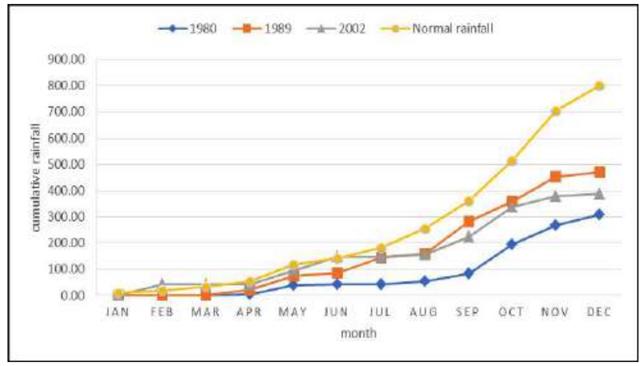

Fig. 4. Cumulative rainfall for selected rainfall deficit years and periods

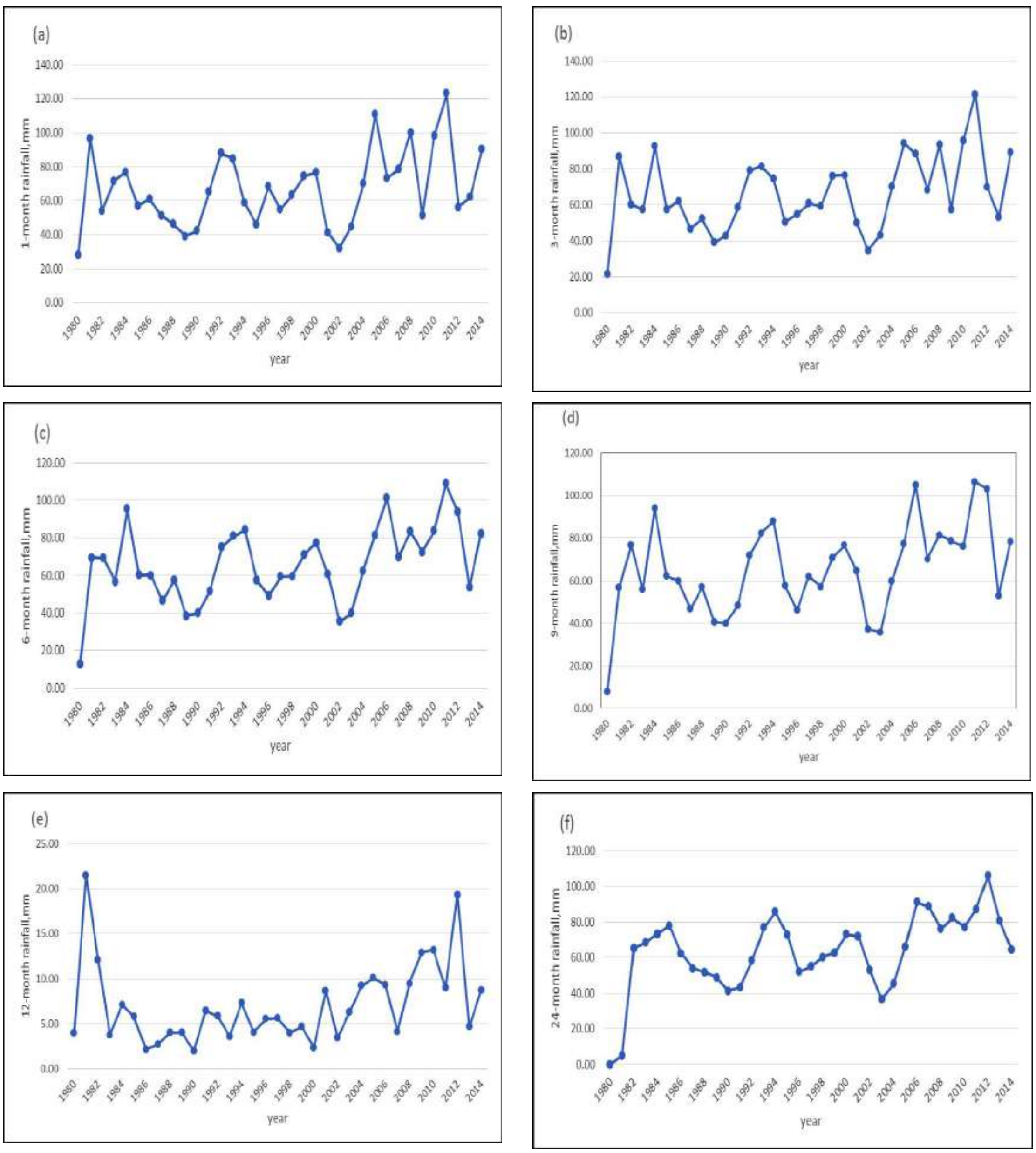

Fig. 5. Meanmonthly rainfall data based on (a) 1-month, (b) 3-month, (c) 6-month, (d) 9-month time scales (e) 12-month, (f) 24-month time scales

rainfall every year and that 19 years (54.3 per cent) out of 35 years study period received less than average rainfall. The study area experienced rainfall deficits during the periods of 1980s, 1989s and 2002s and in the Figure 4, graph depicts cumulative rainfall of the corresponding years. During these three periods the monthly and annual precipitation was considerably below normal. May during summer season, November during north east monsoon season followed by January & February during winter season were the most vulnerable months to droughts.

There were 18 drought years and 17 wet years based on mean annual areal rainfall using SPI method over the period of analysis across the Tiruchirappalli district. Droughts were categorized in the district as 14 mild, 4 moderate, no severe and no extreme drought year.

From Figure 5, Rainfall distribution based on various time scales is associated with different drought duration, say 1, 3 month time scales are of describing short term duration of drought whereas 12, 24 month time scales explains the long term drought. When the time scale increases the accuracy of drought characterization is higher for largest time scales.

The mitigation measures may be suggested as follows,

- Use of Drought tolerant Paddy varieties, which is the major crop in the district.
- Researches and Practices of Drip irrigation for Paddy and Mulching.
- Increase water use efficiency by optimizing irrigation methods.
- Construction of percolation ponds, check dams and rain water harvesting structures for maintaining ground water table.
- Chemicals such as Pink pigmented facultative methylotrophs (PPFM) for sustainability of crop during drought periods.

CONCLUSION

The average rainfall of 862 mm is confirmed. The district Tiruchirapalli has experienced mild and moderate droughts based on SPI index in the 35 years and no extreme or severe droughts occurred which indicates the preparedness of farmers accordingly. The most rainfall receiving month September noted for decision making in agricultural sector. SPI serves as a valuable tool for monitoring and assessment of drought with varied time scales.

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Analysis of Groundwater Fluctuation using GRACE Satellite Data

Vaibhav Deoli and Deepak Kumar[1]

Department of Civil Engineering, Inderprastha Engineering College, Ghaziabad-201 010, India
[1]Department of Soil and Water Conservation Engineering, G.B. Pant University of Agriculture and Technology Pantnagar-263 145, India
E-mail: deolivaibhavdeoli@gmail.com

Abstract: Remote sensing has been proved to be a vital medium for natural resource management. In the present study, GRACE data was collected for Terai region of Kumaon division to study the temporal variation in ground water table from 2002 to 2016. GRACE is a twin satellite system developed by collaboration of NASA and German space agencies and DLR of US respectively. The spatial resolution of GRACE is 1° x1°. For studying the changes in groundwater table, non-parametric trend analysis has been done using linear regression methods Mann Kendall test and Moving Average models. The results suggested that between 2002 to 2016, the average groundwater table fluctuation was 10.47 cm. Maximum positive groundwater fluctuation was 40.59 cm, in September 2003, while maximum negative groundwater fluctuation of 43.14 cm was in March 2016. The outcomes of the study suggested that groundwater fluctuations have sharply decreased during 2002 to 2016 and trend is negative for this study period in all months.

***Keywords*:** GRACE satellite, Groundwater, Trend analysis, Remote sensing

Groundwater is the primary source of drinking and irrigation water supplies in many parts of the world. Worldwide, the pace of groundwater depletion has more than doubled during the last several decades, caused primarily by increasing water demand (Konikow 2011, Wada et al 2011). Thus, it is important to manage the groundwater resources in a way that will ensure sustainable, equitable, and economically prudent decisions, we must enhance our existing capability to monitor and predict water availability. The Gravity Recovery and Climate Experiment (GRACE) was a joint mission of German Aerospace Center and NASA and GRACE satellite was launched in March 2002 and its mission end in October 2017. By estimating gravity peculiarities, GRACE indicated how mass is distributed around the planet and how it changes over time. Data from the GRACE satellites is a critical device for concentrate Earth's sea, topography, and atmosphere. Researchers across the world have used GRACE satellite data to study ground water fluctuations. Rodell et al (2007) worked on Mississippi River basin (USA) using GRACE data to estimating change in ground water storage and assumed that regionally averaged surface water and biomass variability are negligible in the Mississippi River basin and used it to detect changes in groundwater. Chinnasamy et al (2012) worked on terrestrial water storage using GRACE data in Gujarat state of India. Al. (2012) estimated ground water storage change by GRACE satellite data in the California Central Valley, USA and applied new processing approach to GRACE data that estimate changes in GWS from TWS by subtracting SWES, RESS, and SMS. Sun (2013) predicted ground water level change using GRACE data for several wells located in different regions across the US and developed ANN model to predict monthly and seasonal changes in ground water level. Joodaki et al (2014) worked with GRACE data to estimate the human contribution to groundwater depletion in the Middle East. Katpatal et al (2017) checked the sensitivity of GRACE data to the complexity of aquifer systems for monitoring of groundwater in Vidarbha region of Maharashtra, India. Frédéric and Ramillien (2018) reviewed ground water detection change by GRACE satellite data and observed that during the 16 years period Grace Data is valuable to detect ground water changes for large scale water mass redistributions and for the very first time, the opportunity to monitor groundwater changes from regional to global scales. In the present study, groundwater fluctuation of Terai regions of Uttarakhand has been studied using GRACE data. Trend and changes in ground water fluctuations have been determined.

MATERIAL AND METHODS

In the present study, groundwater fluctuations in Terai regions of Kumaon division were estimated. Terai region covered part of Nainital district and Udham Singh Nagar district in Uttarakhand (Fig. 1). The latitude and longitude of Nainital district are 79.44 N and 29.35 E respectively and the longitude and latitude of Udham Singh Nagar district are 28.98 N and 79.40 E, respectively. Udham Singh Nagar district is bounded by Nainital district on the north, Champawat district on the north-east, Nepal on the east and Bareilly, Moradabad, Rampur Bijnor district of Uttar Pradesh state on the south and west. Nainital District is located in Kumaon Division, and is bounded on the north by the Almora District and on the south by the Udham Singh Nagar District.

Data used: The data for studying the groundwater fluctuations have been extracted from a remote sensing satellite, namely, Gravity Recovery and Climate Change (GRACE). The data is available on official website of NASA. The data was downloaded from the NASA website for the time period of 2002 to 2016. This data is further used for analyses.

Parametric and non-parametric test, namely linear regression method and Mann Kendall test has been used to study trend in ground water fluctuations on the monthly data of 16 years. The value of changes in groundwater fluctuations has been determined by San's slope estimator test. The details of the non-parametric tests are provided in following section.

Linear Regression Test: Linear regression was used for predictive analysis. In the event that y = estimated dependent variable score, c = constant, b = regression coefficient, and x = score on the independent variable then the simplest form of the regression equation with one dependent and one independent variable is defined by the formula y = c + bx. This is a parametric test that assumes normally distributed data. It is utilized to test for linear trend by the linear relationship between time and the variable of interest. The correct application of this method requires the variables to be normally distributed and temporally and independent.

Mann-Kendall Test: Mann Kendal test is a non-parametric test used to decide monotonic patterns in arrangement of ecological information, atmosphere information or hydrological information to check the time series information pursue a specific pattern or not i.e. positive negative or no pattern. The null hypothesis, H_0, is that the data come from a population with independent realizations and are identically distributed. The alternative hypothesis, H_1, is that the data follow a monotonic trend. A significance level α is also utilized for testing either an upward or downward monotone trend (a two-tailed test). If Z appears greater than Zα/2 where α depicts the significance level, then the trend is considered as significant.

The application of trend analysis is completed to a time series x_i that is ranked from i=1,2,.......n-1 and x_j which is ranked from j=i+1,2.........n. Each of the data point x_i is taken as a reference point which is compared with the rest of the data point x_j.

The Mann-Kendall statistic S is given as

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \tag{1}$$

$$\operatorname{sgn} = \begin{cases} +1, > (x_j - x_i) \\ 0, \ = (x_j - x_i) \\ -1, < (x_j - x_i) \end{cases} \tag{2}$$

For n > 8, S follows approximately Normal distribution with mean i.e.

E(S) = 0,

The variance statistic var(S) is given by,

$$\operatorname{var}(s) = \frac{N(n-1)(2n-5) \sum_{i=1}^{m} t(p)(p-1)(2p-5)}{18} \tag{3}$$

where, t_i is considered as the number of ties up to sample i. The test statistics Z (Mann-Kendall Co-efficient) is computed as

$$Z = \begin{cases} \dfrac{x-1}{\sqrt{\operatorname{var}(S)}} \text{ if } S > 0 \\ 0 \quad \text{if } S = 0 \\ \dfrac{x+1}{\sqrt{\operatorname{var}(S)}} \text{ if } S < 0 \end{cases} \tag{4}$$

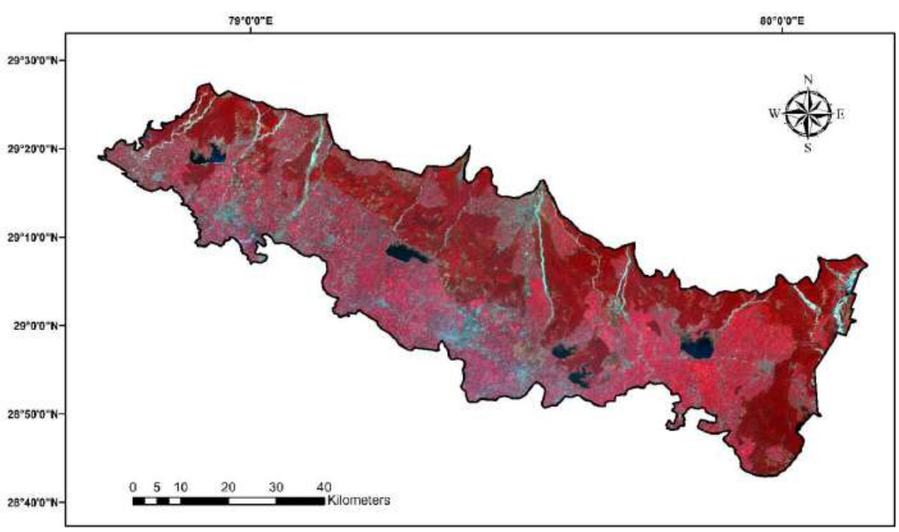

Fig. 1. Study area

The calculated Z here follows normal distribution. The positive value of Z shows positive trend in data and the negative value of Z shows negative trend in data.

San's Slope Test: To know the magnitude of trend in this study, San's slope estimator test has been used. The slope of m and n pairs of data points have been estimated using San's estimator which is given by the following equation:

$$Qi = \text{median of } \frac{x_p - x_q}{p - q} \quad (5)$$

Where x_p and x_q are considered as values of time series data at m and n as p > q and Q_i is slope of data pairs.

RESULTS AND DISCUSSION

The trend analysis for ground water fluctuation was carried out for Terai region of Kumaon Uttarakhand for every year on monthly basis from August 2002 to May 2016. The maximum value of ground water fluctuation is 40.596 in September 2003 and the maximum negative value of ground water fluctuation is -43.14 in March 2016 (Fig. 2).

The maximum and minimum negative fluctuation was more than maximum and minimum positive fluctuation respectively (Table 1). Mean and median of positive fluctuation is more than negative fluctuation whereas Variance, coefficient of variance and standard deviation is more in negative fluctuation.

Liner Regression Method: Based on linear regression it is clear that there is a negative trend in ground water fluctuation for this period (Fig. 3).

Mann-Kendall Test: The maximum value of Z was in January and the minimum in July (Table 2). Based on Mann-Kendall test all months show negative trend in groundwater and decreasing trend in groundwater fluctuations for Terai region of Uttarakhand. January, March, May, and December months show significant negative trend at 5% level of significance and February, April, June and September months significant trend at 10% level whereas July, August, October and November months showed non-significant negative trend at 5% and 10% level of significance.

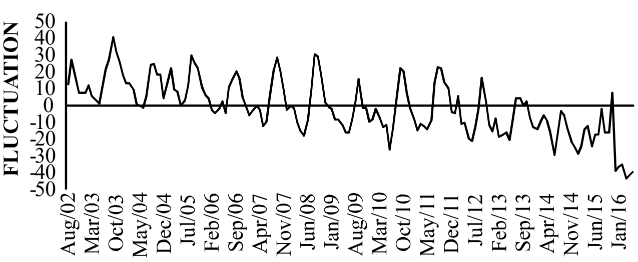

Fig. 2. Fluctuation in groundwater with time

Table 1. Statistics coefficients groundwater fluctuation data

Parameter	Negative	Positive
Mean	-12.39 cm	13.71 cm
Median	3.2041 cm	11.94 cm
Variance	98.41	87.18
CV	80.06%	68.12%
Standard deviation	9.92 cm	9.34 cm
Maximum value	-43.14 cm	40.59 cm
Minimum value	-0.0105 cm	0.136 cm

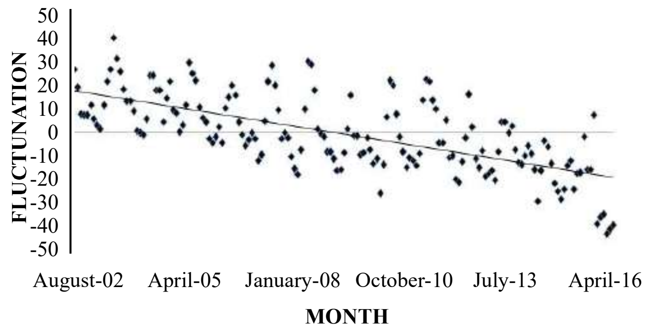

Fig. 3. Trend in groundwater fluctuation by liner regression method

Fig. 4. Mann-Kendall statistic for groundwater fluctuation in different months

Table 2. Values of Z-statistics and San's slope for groundwater fluctuation in different months

Month	Z-Values	San's slope value
January	-2.470*	-2.844
February	-1.647**	-3.064
March	-2.264*	-2.293
April	-1.784**	-1.860
May	-2.196*	-2.293
June	-1.921**	-2.123
July	-1.509	-2.537
August	-0.823	-0.823
September	-1.647**	-2.740
October	-1.509	-2.700
November	-1.441	-2.020
December	-2.183*	-2.613

* Significant at 5% level of significance and ** Significant at 10% level of significance

San's Slope Estimator Test: During all months negative magnitude in ground water fluctuation was observed. February month shows maximum magnitude followed by January. Minimum negative magnitude of trend was in August (Table 3).

CONCLUSION

Groundwater is the major water source used in Tarai region of Uttarakhand for agricultural, industrial and domestic purpose. With increased industrial developments in this region, groundwater is over exploited in the last few decades. To study groundwater fluctuations in Tarai region, GRACE satellite data has been used. GRACE satellite provides gravity data of earth which can further correlated with groundwater storage to study fluctuations. It has been observed that there were high fluctuations in groundwater table in Tarai region and there was decreasing trend for groundwater table in Tarai region during the study period from 2002 to 2016.

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Study on Sentinel 3-OLCI Sensor Validation for Chlorophyll *a* and Total Suspended Matter in Coast Waters of Parangipettai, Bay of Bengal, Southeast coast of India

Suthagar Govindaraj, Ayyappan Saravanakumar* and Mayakrishnan Machendiranathan[1]

Centre of Advanced Studies in Marine Biology, Faculty of Marine Sciences, Annamalai University Parangipettai-608 502, India
[1]College of Ocean and Meteorology, Guangdong Ocean University, Zhanjiang-524 088, Guangdong, China
**E-mail: asarvaan@gmail.com*

Abstract: Present study investigated the sentinel-3 OLCI (Ocean and Land Colour Instrument) sensor retrieved chlorophyll and total suspended matter (TSM) validation. The *in-situ* chlorophyll and TSM concentration ranged from 0.14 µg l^{-1} to 9.36 µgl-1 and 0.15 mg l^{-1} to 39.27 mg l^{-1}, respectively. Sentinel-3 derived chlorophyll (OC4Me) and TSM (TSM NN) algorithm value oscillated from 0.15mg m^3 to 19.21mg m^3 and 0.107 g m^3 to 41.88g m^3. TSM concentration of sentinel-3 retrieved value showed 45% underestimation and chlorophyll 40% over estimation. The present study revealed that more attention and improved methodology for data collection and analyses need to be applied in order to develop remote sensing product that perform well in optically complex water.

Keywords: Validation, TSM, Chlorophyll, sentinel-3 OLCI, Bay of Bengal

Remote sensing is an evolution of scientific technique and their application in the field of coastal oceanography is numerous. Worldwide many applications related to the coastal oceanography provides adequate knowledge and solutions; especially it has the advantage of wide area coverage and repetitive nature (Ambarwulan and Hobma 2004, Pandey et al 2008). In the coastal waters, remote sensing involved in, current patterns, eddies, sea surface heights (SSH), coastal dynamics, atmospheric influences, estimation of water quality such as chlorophyll and total suspended sediment concentration with ecosystem dynamics (Beebee 2008, Kunte 2008). Ocean colour satellite sensors provide more advantages with monitoring and understanding of the natural processes in marine environment. Globally, NASA Ocean color web (MODIS- Moderate Resolution Imaging Spectroradiometer) and European Space Agency's (ESA – Sentinel - OLCI - Ocean and Land Colour Instrument) made freely available data for ocean colour monitoring with different resolutions and composite. Different studies in algorithms and validations with the ocean colour data have been reported worldwide with MODIS and Sentinel (Bricaud et al 1995, Siegel et al 2013, Swirgon and Stramska 2015, O'Reilly et al 1998, Toming et al 2017). However, MODIS have the many applications with the global ocean color monitoring for a longtime, Sentinel 3A launched in 2016 and it's providing the new era for coastal monitoring with higher resolution. OLCI is follow up of MERIS mission (2002-2012) with upgraded capabilities and it has spectral band in red and near infrared (NIR) spectrum are very useful spectrum for retrieving various water quality parameters (Alikas et al 2015 and Paavel et al 2011).

OLCI spectral configuration is specifically designed for inland and optically complex coastal water parameters (Kutser 2004, Paavel 2006, Alikas et al 2015). Satellite ocean colour data offers practical mean for observing the spatial and seasonal variations of near surface phytoplankton and sediment dynamics (Sarangi et al 2008). OLCI is a medium resolution imaging spectrometer that uses five cameras to provide a wide field of view. OLCI has 21 spectral bands with wavelengths ranging from the optical to the near-infrared (Toming et al 2017). The Bay of Bengal (BoB) is situated in the eastern part of India. The unique features of BoB is highly deferential physical and chemical properties especially episodic cyclone with torrential rain along the BoB coast supreme to understand the ocean parameters such as, currents, eddies, oceanic front optical parameters and ecosystems. Indian coastal waters of BoB (east coast) and Arabian Sea (west coast) with validation studies of the Oceansat-OCM (ocean colour monitor) sensor performance in retrieving chlorophyll and TSM along the (Dey and Singh 2003, Chauhan et al 2010, Shanthi et al 2013, Latha et al 2014). Notably, the resolution of the OCM (360m) and Sentinel 3 OLCI (300m) are very similar. The present study attempted to test the performance of Sentinel-3A OLCI in coastal waters of the Bay of Bengal by evaluating the results of ocean colour products produced by S3 OC4ME algorithms with the resolution of 300m.

MATERIAL AND METHODS

The sentinel-3 data were retrieved from the data portal of ESA sentinel (https://sentinel.esa.int/web/sentinel/home). Level-2 marine products of chlorophyll and total suspended matter (TSM) concentrations at 300m resolution data were downloaded based on the product search in Sentinel 3 with the OL_2_WFR (S3A_OL_2_WFR_20171211T044515_20171211T044815_20171215T152101_0180_025_247_2700_MAR_O_NT_002.SEN3). The WFR stands for full resolution ocean colour, water and atmosphere parameters which include algal pigment (chlorophyll) and TSM concentrations. Sentinel-3 OLCI cloud free image were obtained on 11th December 2017. The same date cruise was conducted to collect water samples for analyzing chlorophyll and TSM along the Parangipettai coastal waters (Fig. 1). The data analyses and subset of the region were done in software provided by the ESA Sentinel SNAP 6.0 (S3 toolbox) with the platform of windows 10. To retrieve the chlorophyll concentration from the image, SNAP 6.0 inbuilt "OC4Me" Maximum Band Ratio (MBR) semi-analytical algorithms performed and this chlorophyll algorithm developed by Morel et al 2007. It is the latest version of the MERIS pigment index algorithm, which is fully described in the MERIS ATBD 2.91 and in Morel et al (1998). TSM concentration analyses performed based on the TSM_NN (NN-neural network algorithm Table 1).

Study area: Parangipettai coastal waters situated in the southeast coast of India, Bay of Bengal and notably surrounded by the Vellar estuary (Lattitude 11° 29'N, Longitude 79° 46'E) and Pichavaram mangrove forest vegetations. Parangipettai coastal waters are highly turbid and nutrient rich ecosystem due to the input and flushing of tidal dynamics with the mangrove vegetations. The Parangipettai coastal waters, recorded the range of the chlorophyll and TSS ranges as 0.35 mg l^{-1} to 3.72 mg l^{-1} and 18.04 mg l^{-1} to 44.60 mg l^{-1} respectively (Vajravelu et al 2018). During the cruise sampling was conducted randomly and 20 sites (Fig. 1) water samples were collected in the surface using the Niskin water sampler. Water samples collected for chlorophyll and TSM (1 litre for each), and kept it in polypropylene bottles in the dark ice box and

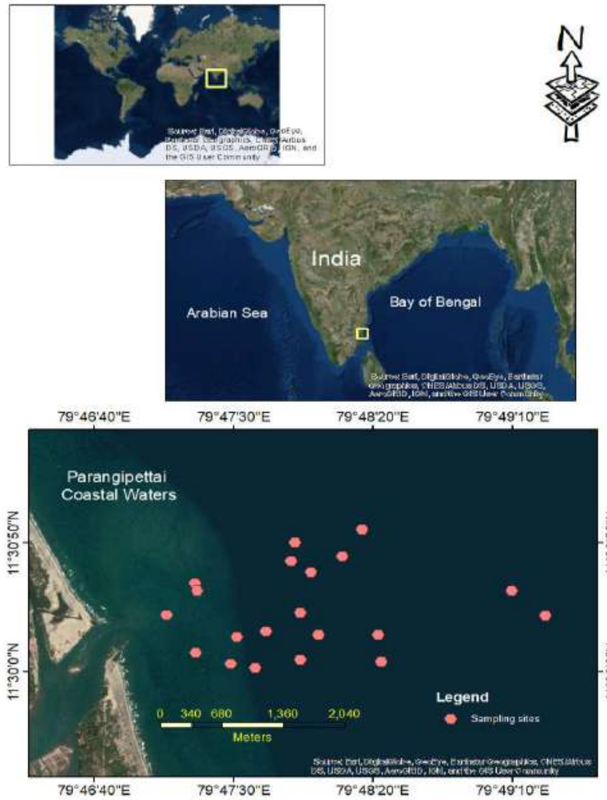

Fig. 1. Study area map, sampling sites of coastal waters (map uploaded with perior permission)

carefully transported to the laboratory. During sample collection, 1 ml of saturated mercury chloride was added in order to avoid planktonic multiplication in chlorophyll water samples.

***In-situ* chlorophyll *a* measurements:** Chlorophyll *a* concentration determined by standard protocol of JGOFS (UNESCO 1994). Chlorophyll *a* measurement was done by using fluorometer (Turner Designs, Triology) and it was previously calibrated with different known concentrations 2, 4, 6, 8, 10 μgl^{-1} of standard chlorophyll *a* (Sigma - C6144) with an accuracy of ± 0.02 μg1^{-1} by using 90% acetone.

***In-situ* TSM estimation:** To measure TSM concentration, well mixed water samples were filtered through a pre-weighed polycarbonate filter paper (Whatmann, 0.45μm). After filtration process, the filter papers were dried at 75°C for 24 hrs in an oven and, later weighed again to estimate the TSM in terms of mg l^{-1} (Gray et al 2000). All the

Table 1. Spectral band of OLCI for TSM and chlorophyll

Parameter	Band	Unit	Description
TSM_NN	Oa1-Oa12, Oa16, Oa17 and Oa21	g.m^{-3}	Total suspended matter concentration
chl_oc4me and chl_NN	Oa3 and Oa6 Oa1-Oa12, Oa16, Oa17 and Oa21	mg m^{-3}	Chlorophyll-a concentration, computed using "OC4Me" or Neural Network algorithms

measurements were completed by using Sartorius electronic balance with seven place precision.

RESULTS AND DISCUSSION

The *in-situ* chlorophyll *a* and TSM concentration ranged from 0.14 to 9.36 µg l^{-1} and 0.15 mg l^{-1} to 39.27 mg l^{-1} respectively (Fig. 2 and 3). Globally, different algorithms are developed for remote sensing data to correlate with the *in-situ* measurements. In the present study, OC4Me (chlorophyll) and TSM_NN (TSM) algorithms were used to correlate the *in-situ* with the remote sensing data. The results show that Sentinel-3 derived chlorophyll-a and TSM values varied from 0.15 to 19.21 mg m^3 and 0.10 to 41.88 g m^3, respectively (Fig. 4 and 5). The regression plot for chlorophyll *a* and TSM data derived from *in-situ* and sentinel-3 found to be significant with an r^2value 0.77 and 0.83, respectively (Fig. 2 and 3). The moderate value of TSM concentration of sentinel-3 retrieved value clearly showed 45% underestimation point spread below the 1:1 line and 10% over estimation 45% more or less similar result acquire in this

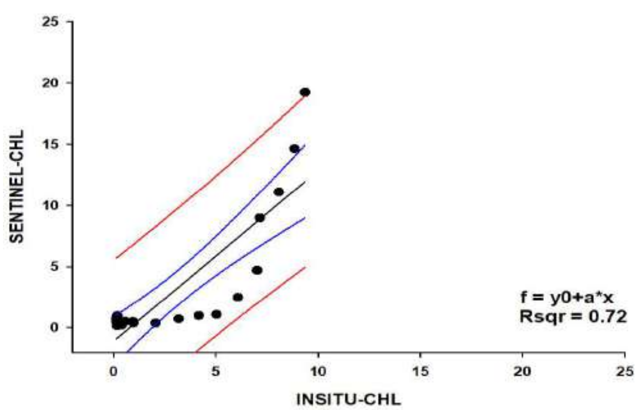

Fig. 2. Regression plot of *in-situ* Vs sentinel-3 derived chlorophyll. Graph shows 95% confidence limits

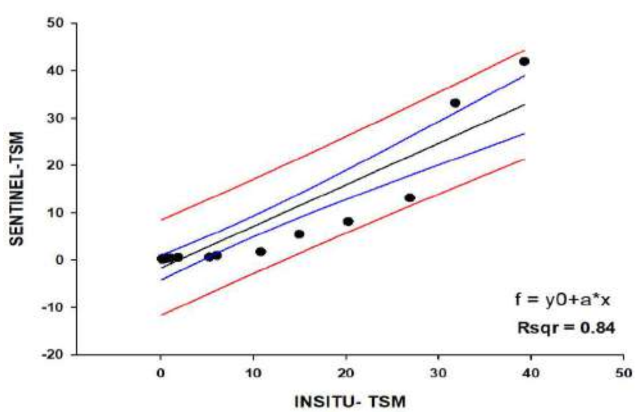

Fig. 3. Regression plot of *in-situ* Vs sentinel-3 derived TSM. (Blue line indicate close fit and red line indicating 95% confidence limit)

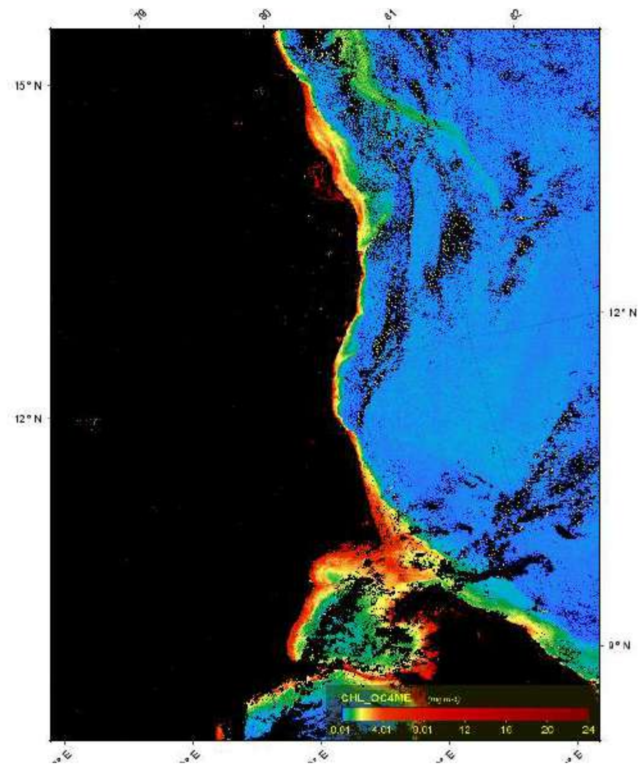

Fig. 4. Sentinel-3 derived chlorophyll concentration at Parangipettai coastal waters of Bay of Bengal

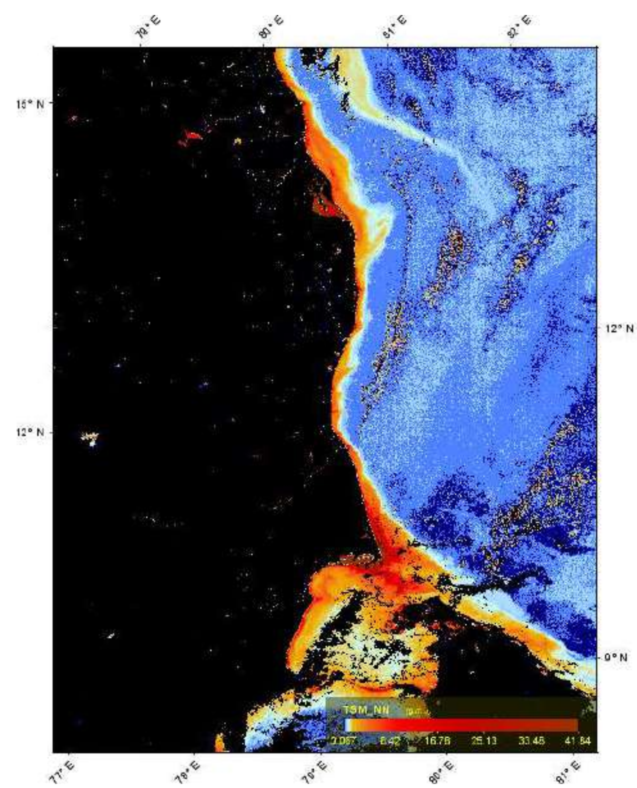

Fig. 5. Sentinel-3 derived TSM concentration at Parangipettai coastal waters of Bay of Bengal

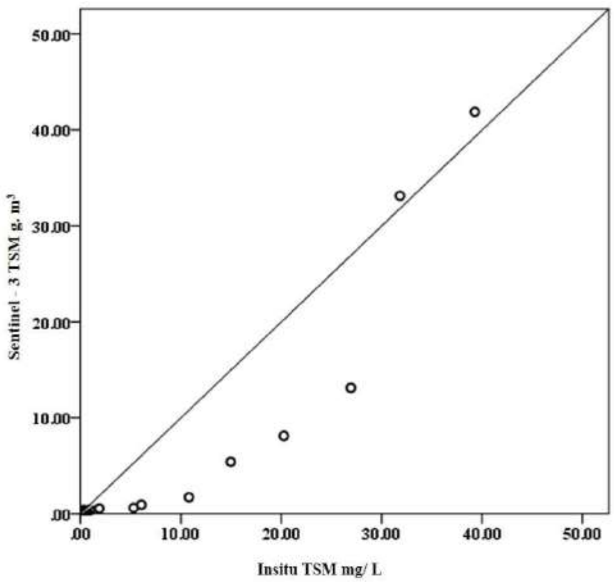

Fig. 6. Comparison and regression plot of *in-situ* Vs sentinel-3 derived TSM

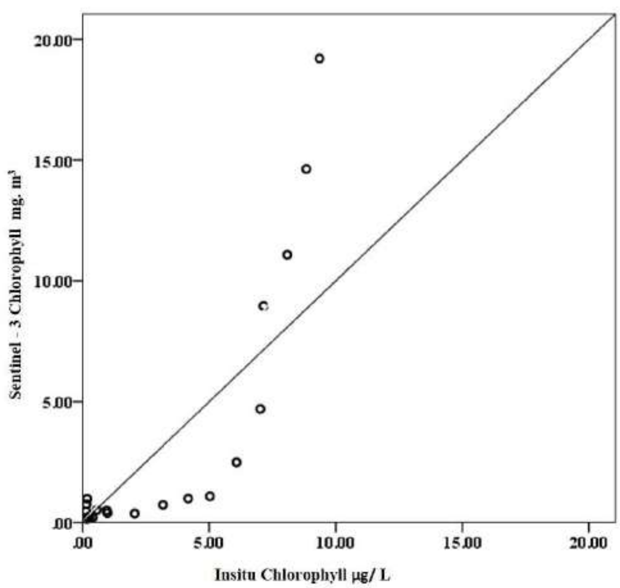

Fig. 7. Comparison and regression plot of *in-situ* Vs sentinel-3 derived chlorophyll

study (Fig. 6). For retrieved medium concentration of sentinel-3 chlorophyll 40% over estimation which clearly showed point spread above the 1:1 line and 35% underestimation with the 25% similar results (Fig. 7).

The chlorophyll values in BoB were in mentioned as < 3 mg m^{-3} and in deeper part was 0.1 to 0.5 mg m^{-3} BoB. However, influences of Krishna and Godavari delta its reaches 3.5 to 4 mg m^{-3} in southern BoB (Dey and Singh 2003). The chlorophyll and TSM retrieved from the Sentinel-3 data shows higher values than this could be an existence of suspended sediment in coastal areas can lead to 20-500% overestimation of chlorophyll *a* concentrations (Ahn et al 2001). The possible reason for overestimation of parameters may be due to the surf zone infer to river discharge and littoral drift (Barua et al 1994). However, Chauhan et al (2002) with the OCM data showed good correlation (r^2 value 0.85) with the OC2 and OC4 algorithms estimation. Analyses of chlorophyll estimation with the OCM-2/OC4V4 algorithm with the SeaWiFS results showed that r^2 = 0.9 more good correlations (Nagamani et al 2008). Compare to previous studies, the present observation more or less similar to the observation made with the IRS LISS II data correlation results of r^2=0.78 and 0.79 (Chauhan et al 1996). It is already documented that large scale fluvial discharges highly influencing the level of sediment concentration along the Bay (Sridhar et al 2008).

CONCLUSION

The present study of Sentinel-3 data products of chlorophyll and TSM results showed that significant with r^2 value 0.77 and 0.83 with the chlorophyll and TSM respectively. It is believed that *in-situ* values are always truth to be validated with the remote sensing data. However, dissimilarity patterns also found with *in-situ* and remote sensing observations. Hence, more attention and improved methodology for data collection and analyses need to be apply in order to develop remote sensing product that perform well in optically complex water case 2 waters.

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Spatial Analysis of Groundwater Fluctuation in Nathusari Chopta Block of Sirsa District (Haryana, India) using Geospatial Technology

Vinod Kumar and Vipin Kumar

School of Earth Sciences, Banasthali Vidyapith, Banasthali-304 022, India
E-mail: vinodjajuda@gmail.com

Abstract: The present research demonstrates the spatial-temporal changing in the groundwater level of the study area i.e., Nathusari Chopta block of Sirsa district. The 15 locations of dug-wells were taken to observe the ground water level of pre-monsoon and monsoon season for two decades (1996-2018). The fluctuations in the groundwater level during two decades in the area were also analysed. The interpolation technique of geospatial technology was used to analyse and mapping of the ground water level and its fluctuation. The groundwater level of two decades showed a range from 1.28 meter below ground level to 29.4 m (bgl) over the locations. The ground water fluctuation of the area had upwelling trained as result showed that upto 6 meter water table rose during the period. The study showed uprising trend in average groundwater level from 12.37 m bgl in 1996 to 7.56 m bgl in year 2018. The changes in the groundwater level were more prominent in centre, North-east and West as rising trends in the area. The probable reason for this trend may be the poor groundwater quality in western and north-eastern parts of the area hampering the farmers from its use. The central part of area is most affected by water table rising problem and most of the area suffers from Waterlogging and soil salinity. The major aim of the study was to find out the spatial and temporal changes in the seasonal groundwater level and its fluctuations.

Keywords: Ground water, Geospatial technology, Thematic maps, Fluctuation

Water has emerged as an essential resource for existence of life because of its increasing demand in agriculture, domestic and industrial uses. Its adequate and continuous supply is essential to provide stability in food production and self-sufficiency to societies. Increased demand for water has stimulated development of groundwater supply. Groundwater has emerged as one of the major source of water for irrigation in areas where surface (canal) irrigation is either insufficient or restrictively costly. Allover the world, the groundwater resources are under stress brought by the strengthening of human activities and other factors specially climate changes. The uncontrolled and unscientific exploration of groundwater has exhausted this limited crisp water asset in both quantity and quality perspective (Thilagavathi et al 2014). The falling of groundwater level and related environmental issues in all cases wanders, even in high precipitation domain areas which experience water scarcity in the months of summer (Werner et al 2012). This issue is significantly exaggerated in nature in dry and semi dry regions. In geographical condition like that of Haryana (India), waterlogging problem has also reached many areas due to water table rise. Therefore, the objectives of the present study were to know the spatial-temporal changes in the groundwater level from 1996 to 2018. The average seasonal fluctuations of groundwater level of two decades were to be identified and mapped in GIS environment for future planning for sustainability of groundwater level.

MATERIAL AND METHODS

Location of the study area: The 'Nathusari Chopta block' of Sirsa district is situated on the border of Haryana and Rajasthan (Fig. 1). It is located between 29°13'21” to 29°31'28” North latitude and 74°54'13” to 75°18'40 East longitude. The block is 20.3 kms far from district headquarter Sirsa. As per Censes, 2011 the block had 56 villages and total geographical area was 756.31 square km.

Methodology: The study includes two fundamental information; Chronological groundwater depth information and Precipitation information. The groundwater level information of two decades (1996-2018) was collected from Central Groundwater Board website. The groundwater depth was taken from 15 locations of dug-well (Table 1), which gave support as temporal-spatial analyses of groundwater level. Seasonal characteristic of groundwater depth was analysed for monsoon, post monsoon and pre-monsoon season. The spatial distribution of groundwater level of all the 15 locations was analysed with the help of interpolation method of ArcGIS 10.1 software. The groundwater level information of two decades was compared to the observations of groundwater level of 2018 and the range of groundwater level fluctuation of selected locations showed. After knowing the present situation of water table level, the execution planning for the sustainable development of study area was prepared. Detailed methodology chart is shown in the (Fig. 2).

RESULTS AND DISCUSSION

The western part of Haryana state falls under semi-arid region. Rainfall is scant and availability of surface water is limited due to insufficient canal network. Water conservation practices are negligible and annual net recharge of groundwater in this area is less than its discharge. Generally the groundwater recharge depends upon the rainfall, topography, and the geological conditions of the area. The results of observations for spatial analysis are shown through following maps.

i. Groundwater level during pre-monsoon period in 2018.
ii. Groundwater level during monsoon period in 2018.
iii. Average groundwater level during pre-monsoon period from 1996 to 2018.
iv. Average groundwater level during monsoon period from 1996 to 2018.
v. Groundwater level fluctuation in pre-monsoon period in 2018 from long period average level.
vi. Groundwater level fluctuation in during monsoon period in 2018 from long period average level.

In the period of pre-monsoon 2018, the level of

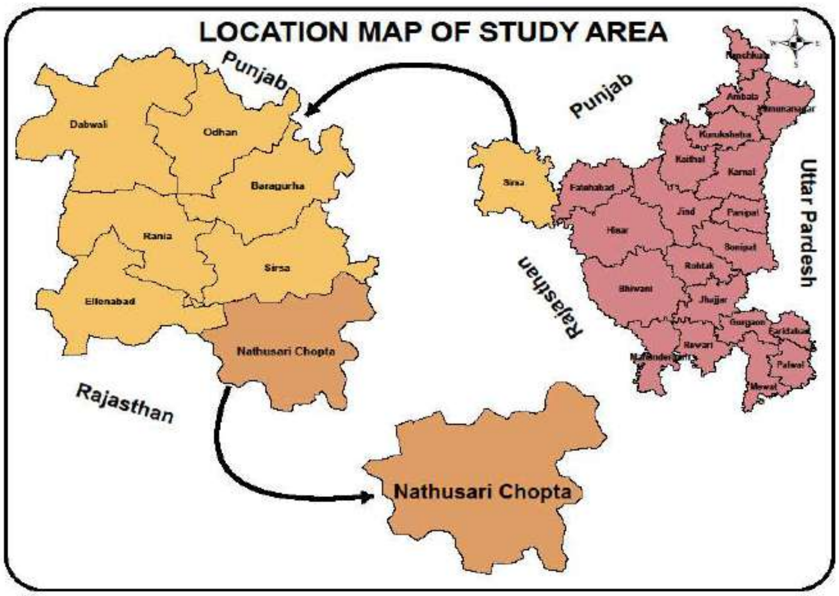

Fig. 1. Location map of the study area

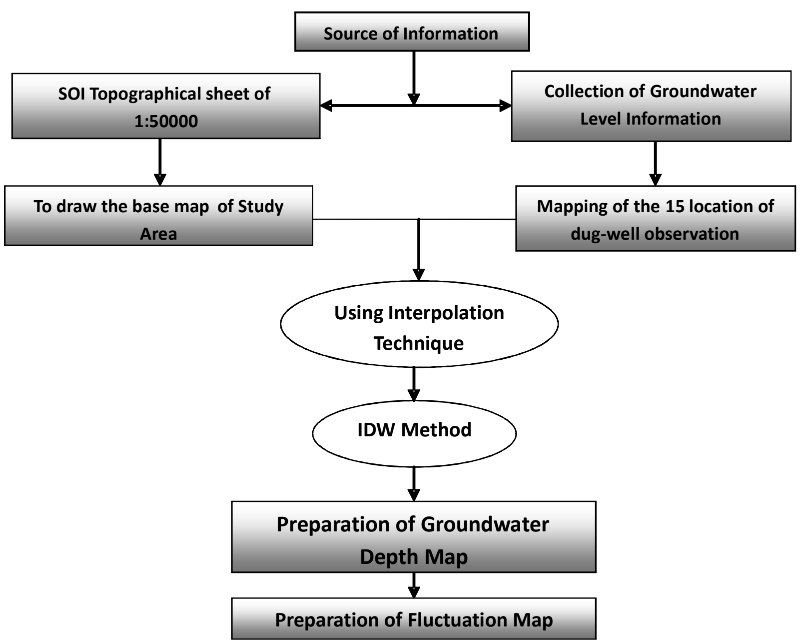

Fig. 2. Methodology chart

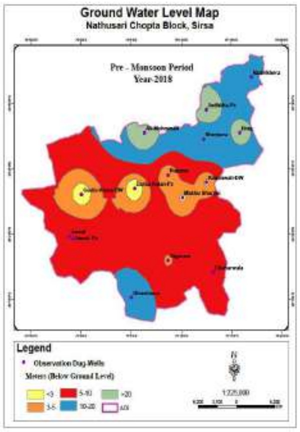

Fig. 3. Ground water Level Map during Pre Monsoon (2018)

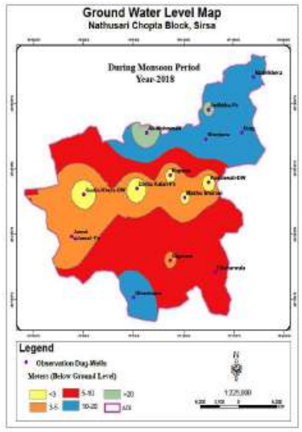

Fig. 4. Ground water Level Map during Monsoon (2018)

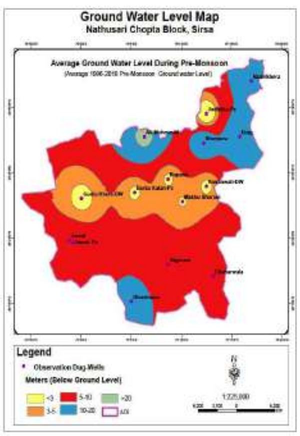

Fig. 5. Average ground water level map during Pre monsoon (1996-2018)

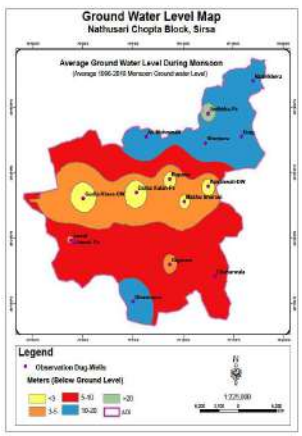

Fig. 6. Average ground water level map during monsoon (1996-2018)

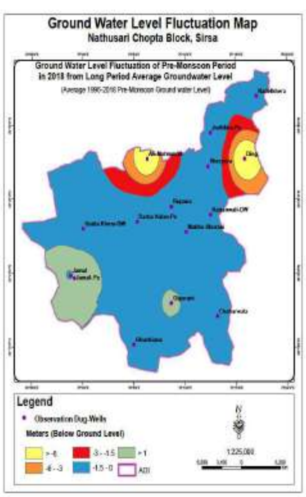

Fig. 7. Average groundwater level fluctuation map during monsoon (1996-2018)

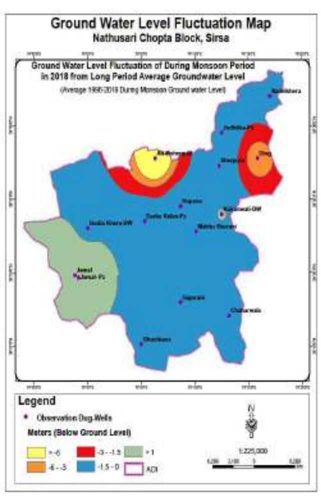

Fig. 8. Average groundwater level fluctuation map during pre monsoon (1996-2018)

groundwater was from 3 mts to 20mts (bgl) in the study area (Fig. 3). The average ground water level in pre-monsoon (2018) was 9.56 mts bgl. The groundwater level of the central part of study area was below 3mts (bgl) surrounding Darba Kalan, Gudiya Khera, Kairnwali and Makhu Shorani villages. These areas suffered from waterlogging and soil salinity problems, whereas in the northern part the ground water was more than 20 mts bgl surrounding Ali Mohmad, Ding and Jodkha villages. During monsoon period of August, average ground water level was 8.38 mts but highest ground water level 1.26mts bgl which was found at Darba Kalan, Makhu Shorani and Gudia Khera villages. In Jodkha and Ding station, ground water level was more than 20 mts bgl. All over in the study area the range of groundwater level was from 2 mts to 10 mts or more. The central parts of the block had slightly higher groundwater level as compared to its northern parts (Fig. 4). The long term (1996-2018) water table data of pre-monsoon and monsoon season was analysed and it was observed that during monsoon and pre-monsoon period the groundwater level ranged from 2mts to 18 mts bgl and 2 mts to 25 mts bgl (Fig. 5-6) in the block for the two seasons respectively. In both periods average ground water level varied from 8.49 mts to 7.53 mts bgl. Groundwater table at Darba Kalan, Gudiya Khera and Makhu Shorani was higher as compared to other parts of the block.

The changing or fluctuation in average ground water level in pre-monsoon and monsoon period (1996-2018) ranged between -6.28 mts to 1.32 mts bgl and -8.09 mts. Trends of groundwater level were also observed in the study area during the same years (1996-2018). The average fluctuation of ground water level of pre-monsoon and monsoon period of two decades varied from -1.06 mts to -0.85 mts (bgl) (Table 1). The rising water level was found in the central to southern parts and the declining water level in eastern parts during the last two decades. Fluctuation of ground water level in 2018 was compared with long period average water level for better estimation of fluctuations (Fig. 7-8).

CONCLUSION

The present study reflects overall inclining trend of depth to groundwater level over the study period. The groundwater level range of 5-10 meters from the year 1996 to 2018 during pre-monsoon period was spread over 334.80 km^2 and during monsoon period increased to 445.53 km^2. A total of 50% of the study area was covered in this range. In 2018, 58% in pre-monsoon period and 62% during monsoon period of the total area was covered in the groundwater level range of 5-10 meter. An area of 85.87% of the whole block comprising of southern, south-eastern, north-eastern and central parts

Table 1. Observation of groundwater level and fluctuation

Site name	Site Type	Ground water level pre-monsoon - 2018 (bgl meters)	Ground water level during monsoon-2018 (bgl meters)	Long period average ground water pre-monsoon 1996-2018 (bgl meters)	Long period average ground water monsoon 1996-2018 (bgl meters)	Ground water level change/ fluctuation during pre-monsoon (5-3)	Ground water level change/ fluctuation during monsoon (6-4)
Ali Mohmmad	Dug Well	29.4	27.4	23.12	19.31	-6.28	-8.09
Chaharwala	Tube Well	9.07	8.32	9.07	8.29	0	-0.03
DarbaKalan-Pz	Tube Well	2.86	1.28	2.58	1.28	-0.28	0
Ding	Dug Well	21.89	17.63	15.12	13.52	-6.77	-4.11
Ghushiana	Dug Well	14.8	14.75	13.86	13.68	-0.94	-1.07
Gigorani	Dug Well	4.85	4.74	4.98	4.71	0.13	-0.03
GudiaKhera-DW	Dug Well	2.15	1.83	1.89	1.68	-0.26	-0.15
Jamal	Dug Well	5.64	4.49	5.26	4.49	-0.38	0
Jamal- Pz	Tube Well	5.95	4.52	7.27	6.85	1.32	2.33
Jodhkha-Pz	Tube Well	57.24	56.6	57.18	56.7	-0.06	0.1
Kairanwali-DW	Dug Well	2.77	1.86	2.39	1.92	-0.38	0.06
MakhuShorani	Dug Well	2.8	2.6	2.8	2.6	0	0
Nadelkhera	Dug Well	13.41	10.71	13.41	10.41	0	-0.3
Rupana	Dug Well	3.07	2.27	2.55	2.15	-0.52	-0.12
Sherpura	Dug Well	15.2	14.98	14.66	14.53	-0.54	-0.45

Bgl= below ground level. Source: Central Groundwater Board

showed inclining trends over the study period from 1996 to 2018. The water table rising trend in average ground water level in western part had influence of Fatehabad branch canal. A very small area of 14.13% of the whole block of the northern and eastern parts of the study area around Ding, Jodhka and Ali Mohamd villages showed declining trend. The subtle use of geospatial technology in spatial distribution and temporal monitoring for sustainable use of groundwater has been demonstrated in the present study.

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Evaluation of Surface Temperatureand Prediction of Changes in Future Projections Using Quantile to Quantile Change Factor Methodologyover Cauvery River Basin-Peninsular India

Parthiban Loganathan and Amit Baburao Mahindrakar*

Department of Environmental and Water Resources Engineering, School of Civil Engineering
Vellore Institute of Technology (VIT), Vellore-632 014, India
**E-mail: amahindrakar@gmail.com*

Abstract: The estimated average surface temperature using Q-Q CFM over the Cauvery river basin explains the rapid changes in climatic conditions. The study illustrates a significant increase in average surface temperature at Cauvery river basin due to global warming. The average temperature trend shows drop in the near future up to 0.5°C especially during the winter season. However, the trend rapidly increases in later years over the entire basin during summer seasons. The maximum change is observed in summer during the far future and which records the average temperature reading crossing 30°C at the lower Cauvery river basin. The maximum temperature change of 1.8°C to 2.7°C is estimated in far future time slice during summer season. The Q-Q CFM technique performs well and overcomes the drawbacks of the single change factor and other multiple change factor methods. The average temperature reading crossing a record 30°C at the lower Cauvery river basin nearing the end of the current century. The Q-Q CFM is computationally efficient and an effective technique for regional climate change assessments. The quantile to quantile change factor method is suggested to overcome the drawbacks of traditional change factor methods.

***Keywords*:** Change factor, Climate change, Cauvery river basin, Global warming, Surface temperature

Evaluation of changes in global climatic conditions has become important due to the increase in floods and droughts in the past few decades. Weather parameters such as precipitation and temperature are mainly focused due to their importance in tracking changes in climatic conditions. Most of the climate studies are performed on a global scale and are not suitable for regional level climate assessment. Thus, regional-scale climate studies are performed to provide a deeper understanding of changes in the local climate. Evaluation of historical climate data provides clarity in observed climate statistics and supports comparison with projected future scenarios for climate change stud. The number of observation stations has been increased and various global climate models (GCMs) which are the numerical simulation of earth's climate have been extensively used in climate studies (Alexander and Arblaster 2017). Several climate institutes developed various GCMs based on different initial and boundary conditions. The climate model outputs are always unreliable and are not suitable for local-scale climate studies. Thus, the assessment of suitable GCM which performs well for a specific region is another challenging task in climate change studies (Srinivasa Raju et al 2017). Systematic errors in GCM are because of large scale variability due to climate-forcing and unpredictable internal variability (Change et al 2012). The future projections can be acquired by adjusting the inaccuracies in large-scale GCM outputs with the support of regional-scale observed climate data.

Several methods have been hired to handle this issue of spatial variability and each of these methods has its own merits and demerits in projecting future scenarios. Future scenarios can be projected in various methods with historical data equivalences between different climatic zones and time scales by simple modification GCMs outputs with the help of observed data (e.g. delta change factor methodology) (Anandhi 2010), and using statistical downscaling and dynamic downscaling (Wilby and Dawson 2013). The main advantage of using Change Factor Methodology (CFM) is the computational efficiency, simplicity, and the direct application of regional observed data to GCM output. Hence, CFM is adopted in many regional-scale climate impact studies around the world (Goodarzi et al 2014, 2015). On the other hand, there are several advantages in this technique such as wet and dry days pattern remains the same while using a single change factor. The cons of single CFM can be neglected by using multiple change factors and this method will be supportive in conditions where change is consecutive overtime which is important for climate impact studies (Diaz-Nieto and Wilby 2005).

Numerous studies on climate change over the Indian subcontinent have been performed earlier (Rajeevan and Nanjundiah 2009, Raju and Kumar 2014, Tiwari et al 2014). However, most of the studies focused on large-scale prediction using the Coupled Model Inter-comparison Project Phase 3 (CMIP3) GCMs. These models had different future scenarios and considerably old compared to the present CMIP5 models. Recently, studies that utilized CMIP5 GCM (Shashikanth et al 2014, Sun et al 2014) suggested better conclusions than that of CMIP3. The performance of CMIP5 GCM was better in projecting temperature than precipitation (Errasti et al 2011), which lead to a surge in the selection of temperature over precipitation as a model performance validation parameter. Surface temperature plays a vital impact as a climate change pointer compared to other weather variables which help in building better impact assessment models. However, not many climate change assessment studies using CMIP5 GCM were conducted over the Cauvery river basin located in peninsular India. The primary objectives of the present study are to project surface temperature at regional-scale for different scenarios using observed data and CMIP5 GCM using Q-Q CFM and to evaluate the changes in surface temperature comparing historical and projected future scenarios.

Study area description: Cauvery River basin falls in peninsular India and lies between 75°27'E to 79°54'E and 10°9'N to 13°30'N. It has a spread over states of Tamil Nadu, Karnataka, Kerala and Union Territory of Puducherry, draining an area of around 85,000 Sq.km. It is confined by the Western Ghats on the west, by the Eastern Ghats on the east and south (Fig. 1). The key regions of the basin are covered with agricultural land up to 67% of the total area and 20 % of the basin is covered by forest area (CWC and NRSC 2014). The Cauvery river basin has four seasons namely winter (December to February), summer (March to June), South-West Monsoon (July to September) and North-East Monsoon (October to November). The basin remains dry in the majority of the area except for the monsoon duration and has both tropical and sub-tropical climate zones whereas the temperature variation in upper reaches of the basin is less compared to the lower reaches. April is the hottest and January turns out to be the coldest month in the basin whereas the average monthly temperature ranges from 18°C to 33°C. Northern parts of the basin are comparatively colder than the southern parts of the basin. The study area is further classified into the upper, middle and lower river basin as shown in Figure 2 for a better understanding of changes within the basin.

Observed data*:* The daily observed average surface temperature is obtained from the Indian Metrological Department (IMD) gridded data (0.5° x 0.5° or 55 km x 55 km) for the Cauvery river basin for the period of 1976-2005. The river basin is further classified into upper, middle and lower Cauvery river basin based on its weather pattern and discharge statistics. Further, the historical GCM dataset is regridded to a 0.5° x 0.5° scale and trimmed to the observed data length.

GCM data*:* The CMIP5 GCM used in this study is CNRM-CM5 due to its best performance in projecting temperature scenario at grid points falling over the Cauvery river basin (Srinivasa Raju et al 2017). The CNRM-CM5 is developed at Météo-France and Centre Européen de Rechercheet de Formation Avancée en CalculScientifique (CERFACS, France). The time scale of 1976-2005 for historical simulation and 2006-2095 for all future projected scenarios are considered in this study. The grid size of the GCM is 1.4° x 1.4° or 155 km x 155 km, the future scenarios available are Representative Concentration Pathway (RCP) – RCP 2.6, RCP 4.5, and RCP 8.5. The daily ensemble realization run used was r1i1p1 (ensemble member-1, initialization state-1, and physical parameterization-1).

The time scale of future projected data is split into three-time slices near future (2006-2035), mid future (2036-2065) and far future (2066-2095). The historical GCM data is compared with future GCM RCPs to extract the change factors between the historical and the future projections. The change factor can be calculated in two ways such as additive and multiplicative where the additive calculates the arithmetic difference and the multiplicative calculates the ratio

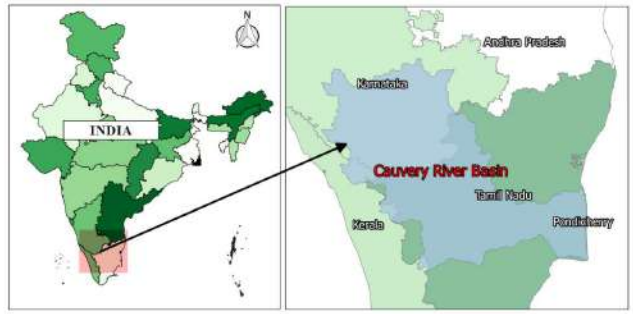

Fig. 1. Cauvery River Basin extent and boundary

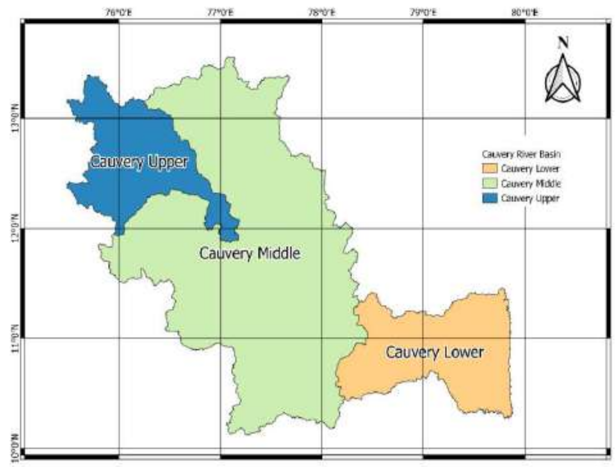

Fig. 2. Classification of the Cauvery river basin

Table 1. Sub-basin wise observed surface temperature

Season	Temperature (°C)		
	Upper Basin	Middle Basin	Lower Basin
Winter	19.8	22.2	24.3
Summer	23.1	26.3	28.3
South-West Monsoon	20.7	24.3	28
North-East Monsoon	20.6	23.2	25.7

between the past and the future (Anandhi et al 2011, Diaz-Nieto and Wilby 2005). The additive change factor is better for temperature because it can be represented in arbitrary values (e.g. +2°C, -4°C). The single additive change factors can be calculated as represented in equations (1) and future projection is calculated by equation (2).

$$CF_{Add} = GCM_{Base} – GCM_{Fut} \quad (1)$$

$$T_{Proj} – T_{Obs} + CF_{Add} \quad (2)$$

Where CF_{Add} additive change factor, GCM_{Base} is GCM historical baseline and GCM_{Fut} is global climate model future scenario, T_{Obs} is historical observed temperature, and T_{Proj} is future projected temperature.

The single change factor method is ineffective because it results in only one change factor value for the entire time series. Thus, a quantile to quantile change factor (Q-Q CF) technique is proposed which provides a change factor for every 1 percentile of the empirical cumulative distribution (ECD) of the compared time series. This can be expressed in the following equations (3) and (4).

$$Q - Q\ CF_{Add,Qn} = GCM_{Base,Qn} - GCM_{Fut,\ Qn} \quad (3)$$

$$T_{Proj} - T_{Obs,Qn} + Q = Q\ CF_{Add,Qn} \quad (4)$$

Where Q is quantile and n range from 1 to 100 i.e. for every percentile.

The Q-Q CF calculated for each percentile is used to project future temperature for all considered scenarios. Further, the changes are observed by comparing the observed temperature statistics and future projections for different time slices at different seasons. A brief flowchart of the methodology is presented in Figure 3.

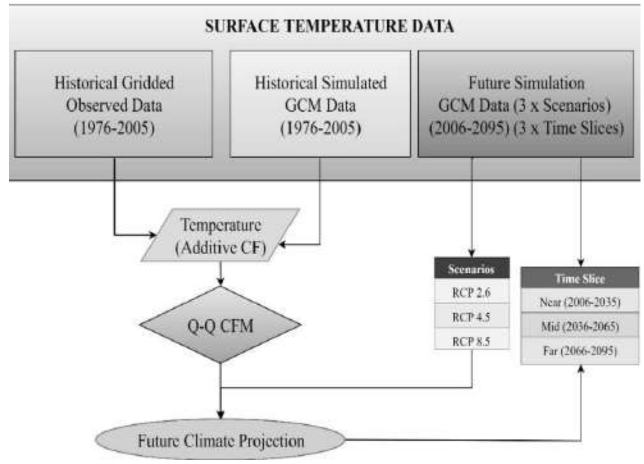

Fig. 3. Q-Q Change factor methodology

RESULTS AND DISCUSSION

Observed climate statistics: The historically observed temperature statistics infers that the upper basin as cooler, middle basin as the moderate and lower basin being the warmer zones throughout all the seasons. The minimum rainfall was recorded in the upper basin during winter and higher at the lower basin during the north-east monsoon. Similarly, the least temperature was recorded

Table 2. Sub-basin wise average temperature for future projected scenarios

Season	Time Slice	RCP 2.6			RCP 4.5			RCP 6.0			RCP 8.5		
		Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Winter	Near Future	19.3	21.7	23.8	19.4	21.7	23.8	19.4	21.8	23.8	19.4	21.7	23.8
	Mid Future	19.8	22.2	24.3	20.1	22.5	24.6	19.9	22.2	24.5	20.6	23	24.9
	Far Future	19.9	22.2	24.4	20.7	23	24.9	20.7	22.9	25.3	22.1	24.4	26.1
Summer	Near Future	23	26.2	28	22.9	26.1	28	22.8	26	28	23	26.2	28.1
	Mid Future	23.5	26.6	28.6	23.7	26.9	28.7	23.5	26.7	28.6	24.2	27.5	29.3
	Far Future	23.4	26.6	28.6	24.1	27.4	29.3	24.3	27.5	29.5	25.6	29	30.7
South-West Monsoon	Near Future	20.4	24	27.8	20.4	24	27.7	20.3	23.9	27.6	20.5	24.1	27.7
	Mid Future	20.7	24.3	28.1	21	24.6	28.3	20.9	24.5	28.2	21.5	25.1	28.7
	Far Future	20.8	24.3	28.1	21.5	25.1	28.7	21.7	25.2	29	22.9	26.4	30
North-East Monsoon	Near Future	20.3	22.8	25.5	20.4	22.9	25.3	20.2	22.8	25.3	20.4	22.9	25.5
	Mid Future	20.7	23.2	25.7	21	23.5	25.9	20.8	23.2	25.9	21.4	23.9	26.3
	Far Future	20.7	23.2	25.8	21.4	23.9	26.4	21.5	23.9	26.7	22.7	25.2	27.5

Table 3. Sub-basin wise temperature changes in future projected scenarios

Season	Time Slice	RCP 2.6			RCP 4.5			RCP 6.0			RCP 8.5		
		Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Winter	Near Future	-0.5	-0.5	-0.5	-0.4	-0.5	-0.5	-0.4	-0.4	-0.5	-0.4	-0.5	-0.5
	Mid Future	-0.1	-0.1	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.1	-0.1	-0.2
	Far Future	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.2	-0.2	-0.3
Summer	Near Future	-0.3	-0.4	-0.2	-0.2	-0.3	-0.4	-0.4	-0.4	-0.4	-0.2	-0.3	-0.2
	Mid Future	0	0	0	0.3	0.3	0.3	0.1	0	0.2	0.8	0.8	0.6
	Far Future	0.4	0.3	0.3	0.6	0.6	0.4	0.4	0.4	0.3	1.1	1.2	1
South-West Monsoon	Near Future	0	0	0.1	0.3	0.3	0.3	0.2	0.2	0.2	0.8	0.8	0.7
	Mid Future	0.1	0	0	0.4	0.3	0.2	0.2	0	0.2	0.8	0.7	0.6
	Far Future	0.1	0	0.1	0.9	0.8	0.6	0.9	0.7	1	2.3	2.2	1.8
North-East Monsoon	Near Future	0.3	0.3	0.3	1	1.1	1	1.2	1.2	1.2	2.5	2.7	2.4
	Mid Future	0.1	0	0.1	0.8	0.8	0.7	1	0.9	1	2.2	2.1	2
	Far Future	0.1	0	0.1	0.8	0.7	0.7	0.9	0.7	1	2.1	2	1.8

at the upper basin during winter (19.8°C) and higher value at lower during the summer season (28.3°C).

Changes in future projections: The projected average surface temperature values using Q-Q CFM is presented in Table 2. The projected values are compared with the historical values to calculate the possibilities changes in average temperature over future time scale (Table 3). A maximum of up to 2.7°C change is observed in the middle basin during summer for the RCP 8.5 scenario.

CONCLUSIONS

Climate change assessment studies are very essential for future planning and other policy development in a selected region. A climate change assessment study using average surface temperature over the Cauvery river basin is conducted. The Q-Q CFM technique performs well and overcomes the drawbacks of the single change factor and other multiple change factor methods. The Q-Q CFM is computationally efficient and an effective technique for regional climate change assessments. The projected average surface temperature using Q-Q CFM over the Cauvery river basin clearly explains the rapid changes in climatic conditions over the region. The trend shows that temperature values tend to reduce throughout the basin for up to 0.5°C during the near future time slice, especially during the winter season. The temperature values are rapidly increasing in the entire basin especially during the summer season at mid and far future time slices.The maximum change is observed in summer during the far future and which records the average temperature reading crossing 30°C at the lower Cauvery river basin.The average temperature trend shows drop in the near future up to 0.5°C especially during the winter season. However, the trend rapidly increases in later years over the entire basin during summer seasons. The maximum change of 1.8°C to 2.7°Cis observed in summer during the far future. The average temperature reading crossing a record 30°C at the lower Cauvery river basin nearing the end of the current century. Quantile to quantile change factor method is suggested to overcome the drawbacks of traditional change factor methods.

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Effect of Differential Substitution of Nutrients on Growth, Quality and Economics of Basmati Rice (*Oryza Sativa*) under Irrigated Sub-Tropics of Jammu Region

M. Banotra, B.C. Sharma and R. Kumar

Department of Agronomy, Sher-e-Kashmir University of Agricultural Sciences &Technology, Jammu -180009,India
E-mail: monikabanotra6@gmail.com

Abstract: A field experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu during *kharif* 2016 to study the growth, yield attributes, yield, quality and economics of basmati rice (*Oryza sativa*). Significantly highest growth parameters viz., plant height and dry matter accumulation; yield and yield attributes viz., number of panicles hill^{-1}, number of grains panicle^{-1}, grain yield (t ha^{-1}) and straw yield (t ha^{-1}) were 100 % [30 kg N: 20kg P_2O_5:10 kg K_20] recommended dose of fertilizer). Non-significant changes were recorded in quality parameters viz., amylose and crude protein content. Minimum cost of cultivation (Rs 20782 ha^{-1}), highest gross returns (Rs.79675 ha^{-1}), highest net returns (Rs. 71322 ha^{-1}), and highest benefit cost ratio (3.43) were also recorded with recommended dose of fertilizer.

***Keywords*:** Basmati rice, FYM, Growth, Quality, Vermicompost

Rice is the most important cereal crop in the world and is the staple food crop for nearly half of the population. However imbalanced use of fertilizer in its wake many fertility problems. Organic matter in soil influences almost all the components of soil linked with crop production (Bhatt et al 2012). The addition of organic matter in soil can play an important role in maintaining the soil health by supplying almost all essential plant nutrients and proving good physical and biological conditions for growth and development of crop plants. Organic manure are very well known source to improve soil property and fertility for sustaining the soil by excluding or minimizing the dependence on chemical fertilizers. So use of organic manure such as vermicompost is another alternative for plant nutrition. In this study, differential substitution of nutrients was done in basmati rice to access the growth, yield, quality parameters and economics under irrigated subtropics of Jammu region.

MATERIAL AND METHODS

A field experiment was conducted at Sher-e-Kashmir university of Agricultural Sciences and Technology Jammu, Main campus Chatha during *kharif* 2016 on sandy clay loam soil, low in organic carbon (0.45 per cent) and available N (249.88 kg ha^{-1}) but medium in available P (13.79 kg ha^{-1}) and available K (148.45 kg ha^{-1}) with pH 7.81. The experiment consisted of sixteen treatments and was laid out in randomized block design with three replications .The rice variety Basmati -370 was used in the experiment at specified row to row distance of 20 cm and plant to plant distance of 10 cm. The recommended dose of nutrients for basmati rice is N (30 kg), P_2O_5 (20 kg) and K_2O (10 kg). The inorganic sources of nutrients used in the experiment were urea, diammonium phosphate and murate of potash, whereas, organic source used in the experiment were FYM and Vermicompost. The mode of application included application of whole quantity of phosphorus, potassium and organic manure along with half of the total remaining nitrogen as basal. Rest of the nitrogen was top dressed in two equal splits in basmati rice at tillering and panicle initiation stage. Experimental plots were drained 12 hours before top dressing and re irrigated 36 hours after application of fertilizers. Growth parameters viz., plant height was recorded at harvest from ground surface to the tip of uppermost fully opened leaf. For dry matter accumulation, samples were taken from the second row by clipping the plants close to the surface from each plot. They were sundried and thereafter shifted in the oven to dry at a temperature of 60$\pm$5 till a constant weight was achieved and expressed as dry matter accumulation g hill^{-1}. The yield attributes and yield parameters viz., number of panicles hill^{-1}, number of grains panicle^{-1}, 1000-grain weight; grain and straw yield; quality parameters viz., amylose content, crude protein content and aroma were estimated by using standard methodologies for analysis and formulae. The economics was worked out at the prevailing market rates of inputs and outputs.

RESULTS AND DISCUSSION

Growth parameters: The plant height was significantly higher with treatment 100 % NPK (recommended dose of fertilizer-T_1, which was found statistically at par with treatment 75% NPK +25% N through vermicompost and FYM (1:1)-T_{12}, 25 % yearly replacement of RDF through vermicompost and FYM (1:1) on N-basis-T_{16}, 75% NPK +25% N through vermicompost-T_2, 25% yearly replacement of RDF through vermicompost on N-basis-T_6, 75% NPK+25% N through FYM-T_7, 25% yearly replacement of RDF through FYM on N-basis-T_{11}. Significantly highest plant height in T_1 might be due to availability of nutrients from the inorganic sources with RDF and due to increase in use efficiency of the nutrients particularly nitrogen because of slow release of the same from Vermicompost and FYM and blending effect of FYM on inorganic source helped to reduce N loss, prolonged the availability of nitrogen to match with absorption pattern of rice plant resulting in improvement of growth parameters. Similar results were also reported by (Awan et al 2011). Significantly higher dry matter accumulation was also recorded with T_1 which was found statistically at par with treatments T_{12}, T_{16}, T_2, T_6, T_7 and T_{11} and significantly superior than other treatments and this was might be attributed to improved uptake of nutrients at all stages which ultimately led to establishment of better growth parameters and have contributed significantly for accumulating higher dry matter in basmati rice as compared to organic treatments. These results were in conformity with the findings of Malviya et al (2012).

Yield and yield attributes: Significantly highest no. of effective panicles hill^{-1} in basmati rice was observed with treatments T_1, T_{12}, T_{16}, T_2, T_6, T_7 and T_{11} which might be due to better mineralization through balanced use of recommended nutrients and more availability of macro as well as micro plant nutrients with addition to vermicompost and FYM in soil. These results were in line with Siavoshi et al (2011). The 1000-grain weight of basmati rice also showed the same trend.

A considerable variation in growth and yield attributing characters of basmati rice led to pronounced variations in grain and straw yields of the crop. Significantly highest grain and straw yields of basmati rice were observed with treatment T_1 which statistically at par with treatments T_{12}, T_{16}, T_2, T_6 T_7 and T_{11}. This could be attributed to their greater availability and uptake of macro and micronutrients and their active participation in carbon assimilation, photosynthesis starch formation translocation of proteins and sugar, entry of water into the plant roots and its development etc. Combination of organic and inorganic fertilizers also enhances the process of tissue differentiation *i.e* from

Table 1. Effect of differential substitution of nutrients through organics on growth and yield attributes of basmati rice

Treatment	Plant height (cm)	Dry matter accumulation g hill^{-1}	Number of effective panicles hill^{-1}	Number of grains panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	118.11	15.56	236.00	74.20	21.86	3.23	7.47
T_2	113.71	15.35	235.15	73.85	21.46	3.13	7.41
T_3	98.03	13.18	209.33	65.89	21.08	2.55	6.22
T_4	82.96	10.97	184.00	55.76	20.96	2.11	5.02
T_5	81.18	10.45	182.14	55.36	20.70	1.93	4.51
T_6	112.94	15.33	234.33	73.77	21.37	3.00	7.35
T_7	112.77	15.27	234.26	73.68	21.25	2.98	7.33
T_8	95.53	13.09	209.43	65.72	21.02	2.54	6.15
T_9	82.15	10.87	183.83	55.54	20.91	2.11	4.69
T_{10}	79.54	9.93	181.00	55.29	20.55	1.92	4.51
T_{11}	112.31	15.26	234.15	73.55	21.15	2.98	7.32
T_{12}	116.75	15.53	236.22	74.11	21.78	3.19	7.45
T_{13}	98.52	13.21	210.15	66.07	21.11	2.57	6.39
T_{14}	81.68	11.00	184.66	58.26	20.98	2.17	5.21
T_{15}	82.53	10.72	183.21	55.42	20.84	1.97	4.60
T_{16}	114.86	15.44	235.36	73.96	21.53	3.14	7.41
LSD (p=0.05)	13.44	1.95	23.55	7.23	N.S	0.37	0.95

T_1-100 % NPK (Recommended dose of fertilizer); T_2-75 % NPK +25 % N through Vermicompost ; T_3-50 % NPK + 50 % N through Vermicompost ; T_4-25 % NPK +75 % N through Vermicompost; T_5-100 % N through Vermicompost; T_6-25 % yearly replacement of RDF through Vermicompost; T_7-75 % NPK +25 % N through FYM; T_8-50 % NPK + 50 % N through FYM; T_9-25 % NPK +75 % N through FYM; T_{10}-100 % N through FYM; T_{11}-25 % yearly replacement of RDF through FYM; T_{12}-75 % NPK +25 % N through Vermicompost and FYM (1:1); T_{13}-50 % NPK + 50 % N through Vermicompost and FYM (1:1); T_{14}-25 % NPK +75 % N through Vermicompost and FYM (1:1); T_{15}-100 % N through Vermicompost and FYM (1:1); T_{16}-25 % yearly replacement of RDF through Vermicompost and FYM (1:1) somatic to reproductive phase leading to higher grain and straw yields. These results are also in conformity with findings of Hossaaen et al (2011) and Mohante et al (2013).

Significantly lowest yield of basmati rice was observed with treatment T_{10} which was statistically at par with treatment T_5 and $T_{15.}$ The lowest yield with organic treatments was might be due to conversion process of nutrients from organic to inorganic form take some time and makes these nutrient elements unavailable to fulfil the timely needs of the crop. The reduction of proportion of NPK through vermicompost and FYM equivalent to N correspondingly reduce the photosynthates accumulation in plant in terms of dry matter and finally contributed to reduce the number of tillers hill^{-1}. These results were similar to the findings of Singh et al (2007).

Basmati rice is very sensitive to poor soil fertility and the crop is exposed to poor nutrient availability, during the initial stage of growth which may cause extreme increase in unfilled panicles in the organic treatments and this would have negative consequences on the productivity of basmati rice Naing et al (2010).

Quality: Non-significant differences were recorded among different quality parameters of treatments of basmati rice with differential substitution of nutrients through organics. Data regarding highest per cent amylose content and per cent crude protein content in basmati rice revealed that highest per cent amylose content and per cent crude protein content were recorded with treatment T_{10} followed by treatment T_5 and T_{15} whereas, lowest per cent amylose content and per cent crude protein content in basmati rice were recorded with treatment $T_{1.}$

There was satisfactory amount of aroma in basmati grains under all under all the treatments. This could be ascribed to inherit trait presence in basmati rice due to presence of 2-acetylene-1-pyrroline as the principal aroma compound responsible for pleasant aroma in scented rice. These results were similar to the findings of Kharub and Sharma (2008) that aroma in basmati rice remains under inorganic and organic applied treatment remains satisfactory.

Economics: The highest cost of cultivation of basmati rice was recorded with T_5 followed T_4, T_{15} whereas; lowest cost of cultivation was recorded with T_1. The highest cost of cultivation of basmati rice with treatment T_5 was due to high cost of vermicompost. The highest gross returns was recorded with T_1 whereas lowest with $T_{9.}$ The highest gross returns in T_1 was due to higher yield attained under this treatment and prevailing market price of basmati rice during the respective year. The highest net returns and benefit cost ratio of basmati rice was recorded was also observed with T_1. Similarly highest net returns and benefit cost ratio was maximum with 100% RDF whereas, highest cost of cultivation with Vermicompost were reported by Malviya et al (2012).

Table 2. Effect of differential substitution of nutrients through organics on yield and economics of basmatirice

Treatment	Amylose content	Crude protein	Aroma	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1	24.07	6.98	S	20782	92104	71322	3.43
T_2	24.55	7.25	S	24309	89500	65191	2.68
T_3	24.95	7.96	S	27836	73131	45295	1.63
T_4	25.13	8.22	S	31363	60438	29074	0.93
T_5	25.31	8.48	S	34597	64938	30340	0.88
T_6	24.60	7.47	S	27836	86110	58274	2.09
T_7	24.64	7.69	S	21637	85494	63857	2.95
T_8	24.99	7.98	S	22493	72951	50458	2.24
T_9	25.16	8.27	S	23346	59923	36577	1.57
T_{10}	25.35	8.53	S	23911	64425	40513	1.69
T_{11}	24.80	7.73	S	22493	85641	63147	2.81
T_{12}	24.33	7.00	S	22973	91102	68129	2.97
T_{13}	24.83	7.87	S	25164	74063	48898	1.94
T_{14}	25.08	8.16	S	27356	62152	34796	1.27
T_{15}	25.30	8.44	S	29254	66218	36963	1.26
T_{16}	24.48	7.22	S	25164	89616	64451	2.56
LSD (p=0.05)	N.S	N.S	-				

CONCLUSION

On the basis of results of present investigation it can be safely concluded that among the different treatments 100% NPK (Recommended dose of fertilizer) followed by 75% NPK+25% N through Vermicompost and FYM (1:1) were adjudged as best treatments under irrigated subtropics of Jammu region.

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Characterization of Plant Based Low Cost Adsorbents in Chhattisgarh State

Varsha Joshi, Jayati Chatterjee Mitra and Santosh Kumar Sar[1]

Department of Chemistry, Dr. C.V. Raman University, Kota, Bilaspur-495 113, India
[1]Department of Applied Chemistry, Bhilai Institute of Technology, Durg-490 001, India
E-mail: abhivarsha327@gmail.com

Abstract: This study evaluates to prepare and characterize plant based adsorbent from leaves. The adsorbent prepared with physical and chemical treatment. The sieving size 125 µm was selected for adsorbents. The physico-chemical parameters of adsorbents pH, moisture content, ash content, volatile matter, bulk density and iodine value were determined. Targeted the functional group of biosorbents were studied by Fourier transform infrared spectroscopy (FTIR).The present research work indicated that all biosorbent shown carbon (68-76%),iodine value (131-223) and important functional group i.e.,carboxylic acid, amino acid, ether, aldehyde and ketone.

Keywords: Moisture content, Volatile matter, Ash content, Fixed carbon Iodine index, FTIR

Pesticides are biologically active substance used to interpret different types of agents that are classified on the basis of their potential to destroy types of insects, pests, and another living organism. Pesticides are distinguished by their unique chemical structure or their pattern in which type used by society and depends upon interconnected to the environment (Ahmad et al 2010). In recent decades, the widespread contamination of pesticides has been served due to increase world food production for the rapidly growing population is well recognized (Agromoorthy 2008). The sporadic use has been leading to significant consequence not only in public health but also in food quality, resulting the ecosystem was affected by small traces of these products entering in the food chain and contaminating soil, air, water and ground water (Colosio et al 2008).

Chlorpyrifos (O,O-diethyl O-3, 5,6- trichlorpyridin2-yl phosphorothioate) is a crystalline organophosphate insecticides. It is used to control pests and insects in commercial, residential, and agriculture area all around the world (Venugopal et al 2012). Chlorpyrifos is moderately toxic to human and exposure has been linked to neurological effects, persistent, developmental disorders and autoimmune disorder (Joshi et al 2017). Several standard methods are used to control organic contamination of water like photo catalytic degradation, combined photo-Fenton and advanced oxidation reduction process, nanofiltration membranes, ozonation, ion exchange, reverse osmosis. These methods are not economical and convenient to bring down the level of contaminates in waste water to permissible. Adsorption has been effective technique for reuse of water in terms of initial cost, simplicity of design, flexibility and easy to operate and does not result harmful outcome (Rashed et al 2013). Activated carbon is most used as an adsorbent to purify water because of its properties like high porosity; high carbon content and large surface area but its high cost possesses an economical problem. In recent years a new class of adsorbents and specifically lignocelluloses material has been invented for this purpose. Their attractiveness resulting from their low cost biodegradable, high effectiveness and easily availability (Patel et al 2012). Several recent publication reported the use of locally available adsorbents rice husk, date stone, rice bran, tea leaves, bamboo leaves, peanutshells, orange peels, coffee husk, mango peels, coconut shell, moringa olefiera leaves, sunflower seed for removal of pesticides polluted water (Cara et al 2015).

On the other hand *Aeglemarmelos* belongs to Rutaceae family and commonly known as Bael. Bael tree has found growing along sub-Himalayan region (Uttaranchal) and central India region (Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh).

Cauliflower leaves belongs to brassiceae family and commonly name as “phoolgobhi”. Psidium Guava or guava, a evergreen shrub be a member of Myrataceae family. Guava was grown in tropical and subtropical region. The aim of this paper to evaluate the adsorptive capacity of this plant based biosorbent, to analyze volatile matter, moisture content, ash content, total fixed carbon, pH, bulk density, iodine index, ftir analysis. This study invigilates various properties of biomass and suggests that this material could be used as a low-cost adsorbent.

MATERIAL AND METHODS

Carbonization of sample: Cauliflower leaves were collected from local market area. Bael and Guava leaves were collected from road side area of Rajnandgaon, Chhattisgarh, India. Firstly Leaves were washed with double distilled water to remove dust particles. The soluble coloured particles were removed by washing through hot deionised water (80°C). Leaves were dried in sun light for 2-3 days then it was further oven dried for 24h at 90°C to remove accessional moisture content. The dried leaves were crushed and grinded into fine powder and sieved through 125 µm size. The final product was kept in a clean, airtight, polyethylene bottles.

Proximate analysis- The proximate analysis serves as a simple means for determining the behaviour of a solid biomass fuel when it is heated. The proximate analysis gives us the composition of the biomass in terms of gross components such as moisture (M), volatile matter (VM), ash (ASH) and fixed carbon (FC).

Content	Lid	Apparatus	Temperature	Time
1. Moisture content	Without lid	Oven	103°C	1 hour
2. Volatile matter	With lid	Muffle furnace	925°C	7 minute
3. Ash content	Without lid	Muffle furnace	(1) 250°C (2) 580°C-600°C	(1) First 30 min (2) Until all carbon is burnt

Fixed carbon (%) = 100 – [M (%) +VM (%) +ASH (%)]....(1)

Determination of pH: The standard test method for determination of biosorbents pH Hanna multiparameter instrument was used. 1.0 g of raw plant leaves (Aegle marmelos, Brassica oleracea. va. botrytis, Psidium guava) was weighed and transferred into a 100 ml borosil glass beaker. 100 ml of distilled water was added to it and the mixture was stirred for 1 h. The samples were allowed to stabilize before the pH was measured using a Hanna pH meter. Samples were run in triplicates.

Determination of the amount of Iodine adsorbed: For the iodine number test, Gimba and Musa (2007) method was adopted. A stock solution was prepared containing 2.7 g of iodine crystals and 4.1 g of potassium iodide per litre. The prepared stock solution was standardized using a standard solution of sodium thiosulphate. To a 100 ml volumetric flask, 0.5 g of the activated plant leaves and 10 ml of 5 % v/v hydrochloric acid were introduced. The flask was swirled until the carbon was wetted. Then, 100 ml of the stock iodine solution was added and agitated at a fast speed, using an electric shaker for a period of 60 min. The mixtures were filtered through a sintered glass crucible. An aliquot portion (20 ml) was titrated with 0.1 M sodium thiosulphate using starch as an indicator. The concentration of iodine adsorbed by the activated plant leaves at room temperature was calculated as the amount of iodine adsorbed in mg**.**

$$\frac{Img}{g} = \frac{B-S}{B} \times \frac{VM}{W} \times 253.81 ....(2)$$

where B and S are the volumes of thiosulphate solution required for blank and sample titrations, respectively. W is the mass of activated sample, M is the concentration (mol) of iodine solute atomic mass of iodine and V is 20 ml aliquot.

Bulk density: Bulk densities were measured by weighing a given volume of bulk solids. Briefly, sufficient quantity of the bio sorbent was transferred into a 10 ml measuring cylinder of 1.0 cm diameter with gentle tapping and weighted and density was calculated using equation (3) The bulk density was expressed in grams per millilitre (Edokpayi et al 2018).

Bulk density (g/mL) =Wb/Vc.................................. (3)

Where Wb = the weight of biosorbent filing 10ml measuring cylinder on gentle tapping

Vc = the volume of the cylinder.

FTIR-ATR spectral measurements: FTIR-ATR spectral measurement of plant leaves powder samples were carried out at NIT Raipur Chhattisgarh using Perkin Elmer Spectrum –Two FTIR spectrophotometer with attenuated total reflectance accessory having highly reliable and single bounce diamond as its Internal Reflectance Element (IRE). FTIR spectra were recorded in the transmittance mode in the frequency range from 450-4500 $cm^{-1}$by averaging scan 16 scans with resolution of 4cm^{-1}. All samples were placed on the crystal of 2mm surface area with single bounce reflecting has 350cm^{-1}.all spectral measurements were carried out at room temperature and each measurement was repeated to ensure the reproducibility of the spectra.

RESULTS AND DISCUSSION

Proximate analysis: The low content of moisture shows high storage time and resistant to microbial growth in biomass and ash content represents incombustible constituent in the form of certain inorganic compound. The ash content was found higher in CFL 18% as compare to 13% for BL and 12% for GL and it shows low maintains and easy handling because of very low content of moisture. A volatile matter (9-14%) was represented organic nutrients including protein, carbohydrate and lipids. The bulk density for BL, CFL and GL were 0.42, 0.35 and 0.53 g cm^{-3} is relatively small and varied according the different shape and size of particle (Table 1).

The values of iodine number obtained for GL (223.352) are higher than the value obtained CFL (152.286) and for BL (131,981) was lowest with compare to both biomaterial (Table 1). The higher the iodine value, the greater is the sorption capacity. According to the result it can be said that

GL has higher sorption capacity with compare to both adsorbents. The pH value for BL, CFL and GL was 6.27, 6.11, and 6.67 respectively which reported slightly acidic in nature. The bulk density for BL, CFL and GL were 0.42, 0.35 and 0.53 g $cm^{-3.}$

FTIR (Fourier Transform Infrared Spectroscopy) of different plant biomass: The FTIR absorption spectrum of BL, CFL and GL is represented in Figures 1, 2 and 3. The prominent broad band position around 3219.16 and 1231.15 cm^{-1} was assigned due to N-H stretching and C-N stretching mode respectively aliphatic amide of protein. The methyl (CH_3) asymmetric mode was observed at 2918.11 cm^{-1}. In the FTIR spectra of bael leaves strong peak obtained at the 1602.23 cm^{-1} results from c=c stretching in aromatic nuclei. While the band at 1407.05 cm^{-1} due to bending O-Hand 1026.68cm^{-1} due to C-O stretching represents primary and tertiary alcohol and phenol in compound. FTIR spectroscopic study of Aegle marmelos leaves showed Hydroxyl (-OH), alkenes, alcoholic, aldehyde, phenol and aromatic compound of coumarin. For CFL, the stretching absorption peak centred at 3418.23 cm^{-1} can be attributed to the intermolecular asymmetric N-H group of primary amide. The band observed at about 2917.3 and 2842.17 cm^{-1} is assigned to C-H stretching vibrations of $-CH_3$ or $-CH_2$ group of carboxylic acid and alkanes. The peak at 1634.27 cm^{-1} is attributed to the enolic form of α, β diketone or aromatic or N-H group of amino acids. It exhibits the intense broad band in the 1640-1580 cm^{-1} region. The intense and displaced absorption peak observed at 2842.17 cm^{-1} result for intra-molecular H-bonding. A band 1465.25 cm^{-1} are assigned to stretching and vibration of O-H of carboxylic acid respectively. The peaks at 1215.89 cm^{-1} and 1019.13 cm^{-1} represents C-O stretch due to ether/ tertiary alcohol respectively. The absorption peak centered at 696.17 cm^{-1} indicates the presence of mono substituted benzene.

For GL according to Figure 3, a broad band arises at 3287.41 cm^{-1} is due to N-H stretching mode of protein amides. The stretching of O-H group bound to methyl group presented a signal at 2919.25 cm^{-1}. The peaks located at

Table 1. Physico-chemical characteristics of bio-adsorbents

Properties	BL	CFL	GL
Moisture (%)	2	2	3
Ash (%)	13	18	12
Volatile matter (%)	14	12	9
Fixed carbon (%)	71	68	76
pH	6.27	6.11	6.67
Bulk density	0.419	0.351	0.528
Iodine value	131.981	152.286	223.352

BL – Bael leaves, CFL – Cauliflower leaves, GL – Guava leaves

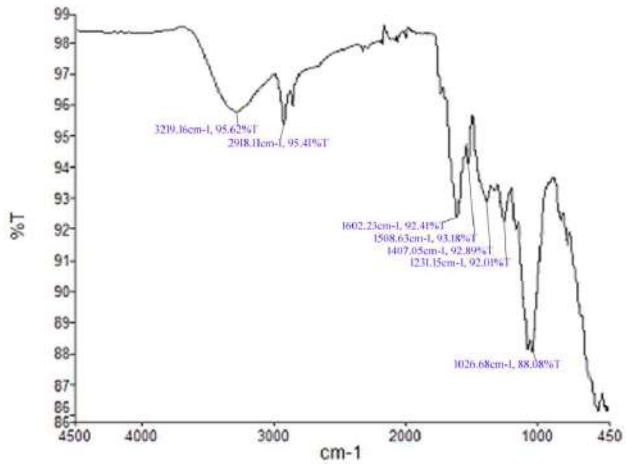

Fig. 1. FTIR-ATR spectrum of bael leaves in frequency region 450-4500 cm^{-1}

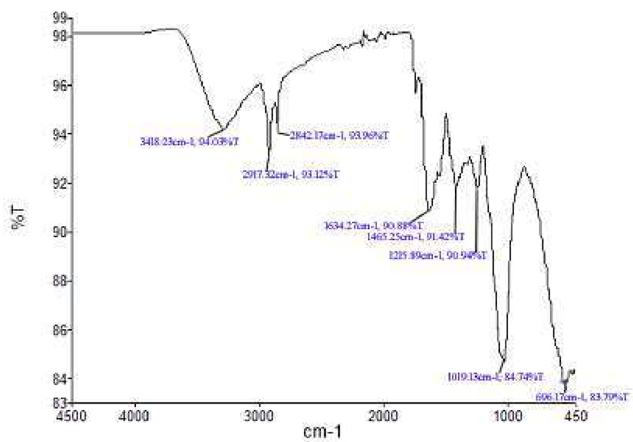

Fig. 2. FTIR-ATR spectrum of cauliflower leaves in frequency region 450-4500 cm^{-1}

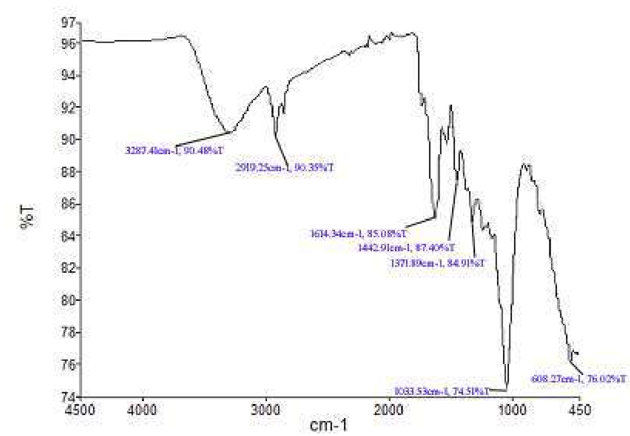

Fig. 3. FTIR-ATR spectrum of guava leaves in frequency region 450-4500 cm^{-1}

1614.34 cm^{-1} due to C=C stretching characteristic of carbonyl group (aldehydes and ketones) in aromatic ring. The absorptions in GL spectrum at 1442.91 cm^{-1} and 1371.89 cm^{-1} are attributed to the deformation and bending mode of the C-H/ CH_2/CH_3 groups from the various amino acid (R) side chains and CH_3 of amino acid. The bands around 1033.53 cm-1 were due to symmetrical C-O and C-C stretching in the alcoholic part of molecule. The band at 608.27cm^{-1} represents R-CH stretching vibration, In FTIR spectra of the GL –OH peak is most abundantly apparent due to the wide presence of the-OH group of tannin, flavonoids and euganol.

CONCLUSION

BL, CFL and GL are high potential to remove organic pollutants from water bodies due to its high carbon content and lower ash and moisture content. High iodine value indicated the feasibility of binding sites in terms of high microspore content on the surface of the adsorbent. FTIR analysis produces the result of present functional group in adsorbent BL, CFL, GL, respectively. Due to presence of amino acid, aldehyde and ketone, alcohol group etc in GL it gives better result than CFL and BL. However this was also prove with data of iodine value that GL is working very efficiently than other bio adsorbent.

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Impact of Integrated Nutrient Management on Growth, Yield and Nutrient Uptake by Wheat (*Triticum aestivum*)

Diksha Dhiman and Rajpaul Sharma
Department of Soil Sciences
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176 061, India
E-mail: dikshadhiman394@gmail.com

Abstract: The present investigation was carried out in the on-going long-term fertilizer experiment initiated during 1972. The long-term use of optimal dose of chemical fertilizers and FYM increased the plant height (88 cm),yield attributes [effective tillers m^{-1} row length (98), number of grains ear^{-1}(32) and test weight (49 g) and yield (grain (30.34 q ha^{-1}), straw (53.22q ha^{-1}), biological (83.56 q ha^{-1}) and nutrient uptake (N, P, K, Fe, Mn, Cu and Zn). The enrichment of soil with 100 per cent RDF significantly increased the plant height (66 cm), yield attributes [effective tillers m^{-1} row length (71), number of grains ear^{-1} (25) and test weight (41 g) and (grain (20.22 q ha^{-1}), straw (36.4 q ha^{-1}), biological (56.67 q ha^{-1}) yield and nutrient uptake (N, P, K, Fe, Mn, Cu and Zn) over 100 per cent NP and 100 per cent N.

***Keywords*:** Wheat, Yield attributes, INM, Nutrient uptake

Wheat (*Triticum aestivum* L.) is the second most important food grain crop being consumed next to rice. It is grown all over the world for its wider adaptability and high nutritive value. The wheat cultivation in India is 29.58 million hectares with production of 99.70 million tonnes (Anonymous 2018). In Himachal Pradesh, wheat is grown on area of 364.20 thousand hectares with a production of 608.6 thousand tonnes. The productivity of wheat in Himachal Pradesh is, however, very low (1.67 t ha^{-1}) as compared to average national productivity (3.37 t ha^{-1}). Wheat requires a good supply of nutrients for its growth and yield but chemical fertilizers alone are unable to maintain the long-term soil health and crop, because they are unable to supply many other minor and trace elements. Improper and imbalanced use of chemical fertilizers coupled with less addition of organic manures has resulted in deterioration of soil health with multi-nutrient deficiencies. The addition of organic manures not only supplies the nutrients for crop growth but also improves the physical condition of the soil by improving different soil physical properties. The advantage of combining organic and inorganic sources of nutrients has proved superior to the use of each component separately (Palaniappan and Annadurai 2007). In short-term experiments, effect of nutrient management practices on soil properties is not substantial. But long-term fertilizer experiments provide an ideal base to assess the changes in soil properties as influenced by nutrient management practices in the crop production. In number of experiments in India, major attention has been given in general to yield performance of crops under different nutrient management practices and effect on soil health did not receive due attention. Keeping this in view, the present investigation was undertaken.

MATERIAL AND METHODS

Detail of experimental site: The present investigation was carried out in an ongoing long-term fertilizer experiment started during 1972-73 (*rabi*) at Department of Soil Science, College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur (HP), India. The experimental area falls under mid hill sub receives an average rainfall of 2600 mm per annum. The soil belongs to the order Alfisol. The physico-chemical characteristics of the surface soil (0 - 0.15 m) at the initiation of the experiment were: pH (1:2.5, soil: water) 5.8; organic carbon (Walkley and Black 1934) 7.9 g kg^{-1}; available N 736 kg ha^{-1} (Subbiah and Asija 1956); 0.5 M $NaHCO_3$- extractable Phosphate 12.1 kg ha^{-1} (Olsen et al1954); neutral 1 N NH_4OAcextractable Potash 194 kg ha^{-1} (Jackson 1973) and DTPA extractable Fe, Mn, Zn, Cu were 26.0, 24.3, 1.9, 0.4 mg kg^{-1}, respectively (Lindsay and Norvell 1978).

Experimental details: Eleven treatments consisting of combination of chemical fertilizers and amendments (FYM and lime) at different levels were tested in randomized block design replicate thrice with a plot size 5.0 m x 3.0 m (Table 1). Due to marked buildup of available P, the original treatment structure was slightly modified from *kharif* 2011, optimal and super optimal doses of P were reduced by 50 % and in case of sub optimal dose (50 % NPK), addition of FYM @ 5 t ha^{-1} on dry weight basis to maize crop only was also included. The recommended dose of fertilizers for wheat was 120:26:25 (N: P_2O_5: K_2O) for wheat. Half the dose of N and full dose of P and

K were applied at the time of sowing of wheat crop. The remaining half of the N was top dressed in 2 splits i.e. at maximum tillering and flowering stages of wheat. The nutrients i.e. N, P and K were supplied through urea, single super phosphate and muriate of potash, respectively. To study the effect of sulphur free P fertilizer on crop performance i.e. in 100% NPK (-S) treatment, P was applied through di-ammonium phosphate. Zinc was applied in T_5 as zinc sulphate at the rate of 25 kg ha^{-1} every year till 2011. Farmyard manure application was made at the rate of 5 tonnes ha^{-1} on dry weight basis. The FYM used in the experiment contained 60% moisture and the contents of N, P and K were 1.01, 0.26 and 0.40%, respectively. In T_{10}, application of lime was done at the rate of 900 kg ha^{-1} as marketable lime ($CaCO_3$). The regular application of lime was continued up to 1979 when the soil pH was reached to about 6.5. The application of lime in the subsequent years was made only when the soil pH declined to about 6.3. In the present investigation, wheat (*rabi*) crop was sown on November 19, 2015 and harvested on May 4, 2016. The wheat crop was irrigated at the crown root initiation, tillering, late jointing, flowering and dough stages. Chemical weed control was followed except in T_4 (100% NPK + Hand Weeding) where weeds were removed manually and incorporated in the same plot. After the harvest of wheat (2015-16), data on grain and straw yields were recorded.

Growth parameters and yields of wheat: Plant height of 5 randomly selected plants was measured cm from the base of the plant to the tip of the ear of main tiller. Total number of effective tillers per meter row length was counted. Ears of the main tiller were threshed separately and its grains were counted. One thousand fully developed and sun dried grains were counted and weight was taken in grams. After the harvest of wheat (*rabi,* 2015-16), data on grain and straw yield was recorded on dry weight basis.

Analytical analysis: After the harvest of wheat (*rabi,* 2015-16), grain and straw samples were collected for the determination of N, P, K and micronutrients contents. The grain and straw samples of wheat were dried in an oven at 60°C. The dried samples were then ground in a Wiley mill fitted with stainless steel parts to pass through 1 mm sieve. The samples were then kept in paper bags for subsequent analyses. The processed soil samples were analyzed for nitrogen, phosphorus, potassium and micronutrients (Fe, Mn, Zn and Cu) following standard analytical methods.

RESULTS AND DISCUSSION

Growth parameters and yield of wheat: The plant height, No. of tillers/m row length, No. of grains per spike and thousand grain weight in wheat varied from 51 cm, 41, 7 and 34 g in control to 88 cm, 98, 32 and 49 in 100 per cent NPK + FYM treatment were significantly higher in 100 per cent NPK + HW than 150 per cent NPK, 100 per cent NP100 per cent NPK (-S) and control. Significantly higher plant height, No of tillers/m row length, No of grains per spike and thousand grain weight of wheat was higher. In 100 per cent NPK + FYM treatment over rest of the treatments except 100 per cent NPK + lime. The combined use of organic and inorganic sources of plant nutrients in varying proportions resulted in better growth of the plants. The continuous application of N alone through urea has resulted in zero yield of wheat. It is attributed to sharp decline in pH and multi nutrient deficiency. Omission of S {100 per cent NPK (-S)} resulted in significant reduction in number of all the yield attributes as compared to

Table 1. Effect of long-term use of fertilizers and amendments on plant height, number of tillers m^{-1} row length, number of grains per spike, thousand grain weight and yield of wheat

Treatment	Plant height (cm)	No. of tillers m^{-1} row length	No. of grains per spike	Thousand grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1: 50% NPK	66	71	19	37	19.22	34.56
T_2: 100% NPK	66	71	25	41	20.22	36.44
T_3: 150% NPK	52	52	17	38	17.11	31.33
T_4: 100% NPK+ HW	69	76	29	44	23.11	40.89
T_5: 100% NPK+ Zn	61	62	21	42	19.67	35.67
T_6: 100% NP	54	53	15	40	9.89	18.11
T_7: 100% N	0	0	0	0	0.00	0.00
T_8: 100% NPK+ FYM	88	98	32	49	30.34	53.22
T_9: 100% NPK (-S)	51	50	15	42	9.00	16.55
T_{10}: 100% NPK+ lime	85	90	29	47	27.89	49.44
T_{11}: Control	51	41	7	34	3.56	7.14
CD (p= 0.05)	7	11	4	3	3.04	5.62

balanced fertilization (100 per cent NPK). Puniya (2010) documented that combined application of NPK and FYM significantly increased the plant height over imbalanced and unfertilized plots. Mohanty et al (2013) and Nayak et al (2007) also found that application of chemical fertilizers along with organics produced significantly higher number of tillers as compared to 100 per cent recommended dose of fertilizer. Low rates of nutrients application did not meet the nutrient needs of crops, hence, growth parameters were affected adversely (Sahu et al 2015). Balanced nutrition helped in maintaining significantly better vegetative growth leading to greater interception of solar radiation by the crops which ultimately contributed towards the significant increase in number of filled grains. Well-nourished plants increased the number of grains per spike which is ultimately the principal yield determinant. These results corroborate the findings of Sharma (2004) and Islam et al (2013). Grain test weight was significantly improved with the application of fertilizers and manure/lime. The weight of individual grain is governed by the grain growth supported by concurrent CO_2 assimilation during the grain filling phase as well as by the stored reservoir of carbohydrates during the vegetative phase. These results corroborate the findings of Nasim et al (2012) and Chopra et al (2016).

The grain and straw yield of wheat in rest of the treatments varied from 3.56 q ha^{1} (T_{11}) to 30.34 q ha^{-1} (T_8) and 7.14 q ha^{-1} (T_{11}) to 53.22 q ha^{-1} (T_8), respectively. The continuous application of FYM along with 100 per cent NPK increased the grain and straw yield of wheat significantly over 100 per cent NPK, the increase being 50.04 and 46.04 per cent, respectively. The grain and straw yield recorded under 100 per cent NPK + lime was at par with 100 per cent NPK + FYM. The treatments comprising 100 per cent NPK + FYM and 100 per cent NPK + lime recorded significantly higher yield of wheat than rest of the treatments. The continued absence of K and S in crop nutrition led to drastic decline in the grain yield of wheat. Super optimal dose of NPK (150% NPK) could not increase the grain and straw yield of wheat over 100 per cent NPK. The yield obtained under 100 per cent NPK + Zn was statistically at par with 100 per cent NPK alone. The continuous application of N alone through urea has resulted in zero yield of wheat. It is attributed to sharp decline in pH (Table 4) that accelerated process of land degradation by increasing the concentration of Al and Fe ions. These plots have become completely unsuitable for crop growth. A number of workers elsewhere in the country (Swarup 2000) reported complete degradation of soils in plots treated with nitrogen alone over a period of time and thereby resulting in zero yields. The phosphorus is the most important nutrient influencing crop yield. Response of P has been assessed from 100 % NP and 100 % N treatments. Due to addition of P with N, the wheat grain yield was maintained at 9.89 q ha^{-1}, this increase in yield due to P addition over N only treatment has also been reported earlier (Chopra et al 2016). Application of P besides increasing P availability in soil, decreases soil acidity and Al toxicity and increases exchangeable cations, thus influencing crop yield positively (Kumari et al 2013). Decrease in wheat yield was recorded in the treatment where P was applied through di-ammonium phosphate (DAP) as compared to the treatment where P was applied through single super phosphate (SSP). Application of high analysis P fertilizers (DAP) in place of single super phosphate (SSP) has resulted in considerable decline in crop yield. Diammonium phosphate contains phosphorus as a

Table 2. Effect of long-term use of fertilizers and amendments on macronutrients (NPK) uptake by wheat (kg ha^{-1})

Treatment	Nitrogen			Phosphorus			Potassium		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1: 50% NPK	30.04	15.42	45.46	5.94	2.54	8.48	6.27	21.08	27.36
T_2: 100% NPK	32.05	16.94	48.98	7.58	2.93	10.51	7.49	23.56	31.04
T_3: 150% NPK	27.40	15.99	43.39	6.91	3.54	10.46	6.67	21.39	28.06
T_4: 100% NPK+ HW	36.25	19.21	55.47	8.31	3.50	11.81	8.35	26.03	34.38
T_5: 100% NPK+ Zn	31.39	17.12	48.51	6.47	2.38	8.85	7.18	22.06	29.24
T_6: 100% NP	15.07	7.98	23.04	3.25	0.77	4.01	2.71	8.06	10.77
T_7: 100% N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_8: 100% NPK+ FYM	51.59	31.45	83.05	12.61	5.34	17.94	12.37	41.74	54.10
T_9: 100% NPK (-S)	13.85	7.08	20.93	3.46	1.02	4.47	2.99	10.05	13.04
T_{10}: 100% NPK+ lime	46.32	25.40	71.72	11.17	4.12	15.29	10.37	36.08	46.46
T_{11}: Control	5.23	2.71	7.94	1.00	0.24	1.24	0.96	3.12	4.08
CD (p= 0.05)	5.14	3.14	8.40	1.28	0.74	1.69	1.69	3.79	4.81

supplementary nutrient but no sulphur and calcium content. It's continuous use has, therefore, led to sulphur deficiency in the soil and thereby resulting in drastic reduction in crop yield (Brar et al 2015).

Nitrogen uptake: Application of recommended dose of fertilizers either alone or in combination with amendments increased the N uptake by wheat significantly over the control. Nitrogen uptake by wheat grains in FYM and lime amended plots was 51.59 and 46.32 kg ha^{-1}, respectively. Both lime and FYM amended plots recorded significantly higher N uptake over rest of the treatments. Application of 100per cent NP alone (without K) and 100 per cent NPK (-S) resulted in significant reduction of N uptake as compared to optimum application of NPK. Furthermore, N uptake by wheat grains in100 per cent NPK was at par with the N uptake in 100 per cent NPK + HW and 100 per cent NPK + Zn treated plots. Nitrogen uptake by wheat straw ranged from 2.71 kg ha^{-1} in control to 31.45 kg ha^{-1} in FYM. Lime and FYM amended plots recorded higher N uptake values over rest of the treatments. Omission of either K (T_6) or S (T_9) resulted in lower N uptake values as compared to balanced application. The use of FYM or lime with 100 per cent NPK improved crop growth and increased wheat productivity that resulted in higher uptake of N. The increase in N uptake in balanced fertilization plots compared to the control plots might be due to supply of N through external inputs and better root proliferation. Similar results have been documented by Brar (2001) from the soils of Ludhiana (Punjab)

Phosphorus uptake: Application of 100% NPK + FYM was significantly superior over all the treatments. Treatment receiving only 100 per cent N as urea for last forty four years resulted in zero uptake of phosphorus as no grain as well as straw yield was recorded from these plots. Significantly higher P uptake was recorded in 100 per cent NPK + FYM treatment over rest of the treatments. Similarly, 100 per cent NPK + lime also recorded significantly higher P uptake by wheat grains than rest of the treatments except 100 per cent NPK + FYM. P uptake in wheat grain, long-term application of 100 percent NPK + FYM recorded significantly higher P uptake by straw over rest of the treatments. Compared to control, application of 100 per cent NPK, 100 per cent NPK + FYM and 100 per cent NPK + lime resulted in 2.69, 5.10 and 3.88 kg ha^{-1} higher P uptake, respectively. Due to the continuous use of lime, there was increase in pH of the soil which might have resulted in precipitation of Al^{3+} thereby leading to reduced P fixation and increased P availability. These results are in consonance with the findings of Singh et al (2009) and Sathish et al (2011).

Potassium uptake: Application of 100 per cent NPK + FYM recorded significantly higher potassium uptake by wheat grain over rest of the treatments. Similarly, lime amended plots recorded significantly higher K uptake by wheat grain over rest of the treatments except 100 per cent + FYM. The K uptake was significantly lower in lime amended than FYM amended plots. Potassium uptake by wheat grain in 100 per cent NPK was at par with the K uptake in 100 per cent NPK + HW and 100 per cent NPK + Zn treated plots. Omission of potassium led to significant reduction in potassium uptake by wheat grains, the reduction being 4.78 kg ha^{-1}.Compared to 100 per cent NPK (T_2) , there was a significant reduction in the uptake of K by wheat grains with the application of 100 per cent NPK (-S) and the decrease was 4.50 kg ha^{-1}. Zero fertilization resulted in significantly lower K uptake as compared to rest of the treatments. Potassium uptake in

Table 3. Effect of long-term use of fertilizers and amendments on micronutrients uptake by wheat (g ha^{-1})

Treatment	Iron			Copper			Zinc			Manganese		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1: 50% NPK	108	491	599	66.8	163.0	229.8	45.6	158.0	203.6	91.6	257.8	349.4
T_2: 100% NPK	121	533	654	71.4	174.3	245.7	49.5	170.7	220.2	103.1	275.8	378.9
T_3: 150% NPK	108	485	593	63.1	152.5	215.6	43.1	148.3	191.4	83.8	241.9	325.7
T_4: 100% NPK+ HW	119	571	690	88.7	190.7	279.4	57.4	192.0	249.5	112.3	324.0	436.3
T_5: 100% NPK+ Zn	107	525	633	70.9	156.9	227.8	80.4	264.8	345.2	94.5	257.9	352.4
T_6: 100% NP	47	237	284	31.0	76.3	107.3	20.2	65.6	85.8	44.0	126.5	170.5
T_7: 100% N	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_8: 100% NPK+ FYM	196	902	1099	121.2	288.4	409.6	103.8	316.5	420.3	168.6	465.1	633.7
T_9: 100% NPK (-S)	46	217	263	30.2	72.3	102.5	21.3	61.5	82.9	39.8	116.3	156.1
T_{10}: 100% NPK+ lime	154	816	970	107	244.5	352.2	66.8	253.6	320.4	144.0	409.3	553.3
T_{11}: Control	14	66	81	10.1	25.4	35.4	6.8	20.5	27.4	11.3	34.2	45.5
CD (p= 0.05)	22	104	122	12.8	36.3	47.3	11.9	27.4	36.7	15.8	47.9	62.0

wheat straw varied from 3.12 kg ha^{-1} in control to 41.74 kg ha^{-1} in FYM with 100 per cent NPK (Table 4). All the treatments except 100 per cent NP recorded significantly higher K removal over untreated plots, which is due to the addition of K through fertilizer over the years. Application of FYM resulted in highest K uptake which might be due to the favourable conditions for crop growth and secondly, supply of K (0.4 %) through FYM in addition to chemical fertilizers. The positive influence of lime on the K uptake was due to the improvement in soil pH, enhanced nutrient availability and ultimately crop yield. Similar positive influence of in-organics alone or in combination with organics on K uptake by wheat has also been observed by earlier workers under varied agro-climatic conditions (Pathak et al 2005, Mann et al 2006, Prasad et al 2010).

Micronutrient uptake: The recommended dose of chemical fertilizer along with FYM (T_8) significantly increased the Zn, Fe, Cu and Mn uptake in wheat over sole use of chemical fertilizers. Significant improvement in Zn Fe and Cu and Mn uptake were also noticed with 100 per cent NPK + lime application. There was a reduction in micronutrient uptake under 100 per cent NP, 100 per cent NPK (-S), control treatment in comparison to 100 per cent NPK (T_2). The treatments 100 per cent NPK + HW and 100 per cent NPK were at par. Application of FYM and lime along with 100 per cent NPK significantly increased the micronutrient uptake by wheat straw as compared to other treatments. Treatments where either K (T_6) or S (T_9) was omitted exhibited a significant decline in micronutrient uptake in comparison to 100 per cent NPK. Compared to control, continuous application of 100 per cent NPK, 100 per cent NPK + FYM and 100 per cent NPK + lime (T_{10}) resulted in higher micronutrient uptake, respectively.100 per cent NPK and 100 per cent NPK + HW were statistically at par in total micronutrient uptake, while control, 100 per cent NP and 100 per cent NPK (-S) recorded significantly lower micronutrient uptake values as compared to optimal use of NPK. The total micronutrient uptake in 100 per cent NPK along with lime and FYM was significantly higher than other treatments. The significant increase in Fe uptake with the application of recommended dose of NPK may be attributed to proliferous root system developed under balanced nutrient application resulting in better absorption of water and nutrients. The Fe is present in P fertilizers as impurities. The increased uptake in FYM may also be ascribed to release of micronutrients from FYM after its decomposition. Low micronutrients uptake in control plots is due to lower yield because of poor inherent fertility status of these plots. The increase in the uptake of micronutrients in organic manure amended plots could be attributed to the fact that organic manures after decomposition release micronutrients, which after becoming available for plant use increase their uptake. Similar results were reported by Prasad et al (2010). Application of FYM along with recommended dose of fertilizers recorded highest Mn uptake which might be due to the favourable soil environment for crop growth in these plots and supply of Mn through FYM. Further, higher uptake in lime treated plots has been mainly due to increased biomass production as a result of better nutrient availability. Substantial decline in soil fertility in control plots because of continuous removal in the absence of nutrients addition from any external source has resulted in low productivity.

CONCLUSION

The wheat showed greater response to recommended dose of fertilizer applied along with FYM and exhibited higher total yield (kg ha^{-1}) and yield attributes than sole use of chemical fertilizers. The nutrient uptake by wheat followed almost similar trend as that of yield. The application of 100 per cent NPK along with amendments like FYM and lime resulted in significantly higher uptake than rest of the treatments. Since zero yield was recorded in 100 per cent N treatment, hence nutrient uptake was zero in this plot.

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Effect of Nitrogen Nutrition and Environmentally Friendly Combined Chemicals on Productivity of Winter Rapeseed under Global Climate Change

Ye. Domaratskiy, O. Kozlova, O. Domaratskiy, Iu. Lavrynenko and V. Bazaliy

Kherson State Agrarian and Economic University, Ukraine
E-mail: jdomar1981@gmail.com

Abstract: The research article presents the results of five-year field studies conducted in the conditions of the steppe zone on ordinary black low-humus soils (47.629, 32.079) to determine the productivity of winter rapeseed under the influence of early spring nitrogen nutrition in combination with environmentally friendly combined chemicals. Field experience was based on a three-factor scheme, where: factor A is early spring nutrition with nitrogen in a dose of N_{60}, N_{90} and without nutrition; factor B is foliar treatment of plants with Wuxal® and Helafit Combi® twice during the growing season of winter rapeseed and a control option-spraying of plants with pure water. Foliar treatments of winter rapeseed plants with chemicals were performed twice with a field sprayer: the first at the end of the second decade after the start of the resumption of spring vegetation; the second in the phase of the beginning of budding-flowering. The consumption rates of the chemical Wuxal Mikroplant® was 4.5 kg ha^{-1}, and Helafit Combi® was 1 l ha^{-1}; the outflow of working fluid is 250 l ha^{-1}. Factor C was the morphobiotypes of winter rapeseed: the *Chornii Veleten* variety, the originator of which is the Vinnitsya State Agricultural Research Station of the National Academy of Agricultural Sciences of Ukraine and the Kronos hybrid, the originator of which is seed company NPZ Lembke, Germany. Studies have established that the yield of various morpho-biotypes of winter rapeseed reaches its maximum when applying early spring nitrogen nutrition with a dose of N_{90} in combination with double application of foliar nutrition of plants with the combined growth-regulating chemical Helafit Combi®, the yield increase of the variety was 0.79 t ha^{-1}, and of the hybrid - 1.11 t ha^{-1}.

Keywords: Winter rapeseed, Yield, Early spring nitrogen nutrition, Foliar treatment, Growth-regulating chemicals

Modern climate changes affect all aspects of human life and agriculture in particular. Agrarians in the European Union are concerned about changes in crop conditions that have occurred over the past decades (Pichura et al 2019). Today's weather and climate transformations, increased soil erosion processes and a decrease in productivity growth rates pose a threat to the cultivation of field crops and global food security in the near future (Dudiak et al 2019, 2020). According to the forecasts of specialists of FAO of the OUN, with the constant course of events, almost 650 million people will suffer from hunger in the near future until 2030 (Russell 2017, Becker et al 2017). Global climatic changes both around the world and in the regions of Ukraine determine the search for and introduction of adaptive varieties and hybrids of field crops into agricultural production while improving their growing technologies in the context of the mandatory use of growth-regulating chemicals in the growing technologies. According to experts (Lisetskii et al 2016, 2017, Kipling et al 2019), we have a frequent further increase in air temperature, which will be accompanied by changes in dry periods with periods of normal and excessive moisture. Recent advances in genomics and agronomy can help alleviate some of the impacts of climate change on food production; however, given the timeframe for crop improvement, significant investment is required to realise these changes (Anderson et al 2020). The greenhouse effect leads to an increase in the temperature background, which, according to various information sources, in the last century was 0.5-0.7°C (Agovino et al 2019). An increase in carbon dioxide can change the photosynthesis of plants, and in combination with other factors, the nature of the production process. Changing environmental factors affect the signs of productivity of agrophytocenoses in time and space, therefore, the primary task is to solve the problem of preparing the agrarian complex in advance for these climate changes (Gosnell et al 2019). Such materials in harsh weather and climatic conditions can serve as a specific tool that optimizes the nutrition of agricultural plants, improves the absorption of macro-nutrients from the soil, mitigates the effects of drought stresses, manifestations of high temperatures, moisture deficiency, etc. (Bazaliy et al 2012, 2018).

In the dry steppes of Ukraine, one of the most influential stress factors is moisture deficiency. A number of scientists (Domaratskiy et al 2018, 2019) believe that it is impossible to achieve optimum moisture in the steppe zone; that this is a temporary situation, the duration of which fluctuates over a short time period. The rest of the growing season is stressful conditions that affect agrophytocoenoses with different intensities.In the technological chain of winter rapeseed growing, nitrogen nutritions and the application of growth-regulating chemicals are elements of spring plant treatments, and therefore, their influence is traced after the spring and summer vegetation. To form the optimal architectonics of plants in autumn before the cessation of autumn vegetation, which suppose the creation of a rosette with 8-10 leaves, rhizome up to 10 cm in diameter and a root neck diameter of 8-10 mm, winter rape consumes: up to 30% of nitrogen, 10% of phosphorus, 20% of potassium (in the first 4-6 weeks after sprouting), 25% of sulphur, 15% of magnesium, 25% of boron from the total need, while accumulating sufficient sugars and other plastic substances for wintering (Weymann et al 2015).

The root system assimilates the above elements differently during the growing season. Consequently, winter rapeseed plants in the initial stages of organogenesis absorb 20% of nitrogen, 10% of phosphorus, 20% of potassium and 10% of sulphur, in spring and summer - 67; 70; 80 and 65% and N - 13, P - 20, S – 25, respectively (Abramyk et al 2016). Compared to winter wheat, rapeseed removes more nitrogen - by 62%; phosphorus - by 66% and potassium - by 100%. During the formation of one ton of the yield, the seeds of winter rapeseed are absorbed from the soil up to 80 kg of nitrogen, 18-40 kg of phosphorus, from 25 to 100 kg of potassium, 30-150 kg of calcium and 35-40 kg of sulphur. Approximately, up to 25% of macro - and micro-nutrients (depending on the level of productivity) rapeseed can assimilate from soil reserves, the remaining necessary elements are provided by additional application of mineral fertilizers (Shcherbakov et al 2009, 2018). In case of violation of the optimal sowing terms, the level of risks significantly increases, leading to a decrease in the yield of winter rapeseed or a loss of the yield in general (Domaratskiy et al 2019). The authors note that winter rapeseed has a rather long period of a possible sowing with a change in risk from 10 to 80%.

With a high level of soil and air moisture deficiency during the sowing season and the initial stages of plant growth and development, there is a need to optimize nutrition processes and reduce the stress state of sowing to the minimum level. One of the promising ways for solving this problem is the use of inexpensive, but very effective elements of the technology for growing field crops, including obligingly foliar treatments of winter rapeseed plants with combined growth-regulating chemicals that are biological based and environmentally friendly. The use of such chemicals will allow to a certain extent to minimize the effect of stressful conditions on plants and, thereby, improve the absorption of macro- and micro-elements from the soil, optimizing the living conditions of the agrocoenosis as a whole. The purpose of the research is to evaluate the intensity of exposure to stress factors, which are quite often manifested in modern conditions of climatic change, as well as mitigate their negative impact due to nitrogen nutritions and growth-regulating substances and determine the effect of such substances of a multifunctional effect on winter rapeseed productivity.

MATERIAL AND METHODS

Field studies were conducted during 2012-2016. In the conditions of the steppe zone (coordinates: 47.629530, 32.079521) on ordinary black low-humus soils. Field experience was based on a three-factor scheme, where: factor A is early spring nutrition with nitrogen fertilizers in a dose of N_{60}, N_{90} and without nutrition; factor B is foliar treatment of plants with Wuxal® and Helafit Combi® twice during the growing season of winter rapeseed and a control option – spraying plants with pure water. Foliar treatments of winter rapeseed plants with chemicals were performed with an ОП-2000 field sprayer: the first - at the end of the second decade after the start of the resumption of spring vegetation; the second - in the phase of the beginning of budding-flowering. The consumption rates of the chemical Wuxal® was 4.5 kg ha^{-1}, and Helafit Combi® was 1 l ha^{-1}; the outflow of working fluid was 250 l ha^{-1}. Factor C was the morphobiotypes of winter rapeseed: the Chornii Veleten variety, the originator of which is the Vinnitsya State Agricultural Research Station of the National Academy of Agricultural Sciences of Ukraine and the Kronos hybrid, the originator of which is seed company NPZ Lembke, Germany. The experimental plots were arranged in three repetitions sequentially. The total sown area of the experimental plot was 2520 m^2, and the accounting area was 600 m^2. Sowing was carried out during the period of September 1-10 (depending on the conditions of soil moistening during the years of research) in drills (sowing distance was 15 cm) with a seeding rate of 1.0 million germinating seeds per ha. The predecessor was black fallow. Leaf area was calculated by the method of felling. The winter rapeseed yield was accounted for by a Class Dominator 96 combine equipped with a rapeseed harvesting device - a “rapeseed header table”.

RESULTS AND DISCUSSION

The main reagent for any factors of plant life is the leaf apparatus, which has a wide range of variation. The size of the leaf area should be at the optimum level, both underdeveloped and hypertrophic leaf surface is a negative phenomenon. In the case of underdevelopment of the leaf apparatus, a low index of the leaf surface adequately has a low level of photosynthetic productivity, and with hypertrophic development, an imbalance between the vegetative mass of plants and generative organs is observed. Plant growth, the formation of vegetative mass and generative organs is carried out due to the photosynthetic activity of the leaf apparatus. Photosynthetic activity is the main component of the formation of vegetative and generative organs in plants, which ultimately provides a certain level of productivity of crops. Photosynthesis is the process of formation of organic matter with the participation of solar energy and biochemical reactions in plant organisms. Chemical reactions occur only in the presence of a green pigment - chlorophyll. Chlorophyll-free photosynthesis is also known, but such a process is a feature of some lower organisms, this is not characteristic of higher green plants. The green pigment has a porphyrin structure, which in its structure is close to the blood heme of animals. The only difference is that heme has an iron (Fe), and chlorophyll has a magnesium (Mg) complex. About 75% of plant biomass is formed from carbon dioxide photo-fixation products from the atmosphere and only 25% from absorbed minerals. Plants are characterized by a close relationship in the metabolism between soil and air nutrition, and one process does not occur without the other. As a result of their interaction in the plant body, a series of successive reactions occur with the formation of carbohydrates, amino acids, proteins and fats. These substances directly form the crop yield (Domaratskiy et al 2019).

It is known that the intensity of photosynthesis is determined by the area of the assimilation surface of the leaves, which in turn depends on the growing conditions. That is why the size of the leaf surface and the duration of the intense activity of the leaves is the basis for determining the amount and intensity of accumulation of organic dry matter by plants. The level of plant productivity depends on three factors area of photosynthetically active leaf surface; length of the activity period of the leaf surface; productivity of photosynthesis. The first two factors are usually presented in form of a single indicator - photosynthetic potential (PP).

Long-term studies have shown that the area of leaves in a dynamic form is an indicator that can be described by a hyperbolic curve (Fig. 1).

The Figure 1 shows that the curve has one peak with a maximum in the plants flowering phase, if you take the entire spring-summer vegetation, then for winter rapeseed it is 110-115 days, including 40 days before flowering and 70 days after it. Thus, the process of leaf surface formation is more rapid than the shrinking that occurs after the end of the flowering phase. This means that rapeseed uses a rather large area of the leaf apparatus for a long time and thus realizes high production potential. Analysis of the level of influence of solar insolation on the processes of formation of plant productivity is one of the main scientific problems of crop production. Modern ideas of the process of photosynthesis come down to the fact that a quantum of photosynthetically active radiation, which is absorbed by a chlorophyll molecule, starts its activity. As a result, it gives up its electron, which migrating, spends energy on the formation of reduced forms of organic compounds. The most characteristic feature of photosynthetically active radiation should be considered precisely the ability to excite chlorophyll molecules, however, solar radiation fluxes are the only factor that cannot be artificially regulated. The main concern should only be about a more efficient use of sunlight and an increase in the efficiency that goes into photosynthesis. Light regulation of various plant functions is carried out through metabolic processes mainly through photosynthesis. This applies both to cases when, due to insufficient supply of plants with moisture, light is excessive, and when, with good supply of moisture and mineral nutrition, light is not excessive.

The main function of the leaf apparatus is the creation of organic matter, which is the goal of the whole technology of growing crops. Like the leaf surface, the aboveground biomass has an inhomogeneous growth rate and it clearly correlates with the size of the leaf surface of the plants. Each agrocoenosis is characterized by its own unique location of the photosynthetic surface in space and the corresponding use of photosynthetically active radiation by plants. Changing the structure of coenosis allows to significantly increase the level of its productivity due to varying competitive relationships. The level of photosynthesis productivity depends essentially on the leaf surface area of plants and can vary by creating the optimal optical-biological structure of agrophytocoenoses. This, in its turn, determines the basic requirement for the size of the assimilation surface,

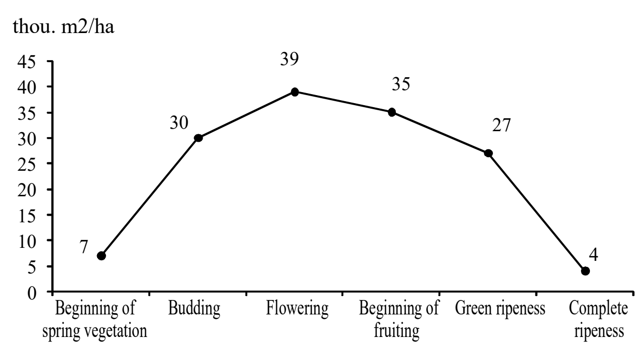

Fig. 1. Dynamics of changes in the leaf index of winter rapeseed in the control variant of the Chornii Veleten variety (Average for 2012-2016)

which should completely cover the soil surface during the growing season of plants. However, most crops at the beginning of the growing season and in its second half do not provide such coverage. Ensuring the accelerated development of the assimilating surface at the beginning of the growing season through the use of intensification factors, in particular mineral fertilizers and growth stimulants and their combined action, is one of the effective possibilities of more complete use of photosynthetically active radiation.

Winter rapeseed is a crop with a high potential for the harvest of aboveground biomass. The area of the leaf surface has the ability to vary, both due to the hydrothermal conditions of the year and to the use of elements of intensive growing technology (Table 1). The Kronos hybrid is characterized by a higher and more stable value of the net productivity of photosynthesis. With an increase in the photosynthetic potential, the productivity of the aboveground biomass also increased, but when comparing different biotypes, the postulate of a close relationship between the photosynthetic potential and the crop is not confirmed. Therefore, it can be concluded that a positive and high correlation between the photosynthetic potential and the yield of aboveground biomass occurs only within a specific biotype.

The level of growth of dry biomass is achieved by increasing the area of the photosynthetically active surface, as well as by prolonging activity duration of the leaf apparatus of plants when using intensification factors. The difference in the growth of dry biomass of the Kronos hybrid between the control variant when treating plants with pure water and the variant when early spring nutrition with nitrogen fertilizers in a dose of N_{90} in combination with double foliar treatment of plants with Helafit Combi® was 1.3 t ha^{-1}. According to the

Table 1. Photosynthetic potential and net productivity of winter rapeseed photosynthesis during the budding-flowering interphase, depending on nitrogen nutrition and growth-regulating chemicals (2012-2016)

Nitrogen nutrition (factor A)	Chemical (factor B)	Average area of leaves, thou. $m^2 ha^{-1}$	Length of the period, days	Photosynthetic potential, thou.$m^2 ha^{-1}$ x days	Dry biomass increase, t ha^{-1}	NPP, g m^{-2} per day
Chornii Veleten variety (factor C)						
No nutrition	Pure water (control)	34.5	24	828	3.0	3.62
	Wuxal®	35.0	25	900	3.3	3.67
	Helafit Combi® (once)	35.8	24	859	3.3	3.85
	Helafit Combi® (twice)	37.0	25	925	3.8	4.11
N_{60}	Pure water (control)	36.2	25	905	3.6	3.98
	Wuxal®	37.8	26	983	4.0	4.07
	Helafit Combi® (once)	36.8	26	957	3.8	3.97
	Helafit Combi® (twice)	39.6	27	1069	4.3	4.02
N_{90}	Pure water (control)	38.5	25	963	3.9	4.05
	Wuxal®	40.0	26	1040	4.2	4.04
	Helafit Combi® (once)	40.0	26	1040	4.1	3.94
	Helafit Combi® (twice)	41.7	27	1126	4.5	4.00
Kronos hybrid (factor C)						
No nutrition	Pure water (control)	34.2	20	684	3.1	4.53
	Wuxal®	36.1	20	722	3.6	4.63
	Helafit Combi® (once)	35.4	20	708	3.5	4.94
	Helafit Combi® (twice)	37.1	21	779	3.8	4.88
N_{60}	Pure water (control)	38.0	21	798	3.6	4.51
	Wuxal®	39.9	22	878	3.8	4.33
	Helafit Combi® (once)	39.4	22	867	3.8	4.38
	Helafit Combi® (twice)	41.8	22	920	4.0	4.35
N_{90}	Pure water (control)	40.1	22	882	3.9	4.42
	Wuxal®	42.0	23	966	4.2	4.35
	Helafit Combi® (once)	41.4	23	952	4.1	4.31
	Helafit Combi® (twice)	43.8	23	1007	4.4	4.37

analysis of the main indicators of photosynthetic activity of winter rapeseed, both morphobiotypes early spring nutritions and treatments of plants with complex chemicals had a positive effect and a significant advantage compared to control (when treatment plants with pure water), but in terms of net photosynthesis productivity (NPP) the general regularity is broken. Therefore, it is necessary to identify ways to increase NPP against the background of an intensive nutrition system. Fertilizers and chemicals, as evidenced by the research results, increased the intensity of the leaf formation process and, accordingly, contributed to the activation of the formation and average daily growth of the leaf surface (Fig. 2).

Against the background of an increase in the rate of average daily growths in leaf surface area, it is important that after the introduction of nitrogen nutrition in a dose of N_{60} and above, this indicator slows down. During the years of research, the processes of leaf formation and growth of biomass significantly differed from the average values given, however, the difference occurred only in absolute values of indicators, and not in the specificity of the influence of nitrogen nutrition and growth-regulating chemicals, that is, the patterns noted above were observed almost identically during all years of research. Whatever the indicators related to the environment, or to the stages of plant organogenesis are considered, whatever indicators are associated with the final result, yield is still the final element in which all the intermediate results are integrated. A means of regulating the content of nutrients in the soil, their assimilation by plants at different ratios, is the nutritive regime system, which has a radical effect on the level of plants providing mineral elements. But practice shows that not only mineral fertilizers solve all issues related to the optimization of the nutritive regime. During the growing season, plants are under stress for a long time, their nutrition in such environmental conditions becomes little effective. The task of the farmer is to create appropriate conditions for the rapid removal of plants from stress. Under these conditions, it is necessary to use multi-functional chemicals that have a complex of micro-elements, notables for fungicidal action, activate microorganisms and stimulate growth processes.

According to the research results, it is necessary to pay attention first to the indicators that were due to the nutrition and the use of growth-regulating chemicals:

- The area of the assimilating surface is growing, and there is no excessive development of the leaf apparatus;
- Due to the increase in the area of the leaf surface and the duration of the base period when nourished, the indicator of photosynthetic potential significantly increases.

These facts by themselves are capable of influencing the yield of winter rapeseed, but nevertheless the complex interaction determines a stable and significant effect. The decision to choose between hybrids and varieties of winter rapeseed depends on a number of factors, such as climate and other conditions of the region where the crop is grown. The more stress factors (drought, cold, soil conditions) occur during the cultivation of rapeseed and the higher their intensity of manifestation, the more advantages hybrids have over varieties. Especially in the conditions of extremely arid zones of steppes with hard hydrothermic coefficient with low rainfall, hybrids are more resistant to these factors. Significant advantages of hybrids in comparison with linear varieties are the development of plants in the early stages in autumn, winter hardness and better ability to regrow. Seeds should be updated annually due to signs of hybridity. Re-cultivation of hybrids is impractical due to the separation of crossing lines. The advantage of linear varieties is their greater variety and, on average, somewhat higher oil content of grain. However, the varieties are not tolerant to sowing dates and do not satisfactorily respond to a shift in sowing dates towards later ones (from mid to late September). The research results showed that in terms of productivity, the Kronos hybrid prevails over the Chornii Veleten variety by 0.49 t ha^{-1}, or 17% (Table 2).

The productivity of hybrids was 12-18% higher than varieties. But, if consider the specificity of the reaction of the variety and the hybrid to the nutrition, the Chornii Veleten variety provided an average yield increase with nitrogen in a dose of N_{60} of 0.26 t ha^{-1} and in a dose of N_{90} of 0.50 t ha^{-1}. As for the Kronos hybrid, the increase in yield from nitrogen nutrition was 0.44 t ha^{-1} in a dose of N_{60}, 0.72 t ha^{-1} in a dose of N_{90}, which indicates the feasibility of hybrids nutrition, which per kg of the active substance of nitrogen provide a higher increase (Fig. 3).

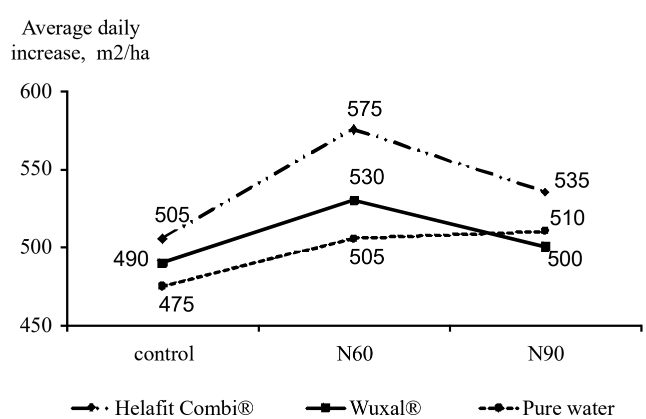

Fig. 2. Average daily increase in leaf area in the phase of budding-flowering (2012-2016)

Table 2. Productivity (t ha^{-1}) of winter rapeseed depending on nutrition and growth-regulating chemicals, (average for 2012-2016)

Nitrogen nutrition (factor A)	Chemical (factor B)	Morphobiotype (factor C)					
		Chornii Veleten			Kronos		
		Dry biomass	Seed	Per cent of seeds to biomass	Dry biomass	Seed	Per cent of seeds to biomass
No nutrition	Pure water (control)	10.2	2.10	20.6	10.0	2.40	22.7
	Wuxal®	10.9	2.29	21.0	10.7	2.61	24.4
	Helafit Combi® (once)	10.3	2.26	21.9	10.5	2.58	24.6
	Helafit Combi® (twice)	11.3	2.39	21.1	11.1	2.75	24.8
N_{60}	Pure water (control)	11.2	2.36	21.1	11.3	2.71	24.0
	Wuxal®	12.1	2.52	20.8	11.9	2.91	24.5
	Helafit Combi® (once)	11.9	2.48	20.8	11.7	2.90	24.8
	Helafit Combi® (twice)	12.5	2.61	20.9	12.2	3.04	24.9
N_{90}	Pure water (control)	12.5	2.60	20.8	12.5	2.99	23.9
	Wuxal®	13.4	2.79	20.8	13.1	3.21	24.5
	Helafit Combi® (once)	13.0	2.77	21.3	12.9	3.16	26.3
	Helafit Combi® (twice)	13.6	2.89	21.3	13.5	3.38	25.0

$LSD_{0.05,}$ (for dry biomass), t ha^{-1}: ABC – 0.08; $LSD_{05,}$ (for seed), t ha^{-1}: ABC – 0.06

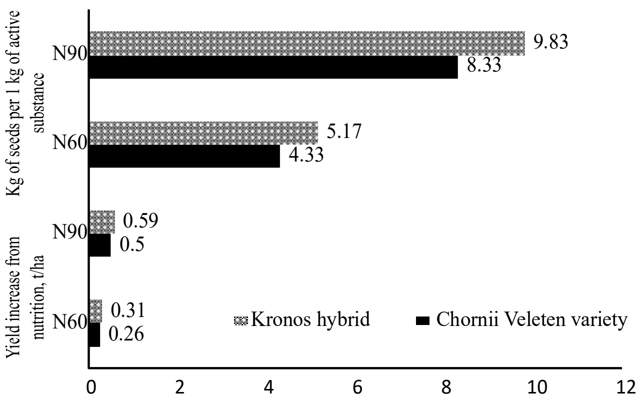

Fig. 3. The yield increase from nitrogen nutrition, depending on the biotype of winter rapeseed, (average for 2012-2016)

From the present study, can draw two conclusions: firstly, the nitrogen dose of 90 kg ha^{-1} of the active substance is more effective both in terms of increase and of return of the yield per unit of active substance; secondly, the Kronos hybrid uses nitrogen from nutrition better for crop formation. The advantage of the hybrid in return against the background of N_{60} is 15.7%, and against the background of N_{90} is 18%. No less clearly observed yield increase from the use of these two chemicals. The results of field studies indicate the same regularity as in the case with nutrition with nitrogen fertilizers, the hybrid is more effective in terms of response to chemicals, but if in the first case the advantage of the Kronos hybrid was due to the high level of intensity, then in the second, despite the higher level of vulnerability to stress compared with the variety, this negative is minimized due to the anti-stress effect of the chemicals and thus causes a deep realization of the potential of the hybrid.

CONCLUSIONS

From the above data, it is absolutely necessary to draw two conclusions: firstly, a nitrogen dose of 90 kg ha^{-1} of active substance is more effective both in terms of increase and of return of the yield per unit of active substance; secondly, the Kronos hybrid uses nitrogen from nutrition better for crop formation. The advantage of the hybrid in return against the background of N_{60} is 16.1%, and against the background of N_{90} is 18%. The maximum seed yield with a more favourable ratio of generative and vegetative components is achieved by nutrition winter rapeseed with nitrogen fertilizers in a dose of N_{90} in combination with double foliar treatment of plants with Helafit Combi® and, according to the research, equals to 2.89 t ha^{-1} of conditioned seeds for Chornii Veleten variety and 3.38 t ha^{-1} of conditioned seeds for Kronos hybrid.

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Measurement of Exhalation of Radon-222 from Soil of City of Rivne, Ukraine

Oleksandr Lebed, Oleksandr Klymenko, Igor Fizyk, Larisa Potravka[1] and Vitalii Pichura[1]

National University of Water and Environmental Engineering, Rivne, Ukraine, 33028, Soborna str. 11
[1]Kherson State Agrarian University, Ukraine, 73006, Kherson, Stritens'ka str. 23
E-mail: pichuravitalii@gmail.com

Abstract: These studies show that the radon content in the air of buildings of Rivne city is mainly influenced by the factors radiological characteristics of the underlying soils under the buildings and building materials (first of all, the radon emanation coefficient in soil, soils gas permeability, etc.). characteristics of the ventilation systems of buildings and modes of ventilation, design features of buildings (number of floors, type of foundation, available aerodynamic connection between floors, location of communication systems within outlines of building, etc.), the type of glazing (the degree of tightness, available ventilation valves, etc.), the type of heating (stove, electric, gas or central) and the level of floor in spaces: basements, semi-basements, first floors regarding land surface. Considering the given factors, can conclude that essential reduction in radon content in indoor air of buildings can be achieved by) choosing a site for building, where radon release from soil is low, applying building envelopes that effectively prevent entering of radon from the soil into building, removing of radon from indoor air. In order to comply with these requirements it is necessary to monitor radiation safety parameters according to volumetric activity in indoor air and radon flux density (RDF) from soil under buildings. The results thereof should be used for sanitary and epidemiological assessment of land sites for building and environmental safety in living spaces. We consider that the main parameter of the anti-radon pre-design stage of construction is the determination of RDF from soil in building site and mapping of RDF from soil in modern cities will allow to develop plans for ecological building and ensure reduction of the ecological radon risk for the citizens. Mapping is based on the analysis of the spatial distribution of values of radon flux density, which is released from surface of city soils. Such approach allows to use the map in urban planning, in pre-design surveys for building, in hygiene studies, for estimating of the doses that are received by citizens due to radon exposure and, finally, as a resource for informing the citizens.

***Keywords*:** Radon, Exhalation, Radon flux density, Lung cancer

Recently, in connection with the adoption of a number of documents by world organizations, wherein new and more severe provisions regarding radiation contamination of the inhabited territories in Europe and the world, which are prescribed in the Council Directive 2013/59 / EURATOM (Council of the European Union 2014) and WHO (Zeeb and Shannoun 2009), are generated. The study of radon fields of cities with a large cluster of people located in platform areas that are characterized by a calm geodynamic environment is the subject of interest. Currently, the national legislations of the countries of the world have a number of regulations that govern the radon concentration in residential and industrial spaces and the radon RFD from soil surface in the built-up area or the area that is planned to be built-up [DBN 1.4-2.01-97 (Ukrainian national construction regulation), 1997; SP 2.6.1.2612-10 2010 (Set of Rules, etc.]. The limiting RFD rate is the value 80 mBq/($m^2 \cdot c$). Despite the fact that studies of radon fields from geo-ecological points have been actively carried out by both Ukrainian and foreign experts in recent decades, the unified theoretical and methodological base of these studies has been developed insufficiently. This is partly connected with divergence of views among researchers regarding formation mechanisms of the radon field of soil massifs (Mykliaev 2015). According to the general opinion of researchers, its transfer in rocks, soils, and the further exhalation from the surface are complex processes subject to the influence of numerous natural factors. We note that ^{222}Rn (formed during the decay of ^{226}Ra) rises from the depth of rocks to soil surface, which is facilitated (or obstructed) by diffusion due to gradient of radon concentration; effusion due to pressure gradient in the rock mass; thermal, liquid and gas convection arising upon availability of geothermal gradient; gaseous cavitation and raising of geogas bubbles in pores filled with water; filtration and infiltration of water flows; turbulent effects in the soil air upon changes of external meteorological conditions; fluctuations of the hydro-geode formation field of the Earth; seismic activity, etc.

All these processes, except for molecular diffusion, are difficult to differentiate and quantify (Ivanova 1999). Amidst such uncertainty in the range of impact of the above factors on the mechanisms of formation of radon fields in soil, atmosphere, spaces, there is a discussion regarding parameters that characterize radon field and they are to be measured. Some scientists believe that basic information about causative bodies in geological structures is carried by volumetric activity (VA) in the soil (subsoil) and / or atmospheric air, others consider that only RFD through the surface can provide necessary and reliable information about radon sources in deep structures that allow radon to pass through and generate radon anomalies. The purpose of this study - mapping of density of Radon-222 flux from soil of Rivne city (Ukraine). Object of study: indicators of density of Radon-222 flux from soil of Rivne city. Subject of research: samples of air that comes due to exhalation of Radon-222 from the soil of Rivne city.

MATERIAL AND METHODS

Geology of Rivne city*:* Rivne is located within the Volyn-Podilia plate in the Rivne loess plateau, which divides Male and Volyn Polessia with deep faults (Klymenko et al 2014). Yustia river runs into this plate that divides the river in submeridional direction into two parts with the floodplain and above floodplain terraces. The geological structure in the city is introduced by Proterozoic, Paleozoic, Mesozoic and Cenozoic sediments (Herenchuk 1976, Zaleskyi 2005, Klymenko et al 2001). This Volyn-Podilia plate is the western slope of the Ukrainian crystalline shield (rich in uranium ore deposits), divided into a complex system of faults. Almost the entire territory of the Rivne region, including Rivne city, is covered with a significant layer of Upper Cretaceous rocks of the Cenomanian, Turonian, and Santonian layers. Deposits of the Turonianst age are the most wide-spread on the territory of the city. They are introduced by white writing chalk, greenish-gray marls and chalk-like lime stone with flint of depth from 20 to 45 m. The Neogene deposits in the southwest and east of the city are introduced by deposits of the Sarmatian stage with depth of 30 m. These are sands, limestone and clay.

Soil-forming rock of Rivne city*:* Right bank of Yustia river is characterized by loess soils - gray and podzolized chernozem, leached chernozems were developed on the left bank. The soils of the floodplain area of the city are not so deep and not so diverse. The silty-marsh soils are located in the southern part and the peat-boggy soils are in the northern part. This is due to the relative sameness of the conditions of their creation. Over the long history of the city they were repeatedly transformed, artificially filled up and dried out. Studies of individual spots of Rivne city show that the natural soils of the floodplain and above floodplain terraces are covered with a layer of artificial filled up soils with depth of up to 4.5 m.

Sampling points, methods and instruments of measurement: The territory of Rivne city was divided into 48 tested sites. At each site the RFD was measured at three points (7 times at each point with further averaging), total number of measurements is 144 in the spring-summer periods 2016-2017. The radon flux density from the soil was measured by the complex "Alfarad plus" to monitor radon, thoron and their daughter products. This complex can carry out rapid measurements and continuous monitoring of the RFD of Radon-222 from the soil surface (within (20-10^3) mBq/(m^2·c)), soil air (within (10^3-10^6) Bq/m^3), with a relative error $\leq$ 30% (Fig. 1).

The principle of determination of the VA of Radon-222 is based on electrostatic deposition of charged ions of ^{218}Po from the air sample taken onto the surface of the *α*-detector (semiconductor detector). The core of ^{222}Rn, which decays inside the chamber, leaves the product of its decay, ^{218}Po core, as a positively charged ion. The electric field inside the chamber drives this positively charged ion in the direction of the detector, to which it is being electrostatically attracted. The flux density of ^{222}Rn is determined by the number of *α*-particles detected during decaying of ^{218}Po atoms that deposited on the detector. After measuring is completed, the results are shown on the monitor. The results include date, measurement completion time, number of impulses, operating mode, value of radon RFD from soil, measurement error, pressure, temperature, humidity, and they are shown on the complex screen (Fig. 3).

RESULTS AND DISCUSSION

The Table 1 and the histogram (Fig. 2) show the results of determination of the density of radon flux from the soil of Rivne city (Ukraine). The measured RFD values are within quite wide limits: from 16 mBq/(m^2·s) (Fig. 3) to 173 mBq/(m^2s) (Fig. 4).

The obtained values of the RFD indicate a complex radon situation in the city, as proved by studies of radon VA in basements, semi-basement rooms and spaces of the first floors of residential buildings (Klymenko & Lebed, 2017, Lebed and others 2018). A significant range of RFD (from 16 to 173 mBq/(m^2s) is obviously determined by meteorological, climatic and biotic factors. The obtained statistics shows that radon fluxes from the city's soil are comparable to generally accepted radon-hazardous zones of the world, such as the Caucasus, Irkutsk Region, Tatarstan, Krasnoyarsk krai (Russia), Illinois (USA) (Table 1). The average continental value of radon exhalation in Europe is considered to be 21 mBq/(m^2c), which is 1 atom/(cm^2·s), however, they vary considerably in space and time. Average values of the flux of ^{222}Rn from soil to atmosphere for different regions of the world are shown in Table 2.

The distribution of the frequency of falling of the measured RFD value within the appropriate range has lognormal nature. The statistical characteristics were calculated according to the obtained values (Table 2).

Today, it can be argued that the radon flux density field of platform territories has a discrete spatial structure and it is divided into background and anomalous components (Mykliaev 2001). These parameters are constantly changing in time (Rogalis et al 2001). Radon anomalies are associated with geodynamic active zones and connected with anomalous deformations of near-surface soils. The average continental value of radon exhalation in Europe is considered to be 21 mBq/(m^2c), which is 1 atom/(cm^2·s), however, they vary considerably in space and time. Average values of the flux of ^{222}Rn from soil to atmosphere for different regions of the world are shown in Table 3.

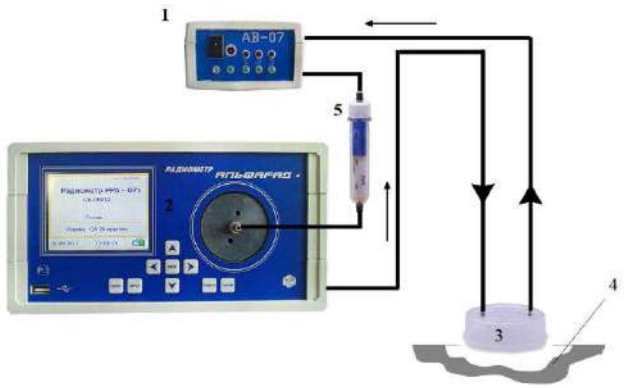

Fig. 1. Scheme of air sampling for density of radon flux from the soil (1. Self-contained blower; 2. RFD measurement unit; 3-Accumulation chamber; 4. Soil; 5. Dehydrator plug)

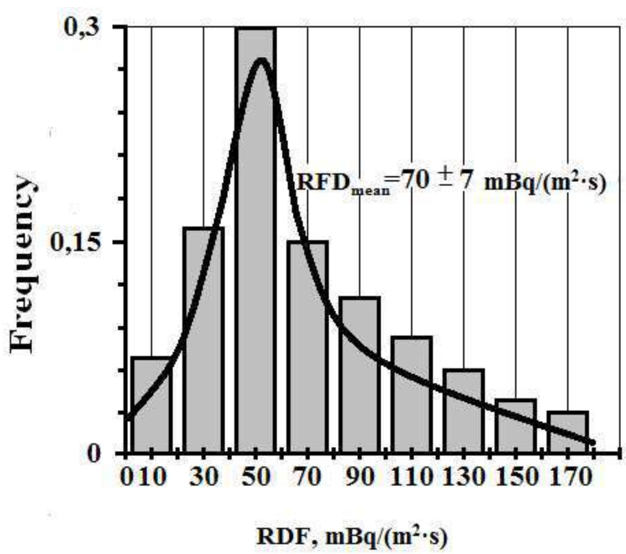

Fig. 2. Frequency of falling of density flux values (RFD into corresponding range

Fig. 3. Values of the meter when measuring RFD in soil on Vynnychenko Str.

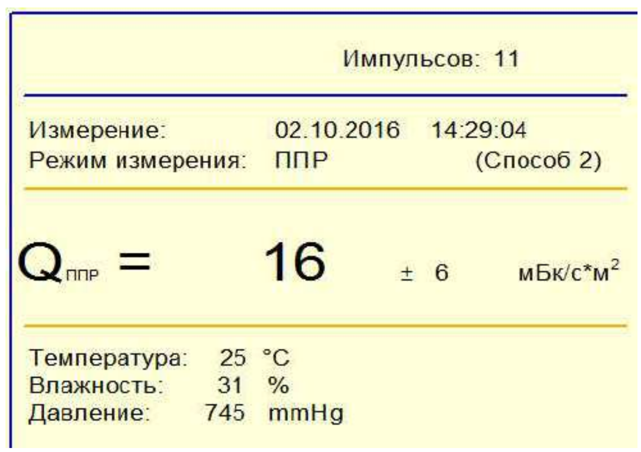

Fig. 4. Values of the meter when measuring RFD in soil near "Avanhard" stadium

Table 1. Rradon flux density (RFD, in) from soils of the city

RFD (mBq/(m^2·s)	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180
Number of sampling spots	10	23	42	21	16	12	9	6	5
Repetition rate	0.07	0.16	0.30	0.15	0.11	0.08	0.06	0.04	0.03

Table 2. RFD statistics in mBq/(m^2 s) from soils of Rive city

Type of determination	Number	Arithmetic mean	Geometrical mean	Standard deviation	Median	Max.	Min.
RFD from soil	144	707±7	60	41	62	173	16

The RFD parameter is more sensitive to changes in the stress-strain behavior of the geological environment than the VA value. It can be used as an independent or additional prognostic parameter. Simultaneous use of two values – VA of soil radon and RFD from the soil surface allows to increase reliability of predicted evaluation in dynamics of radon entry indoors (Korshunov et al 2012). The high concentrations of radon were recorded in clay soils and in very rotted and old rocks. Low radon concentrations are observed in pure limestone and sand. The values of exhalation depending on the type and condition of the soil are shown in Table 4.

On average, in loose homogeneous sedimentary rocks the maximum volumetric concentration of soil radon is reached at a depth of about 5 m. As a result of the vertical migration of radon in soil, it is released into the atmosphere. For the model of expansion of gas - emanation in non-

Table 3. Average values of flux of ^{222}Rn from soil to atmosphere for different regions of the world

Region	RFD of ^{222}Rn from soil, mBq/(m^2·c)	Source
Australia	22	Schery et al (1989)
Innsbruck (Austria)	9-16	Zeilinger (1935)
Nepal	39	
China	29.7±9.4	Zhuo et al (2018)
Seclin (France)	15	Servant (1964)
Aachen (Germany)	17	Israël (1970)
Heidelberg (Germany)	19	Dörr et al (1989)
Sakarya (Turkey)	0.2-1.4	Tabar et al (2018)
Osaka (Japan)	8-11	Megumi and Mamuro, (1972,1973), Tojo (1989)
New Zealand	4	Rosen 1957)
Gunma (Japan)	2-11	Prasad et al (2012)
Warsaw (Poland)	7	UNSCEAR (1982)
Socorro (New-Mexico, USA)	34	Wilkening and Hand (1960)
Uttar Pradesh (India)	0.1-0.3	Zubair et al (2012)
Yucca Flat (Nevada, USA)	21	Wilkening et al (1972)
Linkoln (Massachusetts, USA)	50	Wilkening et al (1972)
Chapman County (Illinois, USA)	53	Pearson and Jones (1966)
Argonne (Illinois, USA)	21	Pearson and Jones (1966)
Central Europe	7	(Milin et al (1968)
Kazan (Russia)	17-149	Apkin (2016)
Northern Russian Federation	38	Kirichenko (1970)
Caucasus	73	Kirichenko (1970)
Middle Asia	19	Kirichenko (1970)
Moscow (Russia):		
Clay soils;	38	Milin et a (1968)
Sandy soils;	21	Milin et al (1968)
Krasnoyarsk (Russia)	40	Berezina (2014)
Krasnoyarsk (Russia)	32	Kurguz (2002)
Irkutsk (Russia)	50-100	Berezina (2009)
Keiga (India)	3	Berezina (2014)
Malaga(Spain)	10-25	Berezina (2014)
Vilnius(Lithuania):		
Clay soils;	38	Berezina (2014)
Sandy soils	25	Berezina (2014)
Rivne (Ukraine)	70	Our studies

radioactive soil layer upon availability of convective transfer from emanation source, the solution of the radon transfer equation is as follows (Shuleikin 2010):

$$Q = Q_0 \cdot \exp\left(z \cdot \left[\frac{\upsilon}{2r} - \sqrt{\frac{\upsilon^2}{4r^2} + \frac{\lambda}{r}} \right] \right) \tag{1}$$

where r is the diffusion coefficient (cm^2/s), Q, Q_0 is the amount of gas-emanation in one cubic centimeter of soil air at a depth of z and z = 0, respectively; λ is the radioactive constant (1/s); υ is the radon transfer rate (cm/s, for sedimentary rocks $\upsilon = 5 \cdot 10^{-4}$ cm/s); z is the vertical coordinate, the beginning of which is located on the border of the emanation layer (cm).

This equation quite fully covers real soil situations; it allows to estimate the depth of radon entry into the near-surface soil layers for cases of diffuse and convective transport mechanisms. Meteorological and climatic factors (Pichura et al 2019) are one of the determining factors for the RFD size from the soils of cities located in platforms of calm geodynamic conditions. It has been established (Hrozdynskyi 1965) that during the day due to solar radiation the increased turbulence over the soil surface leads to intensive air mixing; at night and in the morning temperature inversion suppresses radon transfer. This dependence in the daily variations of lightness can lead to a double change in the rate of exhalation.

The impact of biotic factors leads to loosening of soil by the roots of plants, occurrence of channels where rotten roots used to take place. The activity of burrowing animals, earthworms collectively leads to a complete restructuring of the parent rock, changes in its structural features and permeability. The soil layer is characterized by an intense development of macropores-large secondary openings and channels with sizes more than 1 mm, the occurrence of which is caused by the processes listed above, so as cracks that occur with changes in humidity, temperature and mechanical (man-made) effects. The depth of the soil layer that contains macropores and cracks is determined by the type of soil, climatic and other conditions and usually it is 25-50 cm, very rarely it is 1 m. Soil compaction (for example, due to trampling) leads to the collapse of macropores and, accordingly, deterioration of soil aeration, which contributes in the accumulation of radon in the soil air. Radon anomalies that are connected with soil over compaction are well known in uranium exploration geology and they are called the “path effect” (Miklyaev 2001). It should be noted that the radon exhalation is influenced by soil moisture, its porosity and permeability, but fluctuations in the values thereof can be considered insignificant for several days and at distances of several kilometers.

Table 4. Radon exhalation from the underlying surfaces of various types

Type of surface subject to emanation	RFD, $mBq/(m^2 \cdot c)$
Recent deposits (soils, sands, clays)	1.85–11.1
Various types of granite*	18.5–111
Zones, that contain secondary uranium minerals	3700–11100
Water surface	$<3.7 \cdot 10^{-3}$

* - in spots with high radioactivity of soil, for example, in areas of granite release the content of radon in the air and RFD is significantly increased

The degree of filling of soil pores with water (moisture saturation) is increased together with humidity and, accordingly, the exhalation of radon is decreased due to the dissolution of its atoms in water. When saturation is more than 70%, the air movement in pore channels of soil is practically absent. The release of gases into the atmosphere in this case is possible only due to diffusion from the surface of weakly permeable blocks. When moisture is slightly decreased, the macropores are dried and the gas permeability is significantly increased. It reaches its maximum values when the degree of pore filling with water is less than 15–20% (Shestakov 1982, Miklyaev 2001). Humidity and, accordingly, the gas permeability of soils and rocks in zone of incomplete water saturation (from ground surface to groundwater level) are subject to significant temporal fluctuations. The nature and amplitude of fluctuations changes together with depth. The highest amplitude and aperiodic moisture fluctuations associated with changes in meteorological conditions, precipitation regime, water consumption for evaporation and transpiration (moisture consumption by plant roots) are observed in the upper layer of soil that contain macropores. Seasonal nature is taken with depth of moisture fluctuations and the amplitude dry out. The depth, at which moisture fluctuations completely dry out, ranges from (2-3 *m*) for clay soils up to (5-10) m for sands and sandy loams (Shestakov 1982).

Natural and artificial land cover (ice, snow, asphalt, concrete, etc.) also affect the decrease in radon exhalation. So, snowing on the ground, freezing of underlying surfaces, heavy showers facilitate in accumulation of radon in soil. Intensive infiltration of precipitation can cause a decrease in radon concentrations in the upper areas or throughout the zone profile. Therefore, in the marshy lands the zone of air migration of radon is almost completely absent (Miklyaev 2001). The reason for interseasonal variations of RFD from soil is the active so-called "restructuring" of the soil, when during 24 hours the daily surface is unevenly affected by significant temperature differences, resulting in short-term conditions for formation of crack network in frozen soil layer and intensive migration of moisture in soil and radon. The water content of the soil in this case plays the screening role for soil radon in warm time of the day, and it acts as a factor of initial formation of surface cracks when the soil moisture freezes during cold time of day (Kurguz 2002).

Provided that reliability is sufficient, the RFD from soil and temperature relationship can be approximated by the function of the form:

$$RFD = 34.47 + 0.53 \cdot t \qquad (2)$$

It is obvious that the RFD from soil increases on average by 5.3 mBq/(m^2·c) at every 10 ° C (Kurguz 2002). The increase in atmospheric pressure also reduces radon intake in the surface air. The anomalous component of the RFD is typical for territories of cities with clear deformations of soil, which were formed due to tectonic activity. It appears during earthquakes that can occur even over a distance of tens of thousands of kilometers from the places of registration of RFD from soil and VA in the spaces. The value of the equilibrium volumetric activity (EEVA) of radon in the spaces of such cities may exceed permissible levels by tens and hundreds of times (Pavlov et al 2003).

The highest RFD values are associated to territories, the surface of which is composed of clay deposits (110-170 mBq/(m^2 s)) (Fig. 5). Areas that are composed mainly of sandy soils are characterized by reduced average RFD values in general [20-40 mBq/(m^{2}s)].

The morbidity and mortality statistics of Rivne city in relation tracheal, bronchial and lung cancer in the period 2014-2016 was analused (Golovne Upravlinnja 2016). The obtained data was indicated on the map of tested sites according to the addresses of the sick and dead people (Fig. 6). High correlation between the RFD values from the soil and

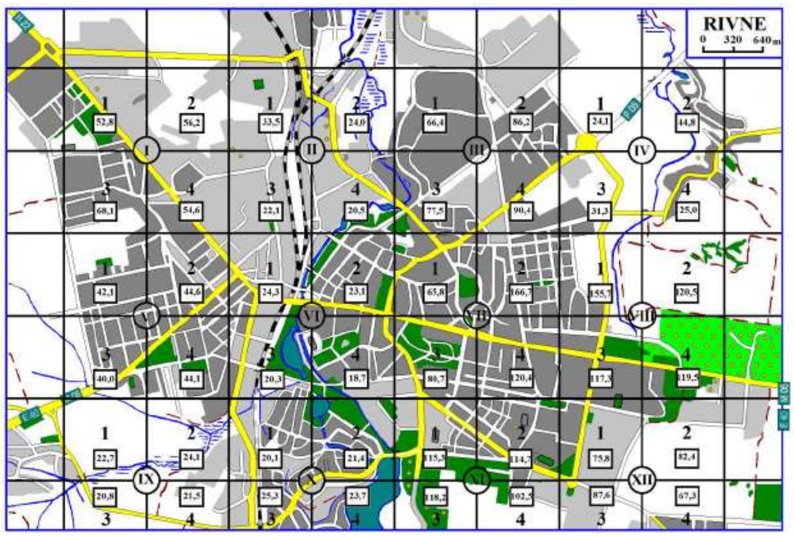

Fig. 5. Average values of RFD from soils of tested sites of Rivne city

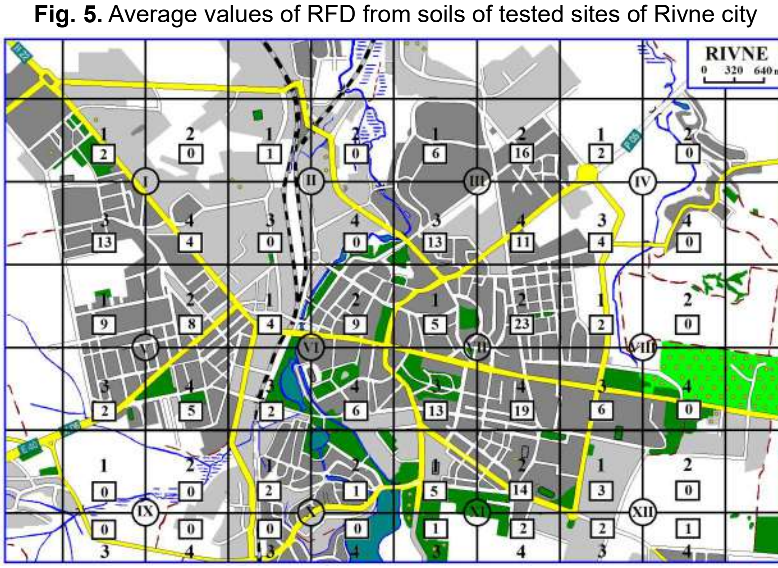

Fig. 6. Number of citizens who have or died due to lung cancer in 2014-2016 in tested sites of Rivne city

the mortality rate due to lung cancer in corresponding tested sites may be noted. The lowest RFD values from the soil were recorded in plot X. For the VII.2 and VII.4 tested sites, where the number of deaths due to lung cancer during the specified period was 23 and 19, respectively, the highest values of RFD are observed in Rivne city: 166.7 and 120.4 mBq/(m^2s), respectively.

CONCLUSIONS

The measured characteristics of the radon field (RFD) are, obviously, a sensitive indicator of the spatial and temporal changes in natural factors, including the difference in atmospheric temperature, pressure and precipitation; changes in the radiological and physico-mechanical properties of rocks; available structural features of rocks (zones of fragmentation, karst); geodynamic state of rocks (preparing for earthquakes and landslide processes). The analysis of spatial distribution of the RFD in the territory of Rivne city shows that the radon flux density field has discrete spatial structure and it is divided into background and anomalous components. The spatial distribution of the radon flux density is, obviously, log normally described, the value of the RFD varies widely, but the overwhelming majority (99%) falls into the 3-sigma interval for lognormal distribution. The interval is 10-180 mBq/(m^2c) for the average values for tested sites with the arithmetic average of 70$\pm$7 mBq/(m^2c) and geometric average 60 mBq/(m^2c). These values may be considered as regional RFD background for the territory of Rivne city (background radon field). Comparison of the spatial distribution of the background radon field and the field of morbidity and mortality of citizens due to lung cancer in 2014-2016 indicates clear correlation between them.

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Effect of Zinc Soil Contamination on the Survival of Earthworms *Aporrectodea caliginosa* and Effect on Protein Content and their Tissues

Safaa Mohammed Mahmood

Department of Biology, Faculty of Education for Pure Sciences, Mosul University, Mosul, Iraq
E-mail: mohammedsafaa1978@gmail.com

Abstract: This study aimed to evaluate the effects of zinc toxicity (750, 1000 and 1500 mg kg^{-1}) during periods (15 days) on worms (*Aporrectodea caliginosa*) collected from poultry breeding fields and effect on the protein content and the mortality rate. The highest mortality was (33%) at concentration 1500 mg kg^{-1} and within 15 days of treatment. The histological sections showed that when the worms exposed to different concentrations of zinc, it resulted in shrinkage in the thickness of the body wall and bleeding under the epidermis and the presence of fragmentation, necrosis and contraction in the longitudinal muscle layer. The zinc metal reduces the proportion of protein in the body of worms in all concentrations, especially with increased concentration. Thus, this reduction in protein affects the diet of poultry and cows that add worms as nutrients in their diet to raise the level of protein in their bodies.

Keywords: Feeders for poultry, Mortality, Percentage survival, Protein content, Zinc toxicity

The pollution of the soil with heavy elements has become a serious problem at present because of the entry of heavy elements in various areas of life, which led to contamination of food, water and soil. The importance of earthworms as biomarkers in soil pollution is due to the fact that it absorbs a large amount of biodegradable waste, organic fertilizer and other organic matter deposited in the soil and transforms it into a rich surface soil that benefits plants and other living organisms soil (Sandoval et al 2001). Earthworms are a meal rich in protein and is used in poultry's diet, The earthworms have the ability to absorb and accumulate heavy metals in their tissues, hence the transition to poultry and other animals (Prayogi 2011, Sogunle et al 2018). There have been few studies on the effects of heavy metals on earthworm tissues, through which the impact of industrial pollution, pesticides, organic waste, etc. can be determined at the level of the tissues of the organism. Therefore, current study attempt is made to study the histological changes in the intestine of the earthworm *A. caliginosa* when exposed to different concentration of Zn metal.

MATERIAL AND METHODS

Worm collection: Earthworms (*Aporrectodea caliginosa*) collected from poultry fields and nearby areas where poultry waste is dumped in Mosul, Iraq, in an area that has not been treated with pesticides. Earthworms of similar size and length and weight were used in the studyand were maintained in a soil mixture in the dark at 24±1ºC for 48 h before the experiment. After 48 h, they were randomly divided into either control group or treated group with zinc each of them containing 30 adult earthworms. *A. caliginosa* were added to soil contaminated with of different concentrations of zinc (750, 1000 and 1500 mg kg^{-1}) and a control group treated with distilled water. They were maintained under laboratory conditions in the dark at 24±1ºC (Cabrera et al 2010). Zinc metal used as $ZnSO_4$ $7H_2O$.

Mortality: The mortality in the groups were recorded at 5 days interval three times .The percentage mortality was calculated using (Abbott 1925) method for toxicity studies after correcting for natural (control) mortality using the formula:

Hhistological studies: For all experimental groups, earthworms were fixed in Bouin's fluid at 4°C for 24 h. Fragments of earthworms were processed according to the standard histological techniques, embedded in paraffin and cut into 5 µm transverse sections in the intestinal region, approximately 10 segments behind the clitellum. Them after cutting it at 5 micrometers to serial sections and dyeing with Gill's hematoxylin-eosin (Gill et al 1974) and photographed with using light microscope that was equipped with a Leica digital camera (Olympus OM- Japan).

Quantitative assessment of protein: The protein content of the worms were calculated using the Lowry (1951) method as modified by Schacterle and Pollack (1973). Using Bovine serum albumin-BBS as a standard solution with a molecular absorption factor of 0.67 (Holme and Peck 1988).

RESULTS AND DISCUSSION

Mortality: The result of Zn toxicity to *A. caliginosa* shows that there was no mortality in the control group throughout the study period. The mortality *A. caliginosa* in the treatment differed significantly (Fig. 1). The percentage of mortality in with 1000 and 1500 mg kg^{-1} soil did not vary after 5 and 10 day. The percentage mortality increased from 17 to 30 % at 750 mg kg^{-1} and, from 10 to 20 % at 1000 mg kg^{-1}in period 5 to 15 day and 27 to 33% at 1500 mg/kg in period 5 to 15 day (Fig. 1). These results due to the fact that the time period increased with the increasing of death rate (Wieczorek-Olchawa et al 2003, Stanly and Joy 2014). The survival rate was record 100% in the control group then it was decrease to 67% at the lowest concentration of 1500 mg kg^{-1} during the 15-day period of the treatment. At 750 mg kg^{-1} the survival rate reached 70% for the same period (Table 1). Similar observation has been reported by Aemere and Olufisayo (2012) and Latha and Mahaboob-Basha (2016).

Protein content: The Zinc contamination significantly reduced the protein content in worms. The content of protein in the body of worms at concentrations 750 mg kg^{-1}, 1000 mg kg^{-1} were 0.106 mg kg^{-1} and 0.053 mg g^{-1}, respectively, whereas, the lowest protein content recorded at the concentration was 1500 mg kg^{-1}, which amounted to 0.045 mg g^{-1} (Table 2). The lower content of protein in the bodies of worms is due to an inverse relationship between the concentration of pollution and, the protein content. This study is consistent with Nadeau et al (2001) observed that when *Lumbrcius terrestris* exposed to heavy elements protein content in its tissues is reduced. The Maity et al (2005), also observed a decrease in protein content in *Lampito mauritii* when exposed to soil contaminated with zinc. The study is similar to (Faheem and Farhanullahkan, 2010), which reduced protein content when exposed to imidacloprifd. Affect Zn on hatchability when used mixed zinc with food which affected negatively the growth chicken and hatchability egg and meat chickens (Sogunle et al 2018).

Histopathology: The epidermis was significantly affected with the concentrations of 750 and 1000 mg kg^{-1} with thickness of 8.5 and 25.5 micrometers. The body wall was affected significantly in all concentrations. The thickness of the body wall was less than 138.83 micrometer at the concentration of 750 mg kg^{-1}. The intestinal epithelium was significantly affected by the zinc element. There was a decrease in epithelial thickness at all concentrations, the highest reduction was recorded at 750 mg kg^{-1}concentration and was 17.36 micrometers when compared with the control group and recorded 73.78 micrometers (Table 3). Kilic (2011) and Al-Mashhadane (2019) observed in *L. terrestris* which treatment with soil contaminated with heavy metal loss in thickness of circular and longitudinal muscles.

The microscopic examination of sections from the central area of the worm body, after 15 days of treatment

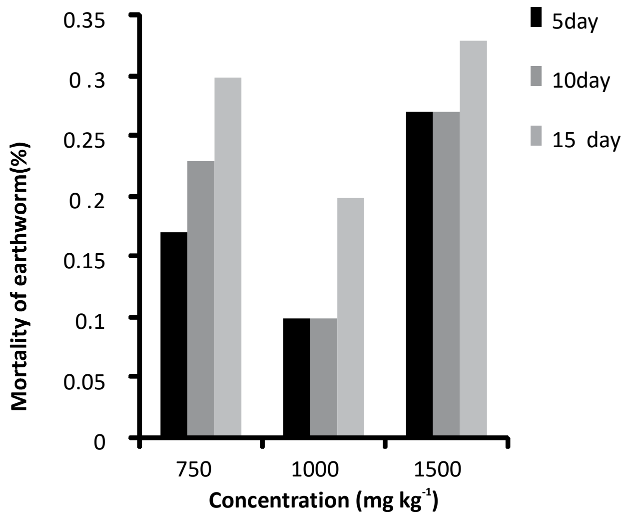

Fig. 1. Mortality of *A. caliginosa* when exposed to soils contaminated with different concentration of Zinc

Table1. Percentage survival of *A. caliginosa* when exposed to soils contaminated with different concentration of Zinc

Concentration mg kg^{-1}	The time period to treatment (day)		
	5	10	15
Control (0.0)	100	100	100
750	83	77	70
1000	90	90	80
1500	73	73	67

Table 2. Effect of Zinc element on the protein content of the earthworm *A. caliginosa*

Concentration (mg g^{-1})	Control	750	1000	1500
Protein content	0.184a	0.106b	0.053C	0.045c

*Duncan test, significance level < 0.05

Table 3. Effect of zinc element on radial section thickness of epidermis, body wall, and intestinal epithelium in the earthworm *A. caliginosa* after 15 days from exposure

Concentration (mg kg^{-1})	Radial thickness(µm)		
	Epidermis	Body wall	Intestinal epithelium
Control	34a	392.5a	73.78a
750	8.5c	138.83c	17.36c
1000	25.5b	218.17b	40.507b
1500	34a	266.33b	47.74b

*Duncan test, significance level < 0.05

showed shrinkage in the thickness of the body wall layers and bleeding under the epidermis and the presence of fragmentation, necrosis and shrinkage in the longitudinal muscle layer In addition to the appearance of the epithelial appearance of the gut epithelium is similar to the leaf clover and gaps in the epithelium of the gastrointestinal tract , the presence of crystalline groupings is the zinc crystals collected in the epithelial and under the epithelium and the presence of bleeding under the epithelium of the gastrointestinal tract when worms treated with Zinc at concentration 750 mg kg^{-1} (Fig. 4, 5) compared with the control group that showed the body wall and gastrointestinal tract correctly and fully (Fig. 2, 3) as well as to notice hyperplasia and fragmentation and necrosis in the epidermis

Fig. 2. A transverse section of a worm from the control group shows the epithelium of the gastrointestinal tract, the blind channel (1) and the chloragogen cells within the blind channel (2), in addition to the blood vessel (3). Stained H. & E. 100 X.

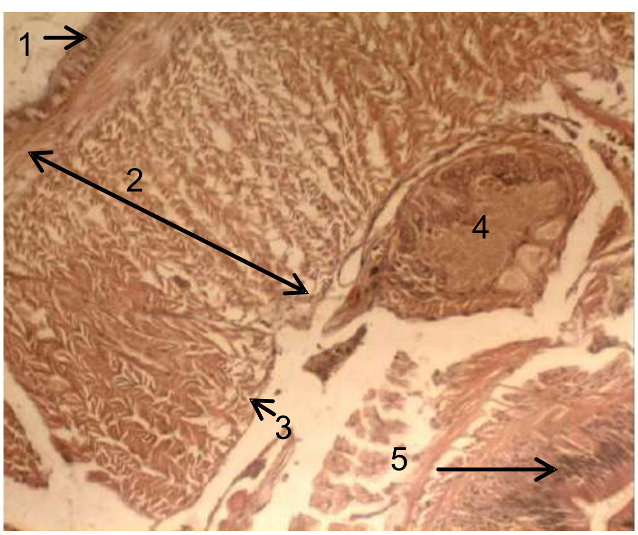

Fig. 3. A transverse section of a worm's middle of the control group shows part of the epidermis (1), the circular and longitudinal muscle layer (2), the peritoneal casing (3), the dorsal nerve cord (4), and the gut epithelium (5). Stained H. & E . 100 X.

Fig. 4. A transverse section of the earthworm treated with the zinc element at a concentration of 750 mg / kg 15 days after the start of the experiment. Shrinkage was observed in the thickness of the body wall layers (1) and bleeding under the epidermis (2) the presence of fragmentation, necrosis and shrinkage in the longitudinal muscle layer (3) stained H & E. 40 X

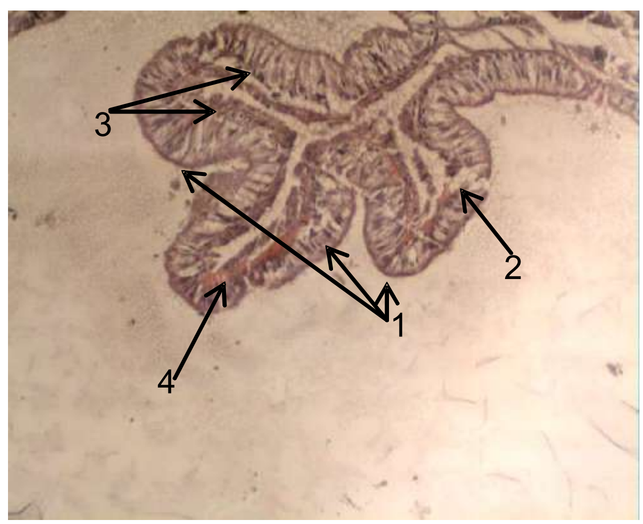

Fig. 5. A transverse section of the earthworm treated with the zinc element at a concentration of 750 mg / kg 15 days after the start of the experiment Observation of the epithelium of the gastrointestinal tract is similar to the clover leaf(1) in addition to gaps within epithelial cells of the gastrointestinal tract (2) and the presence of clusters of crystalline material (believed to be zinc) in epithelial under the epithelium (3) and the presence of bleeding under the epithelium of the gastrointestinal tract (4) Stained H & E. 100 X

stretch to circular muscle layer and the presence of bleeding under the epidermis and the presence of necrosis in the longitudinal muscle (Fig. 6), either when worms treated with Zinc at concentration 1000 mg kg^{-1}notes are to be finger protuberances of the intestinal epithelium, which represent mucous extensions in the intestinal cavity and the presence of hyperplasia in chloragogen cells, congestion and thrombosis of blood vessels in tissues under mucus (Fig. 7) Either when worms treated with Zinc at concentration 1500

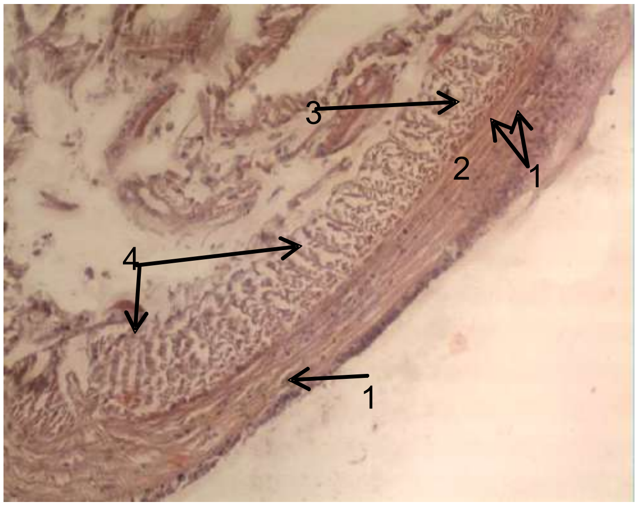

Fig. 6. A transverse section of the earthworm body treated with a zinc element at a concentration of 750 mg / kg 15 days after initiation of the experiment, To notice hyperplasia and fragmentation and necrosis In the epidermis (1) stretch to circular muscle layer (2) and the presence of bleeding in the muscle layer (3) and the presence of fragmentation and necrosis in the longitudinal muscles and below (4) Stained H & E. 100 X.

Fig. 7. A transverse section of the earthworm body treated with a zinc element at a concentration of 1000 mg / kg 15 days after initiation of the experiment, Notes occur finger protuberances of the intestinal epithelium, which represent mucous extensions in the intestinal cavity (1) the presence of hyperplasia in chloragogen cells (2) and the occurrence of fibrosis and necrosis and alienation (ecdysis) epithelial endpoints (3) congestion and thrombosis of blood vessels in tissues under mucus(4) Stained H & E. 100 X.

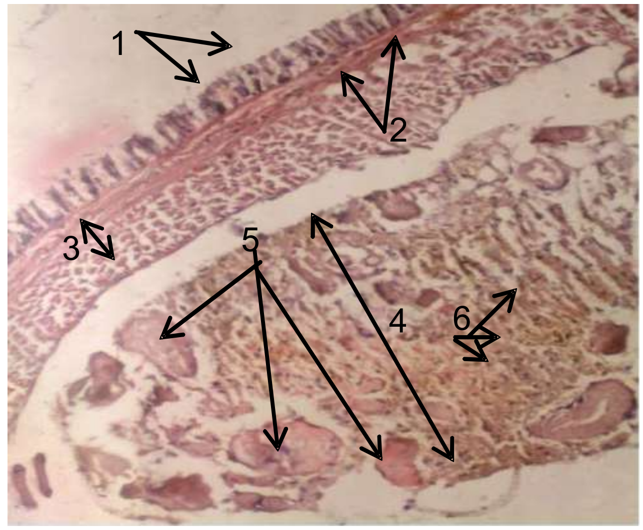

Fig. 8. A transverse section of the earthworm body treated with a zinc element at a concentration of 1500 mg / kg 15 days after the start of the experiment, To notes the occurrence of epidermis necrosis (1) and circular and longitudinal muscles (2), shortening of the thickness of the longitudinal layer (3) in addition to an increase in the chloragogen tissue (4) congestion and thrombosis in the blood vessels and chloragogen tissue (5) notes deposition minutes zinc in chloragogen tissues (6). Stained H & E 100X.

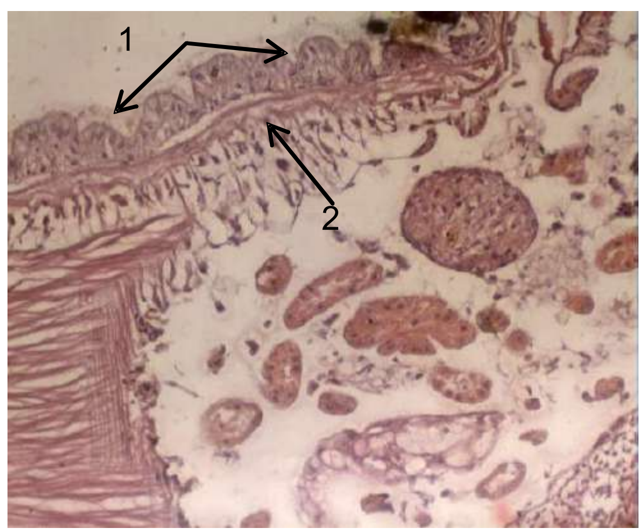

Fig. 9. A transverse section of the central worm body treated with a zinc element at a concentration of 1500 mg / kg 15 days after the start of the experiment shows a flatness of the gastrointestinal epithelium(1) and its separation from the basement membrane (2). Stained H & E. 100 X.

mg kg^{-1} and notes the occurrence of epidermis necrosis and circular and longitudinal muscles and shortening of the thickness of the longitudinal layer congestion and thrombosis

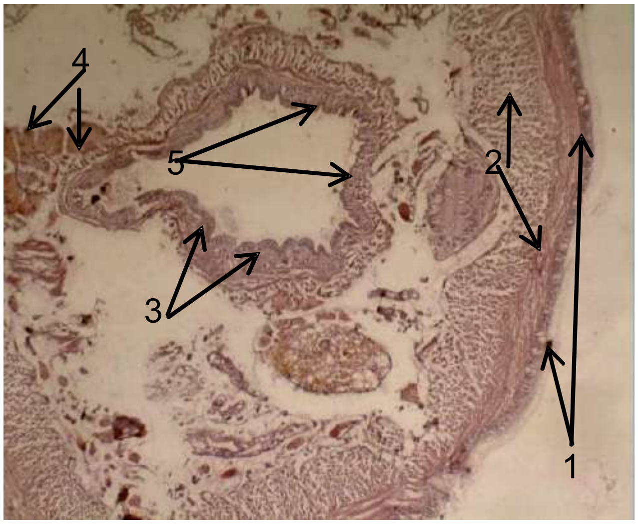

Fig. 10. A transverse section of the earthworm body treated with the zinc element at a concentration of 1500 mg / kg after 15 days from the start of the experiment and An increase in glandular cells of the epidermis is observed(1) and the occurrence of necrosis in the circular and longitudinal muscle layer (2) and bleeding in the circular muscle layer surrounding the intestinal epithelium (3) and flattening of the intestinal epithelium (4) Zinc is concentrated in the cells of the intestinal epithelium (5) Stained H & E. 40 X

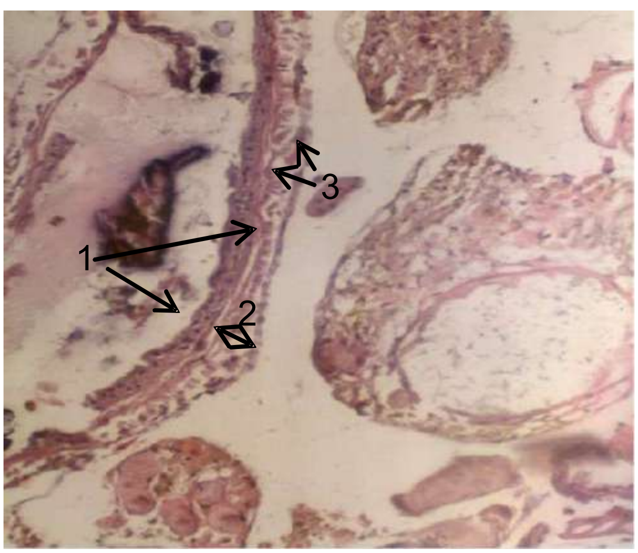

Fig. 11. A transverse section of the earthworm treated with a zinc element at a concentration of 1500 mg / kg 15 days after the experiment began. The flatten of the epithelial cells is observed and dissociated from the basal membrane (1) and the thickness of the longitudinal layer surrounding the epithelium is decreased and degenerated (2) and concentrate of zinc minutes in epithelial cells of the gastrointestinal tract (3). Stained H & E. 100 X .

in the blood vessels and chloragogen tissue as well deposition minutes zinc in chloragogen tissues as in (Fig. 8). In other sections a flatness of the gastrointestinal epithelium and its separation from the basement membrane (Fig. 9). Also an increase in glandular cells of the epidermis was observe and the occurrence of necrosis in the circular and longitudinal muscle layer and bleeding in the circular muscle layer surrounding the intestinal epithelium and Zinc is concentrated in the cells of the intestinal epithelium were shown in Figure 10 and 11. Other studies showed loss in thickness of circular and longitudinal muscles of *L. terrestris* (Kilic 2011) and destroyed the epithelial layer of *E. fetida* (Gobi and Gunasekaran 2010), which is agreement with the current study.

CONCLUSIONS

The soil contaminated with zinc element heavy metal caused a decrease in the proportion of protein in the bodies of worms, in addition to its impact on the histological condition of the body wall and epithelial layer in the digestive system and also affected on the level of survival of earthworms In addition, the worms have the ability to deposit zinc in their tissues and rid the soil of heavy elements contaminated with soil so as to help to purify the soil of contaminants.

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Effect of Spraying Urea and Addition of Potassium on Growth Parameters of Local Citrus Seedling (*Citrus sinensis* L.) Grafted on Sour Orange Rootstock

Mohammed Tarkhan Abo Al-Meekh, Hassan Hadi Alkarawi*, Sabah Lateef Asi and Hammed Kadhim Abd Al-Ameer

Al-Furat Al-Awast Technical University, Al-Mussaib Technical College, Babylon, Iraq
**E-mail: hassan.alkarawi@atu.edu.iq*

Abstract: The effects of different levels of urea spray (0, 0.5, 1, 2%) with a total number of five spraying. The interval between each spray was one month. The second-factor addition of potassium fertilizer (potassium sulfate) applied of partitioning for five batches, the concentration of potassium sulfate was 50 g per seedling. The results revealed that a significant association of the concentration of the urea and growth indicators of the seedlings, by giving the highest averages for seedling length, stem diameter, total leaves number, leaf area, dry weight, the leaves content of chlorophyll, nitrogen, phosphorus, and potassium. Similarly, the potassium fertilizer application was significantly correlated to the growth indicators for a citrus seedling. However, the urea alone or combined with the addition of potassium at the early stages of growth could be useful in improving seedling quality.

***Keywords*:** Urea, Potassium, Foliar spraying, Orange seedling, Sour orange

Orange (*Citrus sinensis* L.; Rutaceae) is an important fruit plant producing two-thirds of the world's citrus demands with a good taste (Vita et al 2019, Li et al 2019). Its' propagation method is grafting on seed rootstocks. Sour orange has been used as a rootstock because it is common to most areas of citrus cultivation and more suitable for the conditions of Iraq because it is resistant to many diseases such as gummosis and rotting roots and it has a root system with many branches, it reaches to high depths of soil and it has good compatibility with most citrus cultivars grafted on it (Albrigo et al 2019). Hazarika and Aheibam (2019) observed that spraying urea on orange trees led to improving the vegetative growth and increasing leaf area indicators and the leaves content of chlorophyll due to increasing the photosynthesis efficiency, thus improving their fruits. Al-Araji et al (2006) reported that fertilizing the seedlings of citrus rootstocks (Troyer citrange) with urea (1 g kg^{-1} soil) led to a significant increase in the traits of the length and diameter of seedling stem, number of their leaves and the leaves content of nitrogen and phosphorus. Al-Jubouri and Al-Hamidawi (2013) indicated when spraying the grow more nutrient solution containing 20% nitrogen on the total vegetative for the local orange seedlings led to a significant increase in seedling height and their diameter, the number, and length of their branches and the number of their leaves and leaf area and the leaves content from the chlorophyll. Karuna et al (2019) and Khankahdani et al (2019) confirmed that spraying the urea solution to 1% concentration on the total vegetative for sour orange seedlings led to a significant increase in plant height, number of branches, the average of their length, number of leaves, leaf area, percentage of dry matter percentage and the leaves content of chlorophyll and nitrogen. Hashim (2014) showed that spraying the nitrogen element within the liquid fertilizer components (LiQ Humus) on the total vegetative for the local orange seedlings led to a significant increase in the height of the seedlings and the leaf area and the leaves content of chlorophyll, nitrogen, phosphorus and potassium compared to the treatment of the seedlings spraying with distilled water only. Al-Hamdani and Al-Bayati (2015) indicated when spraying urea with a concentration of 0.05% on orange trees to existing a significant increase in the percentage of the fruit set and the percentage of fruit remaining on the plant and increasing the percentage of fruit juice and percentage of sugar in it. As well as increase the leaf area for the trees as well as the leaves content of chlorophyll. Brar et al (2011) and Padhan et al (2019) show that added potassium improves nitrogen absorption, thus helps to increase the efficiency of nitrogen use. The synthesis of proteins requires a high level of potassium, which is very important in the photosynthesis process and transferring the photosynthesis products from leaves to the rest of the plant, increases the resistance to diseases, and helps to transfer nitrates in the form of KNO3 from roots to leaves in the plant (Johnston 2010, Munson 2018). Zhang et al (2010) indicated that the interaction between nitrogen and potassium is considered an interesting subject in many studies that focused on nutritious potassium under different nitrogen systems. The addition of potassium has been neglected in many developing countries, therefore led to the depletion of potassium from the Agricultural Ecosystems and this prevented the increase in the traits of the cultivated plant's yield. This study aims to identify the response of local orange seedlings grafted on sour orange rootstocks to spraying urea solution on the total vegetative and adding potassium fertilizer to the growth media of seedlings.

MATERIAL AND METHODS

The study was conducted in Al-Handia Horticulture Station (Karbala province) Ministry of Agriculture for the period from September 2017 to June2018. Four spraying levels of urea solution (0, 0.5, 1 and 2%) were used with sprayings five times at an interval of. The second factor represented five periods of partitioning addition of potassium fertilizer (Potassium sulfate), the period between them is 30 days, with a concentration of 50 g per Seedling. The factorial experiment was conducted according to the Completely Randomized Design (CRD), with three replicates. The seedlings were sown in 10 Kg plastic bags. The first spraying and the first addition for fertilizer on 10 November /2017 The spraying was done using a 2 L hand spray and it was added with each concentration (1 cm^3) of Dishwashing solution as a spreading material (Chhetri and Ghoniem 2019, Pérez-Pastor et al 2019). The spraying was done in the morning and until the complete wetness for the seedlings which it preceded by irrigation of the seedlings before one day. The irrigation prior to spraying reduces the concentration of the solutes in the leaves cells due to the water entering and increasing the swelling, thus opening the stoma, which increases the permeability of the spraying solution ions to the leaf cells (Schjoerring et al 2019). The control treatment was sprayed with water only. The mineral fertilizer was added as DAP at a rate of 30 g per seedlings. The process of irrigation seedlings and cleaning the growth media done as needed. Random samples were taken from the growth media of the seedlings and analyzed for the purpose of determining some of their physicochemical traits (Table 1) estimated according to standard methods (Jackson 1958, Black 1965). After completion of the experiment, three seedlings were selected for the purpose of studying the following average traits from each experimental unit.

The seedling length was measured from the contact area for the stem with soil to the apical meristem of the seedling. The stem diameter was measured from the location of the fifth real leaf on the main stem for the seedlings. The total number of leaves per seedling was calculated. The leaf area for the seedlings identified was measured by calculating the area of 3 full-grown leaves taken from the top, middle and bottom of the seedling using a planimeter, where the leaf was scanned with a scanning device and the average area of the on leaf was multiplied by the number of leaves for seedling. The total number of leaves and number of lateral branches were calculated form 3 plants in each replication. Chlorophyll content (SPAD Unit was estimated by the chlorophyll meter (SPAD) y on the leaves of the seedlings directly by taking the average of three readings per leaf. Five leaves of each known fresh weight seedling were dried at 70-65°C in an electric oven and until the weight is stable, and the dry weight was then measured for estimation of dry matter in leaves.

Table 1. Physical and chemical traits of the nursery soil used in the experiment

Type of analysis	Value	Units
Soil texture	Clay Loam	-
Clay	228.4	g kg^{-1}
Silt	374.3	
Sand	397.3	
pH	7.6	-
Electrical conductivity (Ec)	2.08	dSm^{-1}
Apparent density	1.36	Mg cm^{-3}
Cation exchange capacity	18.2	cmol charge kg^{-1}
Organic matter	7.3	g kg^{-1}
Calcium carbonate	181.2	
Total nitrogen	13.6	Mg kg^{-1}
Phosphorus availability	6.2	
Potassium availability	18.4	

For estimating NPK content of leaves the samples were taken randomly from all parts of the seedling and then washed with distilled water to get rid of the dust and impurities and it was placed in perforated paper bags, and then dried in an electric oven at a temperature of 70 m and until the dry weight is stable, The samples were then milled and a 0.2 g sample was taken and digested by adding 4 mL of sulfuric acid and 2 ml of concentrated pyrochloric acid according to the method in Jones and Steyn (1973). The nitrogen elements were estimated using a modified Kjeldahl method using a micro-Kjeldahl device (Haynes1980)and phosphorus was estimated using Ammonium molybdate and ascorbic acid in the Spectrophotometer device (John 1970) and potassium by using a Flame photometer according to the method in (Hesse 1971).

RESULTS AND DISCUSSION

Length of the seedling and stem diameter of the seedling: The differences were significant between the spraying levels for the urea solution in for average length of the seedling and the stem diameter of the seedling, where the spraying treatment at a concentration of 2% gave the highest average length of seedling and stem diameter amounted to (94.83, 1.28 cm, respectively) compared to the control, 76.05, 0.80 cm, respectively (Table 2). The addition of potassium fertilizer at different levels of partitioning led to a significant increase in of seedling length and stem diameter (102.50, 1.43 cm, respectively) in 4 batches, and there is no difference between them and the method of the partitioning addition for 5 batches.

There was no significant difference between the interaction treatments. The interaction treatment (spraying with urea at a level of 2% and the addition of potassium fertilizer on 4 batches) gave the highest average seedling length and stem diameter (108.3, 1.60 cm), respectively. The lowest average of these two traits was in treatment with no spraying urea and adding potassium fertilizer at one batch.

Number of leaves in the seedling and the leaf area: There were significant differences between the spraying levels for the urea solution on average number of leaves in the seedling and the leaf area, where the spraying at a concentration of 2% gave the highest average number of leaves in the seedling and the leaf area amounted to (102.13 leaves, 22.13 dm^2, respectively) compared to the control treatment (spraying with add water) which gave the lowest averages of 85.60 leaves, 18.93 dm^2, respectively (Table 3). The adding potassium fertilizer at different levels of partitioning led to a significant increase in number of leaves in the seedling and the leaf area (106.35 leaves, 23.60 dm^2), and there is no difference between them. The method of the partitioning addition for 5 batches.

The interaction between the two factors had a significant effect on the increase in the average number of leaves in the seedling and the leaf area. The interaction of (spraying with urea at a level of 2% and the addition of potassium fertilizer on 4 batches gave the high number of leaves in the seedling and the leaf area (114.10 leaves and 25.6 dm^2, respectively).

Chlorophyll (spad) and dry weight of seedling (g): There were significant differences between the spraying levels for the urea solution in chlorophyll (spad) in leaf and dry weight of seedling being higher in the spraying t at a concentration of 2% (46.23 spad, 110.18 g compared to the control treatment (37.98 spad, 96 g, respectively). The adding potassium fertilizer at different levels of partitioning led to a significant higher content chlorophyll in leaves and dry weight of seedling and there is no difference between them and the method of the partitioning addition for 5 batches. The

Table 2. Effect of urea spraying and the partitioning addition of potassium fertilizer on seedlinglength and stem diameter

Potassium fertilizer	Seedling length (cm)					Stem diameter of seedling (cm)				
	Spraying urea solution (%)				Average	Spraying urea solution (%)				Average
	0	0.5	1	2		0	0.5	1	2	
One batch	58.2	67.4	76.2	84.5	71.58	0.5	0.6	0.8	1	0.73
Two batches	68.6	74.7	87.3	89.8	80.1	0.7	0.8	0.9	1.2	0.9
Three batches	82.6	85.4	94.1	96.7	89.7	0.8	0.9	1.2	1.3	1.05
Four batches	94.8	98.1	108.8	108.3	102.5	1.2	1.4	1.5	1.6	1.43
Five batches	95.1	98.3	107.9	108.1	102.35	1.2	1.4	1.5	1.5	1.4
Average	76.05	81.4	91.6	94.83		0.8	0.93	1.1	1.28	
LSD 0.05	Urea = 2.73, Potassium = 3.05, interaction = 5.11					Urea = 0.15, Potassium = 0.17, interaction = NS				

Table 3. Effect of urea spraying and the partitioning addition of potassium fertilizer on number of leaves in the seedling and the leaf area

Potassium fertilizer	Total number of leaves (leaves)				Average	Leaf area (dm^2)				Average
	Spraying urea solution (%)					Spraying urea solution (%)				
	0	0.5	1	2		0	0.5	1	2	
One batch	75.4	78.9	84.7	93.6	83.15	15.2	16.4	16.9	18.2	16.68
Two	79.8	84.6	88.7	95.4	87.13	19.5	20.8	21.1	21.8	20.8
Three	90.4	94.2	100.1	105.4	97.53	20.1	21.4	21.8	22.9	21.55
Four	96.8	105.2	109.3	114.1	106.35	20.9	22.6	25.3	25.6	23.6
Five	96.9	105.6	108.3	112.9	105.93	21.3	22.8	24.8	25.1	23.5
Average	85.6	90.73	95.7	102.13		18.93	20.3	21.28	22.13	
LSD 0.05	Urea = 2.54, Potassium = 2.85, interaction = 5.03					Urea = 1.51, Potassium = 1.68, interaction = 1.83				

interaction between the two factors had a significant effect on the increase in the average of leaves content from chlorophyll and dry weight of seedling. The interaction treatment (spraying with urea at a level of 2% and the addition of potassium fertilizer on 4 batches) gave the highest average.

The average number of branches (branches) and the leaves content from nitrogen (%): There were significant differences between the spraying levels for the urea solution in the average's trait number of branches (branches) and the leaves content from nitrogen (%), where the spraying treatment at a concentration of 2% gave the highest average number of branches and the leaves content from nitrogen amounted to (5.40 branches, 2.15%), respectively compared to the control, 4.38 branches, 1.34%, respectively (Table 5). The addition of potassium fertilizer at different levels of partitioning led to a significant increase the highest averages number of branches and the leaves content from nitrogen amounted to (5.68 branches, 1.97%, respectively)in four batches, interaction treatment had a significant difference. The interaction treatment (number of branches and the leaves content from nitrogen) gave the highest average (6.2 branches, 2.25%, respectively).

Percentage of phosphorus and potassium in the leaves: The differences were significant between the spraying levels for the urea solution in for the percentage of phosphorus and potassium in the leaves (%), where the spraying treatment at two gave the highest average phosphorus and potassium in the leaves amounted to (0.39, 1.94%, respectively) compared to the control (0.24, 1.54%, respectively) in (Table 6). The addition of potassium fertilizer at different levels of partitioning led to a significant increase in the percentage of phosphorus and potassium in the leaves (0.39, 1.92%, respectively) in 4 batches, and there is no difference between them and the method of the partitioning addition for 5 batches.The interaction between the two factors had a significant effect on the increase in the average leaves content from the phosphorus and potassium. The interaction of spraying with urea at a level of 2% and the addition of potassium fertilizer on 4 batches gave the highest average of leaves content from the phosphorus and potassium (0.51, 2.15%, respectively).

These factors (spraying with urea fertilizer solution and

Table 4. Effect of urea spraying and the partitioning addition of potassium fertilizer on chlorophyll content in leaves from and dry weight of seedling

Potassium fertilizer	The leaves content from chlorophyll (spad)					The dry weight of seedling (g)				
	Spraying urea solution (%)				Average	Spraying urea solution (%)				Average
	0	0.5	1	2		0	0.5	1	2	
One batch	31.4	32.8	33.9	36.2	33.58	76.8	80.2	81.8	85.6	81.1
Two batches	36.9	44.3	46.1	48.2	43.88	93.5	95.4	98.7	104.1	97.93
Three batches	38.7	44.2	46.1	48.7	44.43	104.3	115.4	116.9	122.7	114.83
Four batches	44.9	47.7	49.1	51.8	48.38	109.4	119.4	124.6	128.3	120.43
Five batches	44.8	48.1	49.6	50.9	48.35	109.6	120.6	124.1	127.1	120.35
Average	37.98	42.25	43.8	46.23		96	102.6	105.5	110.18	
LSD 0.05	Urea = 2.17, Potassium = 2.43, interaction = 3.86					Urea = 2.24, Potassium = 2.50, interaction = 4.09				

Table 5. Effect of urea spraying and the partitioning addition of potassium fertilizer on number of branches and the nitrogen content in leaves from nitrogen

Potassium fertilizer	Number of branches				Average	Nitrogen in leaves (%)				Average
	Spraying urea solution(%)					Spraying urea solution(%)				
	0	0.5	1	2		0	0.5	1	2	
One batch	3.2	3.6	3.8	3.9	3.63	0.9	1.6	1.7	2.1	1.57
Two batches	4.3	4.8	5.6	5.8	5.13	1.39	1.44	1.98	2.09	1.73
Three batches	4.7	5.1	5.3	5.7	5.2	1.48	1.48	2.07	2.18	1.8
Four batches	5.3	5.3	5.9	6.2	5.68	1.59	1.89	2.14	2.25	1.97
Five batches	5.4	5.2	5.9	6.1	5.65	1.61	1.92	2.11	2.21	1.96
Average	4.38	4.7	5.15	5.4		1.34	1.6	1.97	2.15	
LSD 0.05	Urea = 0.41, Potassium = 0.46, interaction = 0.68					Urea = 0.13, Potassium = 0.14, interaction = 0.23				

Table 6. Effect of urea spraying and the partitioning addition of potassium fertilizer on phosphorus and potassium in the leaves (%)

Potassium fertilizer	Percentage of phosphorus in the leaves (%)					Percentage of potassium in the leaves (%)				
	Spraying urea solution (%)				Average	Spraying urea solution (%)				Average
	0	0.5	1	2		0	0.5	1	2	
One batch	0.17	0.21	0.26	0.29	0.23	1.36	1.49	1.55	1.63	1.51
Two batches	0.22	0.27	0.32	0.36	0.29	1.41	1.53	1.72	1.98	1.66
Three batches	0.27	0.31	0.36	0.39	0.33	1.68	1.71	1.83	1.99	1.8
Four batches	0.31	0.35	0.38	0.51	0.39	1.72	1.85	1.95	2.15	1.92
Five batches	0.32	0.35	0.36	0.5	0.38	1.73	1.84	1.92	2.13	1.91
Average	0.24	0.29	0.33	0.39		1.54	1.65	1.76	1.94	
LSD 0.05	Urea = 0.03, Potassium = 0.04, interaction = 0.05					Urea = 0.11, Potassium = 0.13, interaction = 0.17				

the addition of potassium fertilizer in a partitioning manner) affected significantly in increasing the averages of growth indicators for orange seedlings the local cultivar grafted on the sour orange rootstocks. The level of spraying with urea fertilizer solution at 2% concentration on seedling leaves was significantly excelled in increasing the seedling length, stem diameter, number of leaves in the seedling, leaf area of the seedling and dry weight of the total vegetative for the seedlings, number of secondary branches for seedlings and leaves content of chlorophyll, nitrogen, phosphorus. The reason may be due to the role of nitrogen in increasing cell size, its elongation, and division, which was positively reflected in the increase in vegetative growth indicators or it can be due to the role of the nitrogen element, which increases the stored carbohydrates, vegetative growth and photosynthetic efficiency are positively reflected on plant growth indicators. These results agree with Al-Hamdani (2015) and Khankahdani et al 92019).

The level of adding potassium fertilizer in a partitioning manner and with four batches increases the average of the above traits. The reason may be due to the role of the element in the construction of chlorophyll and the stimulating enzymes in the photosynthesis process in the leaves, which activate the bio-metabolism for photosynthesis products which are used to build the total vegetative and increase its indicators (Abdulrahma 2010, Al-Kahattab 2017). The role of potassium element in the regulation and stimulation of cells and contributes to the regulation of the osmotic potential and the respiration process and the protein metabolizing and the stimulation of enzymes and controlling the osmotic pressure for the guard cells, thus regulates the processes of closing and opening the stomas (Barakat et al 2012). The increase in the averages growth indicators for seedlings due to the addition of potassium fertilizer in batches is due to the availability of this element in different stages of seedling growth, especially the elongation stage, leaf formation stage, chlorophyll concentration, and nutrient elements. This leads to an increase in photosynthesis (Jones 2019).

CONCLUSION

This study unraveled the factors affecting the response of citrus seedling to foliar application of urea, and periods of partitioning addition of potassium (Potassium sulfate). Our findings showed that urea concentration at two percent is good growth indicators of the seedlings control. Potassium at different batches was more effective for the growth indicators for citrus seedling. Foliar spray of urea and partitioning addition of potassium significantly increase the percentage of phosphorus and potassium in the citrus leaves.However, the urea alone or combined with the addition of potassium at the early stages of growth could be useful in improving seedling quality.

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Effects of Optimus Plus and Red Tea Extract Fertilizer on the Growth and Flowering of Freesia (*Freesia hybrida*)

Karim M. Bhiah

Department of Soil Science, University of Kufa 21, Iraq
E-mail: karimm.bhiah@uokufa.edu.iq

Abstract: The experiment was conducted in poly house to find out the effects of optimus plus at 0, 4 and 8 g l^{-1} and red tea (Roselle) extract 0, 6 and 12 g l^{-1} on freesia plant characteristics. Plant height, leaves number, shoot dry weight, number of flowering days, number of flower stalks floret diameter, total chlorophyll content and leaves carbohydrate content and leaves content of anthocyanin increased significantly with the application of extracts.

***Key words*:** Freesia hybrida, Roselle, Optimus Plus, Anthocyanin

Freesia is a genus of herbaceous perennial flowering plants in the family iridaceae. It is highly decorative and aromatic flowers grown from the bulb with a height of 30-40 cm. The leaves of the plant are thin and pointed. It is used as flowering pot plants and cut flowers. The floral form is shaped in the form of mulberry flora of different colors including white, yellow, red, purple flowers blooming in spring (Al-batal 2005). The original habitat of the plant is South Africa. It is also grown in Europe and Japan as a popular cut-flower crop, it is suitable flower for commercial picking as well as favorable for agriculture in ponds and basins (Manning and Goldblatt 2008) .It is cultivated in low frost-free and high humidity areas, For the purpose of producing corms and improving the qualities of flowers (Al-batal 2005). Freesia is one of the commonly produced cut-flower among bulbous, tuberous, and rhizomatous ornamental plants that bears fragrant flowers in the spring. It is suitable for growing in borders and in containers outside or as houseplant (Manning and Goldblatt 2008). Freesia cultivation requires proper root temperature and moist soil. Addition of chemical fertilizers to make plants grow faster, contamination of soil gradually increased with the development of global economy and need for food (Jeyapriya and Shazli 2017). Very limited information is available on the precise nutritional needs of Freesia hybrida. Nitrogen strongly increased corm growth and influenced flowering. It has also been reported that phosphorus increased the weight of fresh and corm growth Xi et al (2019).

Potassium fertilization also increased leaf height and corms growth. Al-Naami (2012) showed that spraying red tea extract plays an important role in improving the growth characteristics of the plant, as it increased the number of leaves and the number of branches and the leaf area. In a study of Al-Mohamadi et al (2013), the foliar application of red tea extract increased the plant height and the number of branches and the weight of dry shoot system. Potassium also led to flowering ahead of time, increased plant height, number of leaves, and larger flowers. The aim of this current study was to find out the suitable level of optimus plus and red tea extract and the proper combination of both so as to achieve a high vegetative growth and maximum flower production with high quality freesia plant.

MATERIAL AND METHODS

An experiment was conducted in the nursery of the Faculty of Agriculture- University of Kufa, Najaf province, Iraq in net house during the winter season 2016-2017. Corms were planted in November 5, 2016 in plastic pots with a diameter of 20 cm and height of 16 cm, filled with 4 kg soil. The corms were brought from reliable sources from Holland. Experiment was carried out using randomized complete block design with three replicates. The optimus plus, had 3% organic N, 3% inorganic N, and 30% OM), was evaluated at 0, 4, 8 ml l^{-1} and red tea extract at (0, 6, 12 g l^{-1}) (Table 1). The spraying was done in early morning three times at interval of 15 days. The soil of the experimental field was loamy sand in texture with pH 8.1 and EC 2.38 dS m^{-1}. The soil was low in available nitrogen (20.2 ppm), and OM (8.3 g kg^{-1}).

The following data were recorded: Plant height (cm): The measurement done starting from the base of the plant to its highest point with metric ruler, number of leaves leaf plant^{-1}, shoot dry weight (g), number of days to flowering (day), number of flower stalk (flower stalk plant^{-1}), Number of flower per flower stalk, floret diameter (cm) measured by vernier calipers between two far points, measuring the chlorophyll content of leaves using the Godwin method (1976), carbohydrate (mg 100g $^{-1}$) by using Duboies method (1956), The anthocyanin pigment (mg 100 g^{-1} fresh weight) by method of Abbas and Abbas (1992).

RESULTS AND DISCUSSION

Plant height: There was significant increase in the vegetative growth characteristics by spraying the optimus plus at 8 ml l^{-1} (Table 1). Plant height increased by 30.93 cm, the spraying of red tea at 12 g l^{-1}, resulted in a significant increase of plant height 28.02 cm, compared to control. The overlapping data shows that plant height resulting from the spraying of optimus plus at 8 ml l^{-1} concentration with the extract of red tea at a concentration of 12 g l^{-1} led to a significant increase in highest value of plant height (34.90 cm) compared to non-spray treatment.

The number of leaves: The results in the Table 2 show that a significant increase in the number of leaves (7.11 leaf plants^{-1}) by spraying the optimus plus at 8 ml l^{-1} compared to the control treatment. Plants that spayed with red tea at concentration of at 6 g l^{-1} recorded high number of leaves (6.11 leaf plant^{-1}). The overlap data indicate that the highest value of number of leaves (8.66 leaf plant^{-1}) obtained from optimus plus at 8 ml l^{-1} and red tea at 6 g l^{-1}.

Shoot dry weight: Noted from the data in Table 2 that the spraying of optimus plus at 8 ml l^{-1}, significantly increased shoot dry weight by 2.47 g compared to the control treatment. Also the spraying of red tea at 6 g l^{-1} resulted in a significant increase of the shoot dry weight (2.07 g) as compared to control. It seems clear from the overlapping data that the highest values of 2.64g shoot dry weight recorded in plants resulting from spraying of optimus plus at 8 ml l^{-1} and red tea at 6 g l^{-1}.

Number of flowering days: The results in the Table 2 indicate that the optimus plus sprayed at a concentration of 8 ml l^{-1} reduced the number of days (126) needed for flowering. The spraying of the red tea extract at a concentration of 6 g l^{-1} led to a reduction in the number of days (132.56) required for flowering compared to control. The overlapping data indicate that the plants resulting from spraying of optimus plus at 8 ml l^{-1} concentration with the extract of red tea at a concentration of 6 g l^{-1} led to a significant decrease in number of flowering days (122.67 d) compared to the control.

Number of flower stalks: Noted from the data in the Table 2 that the spraying of optimus plus at concentration of 8 ml l^{-1} has a significant impact on the number of flower stalks (4.78). The spraying of the red tea extract at a concentration of 6 g l^{-1} had no effect of flower stalks. The overlapping data indicate that the plants resulting from spraying of optimus plus at 8 ml l^{-1} concentration with the extract of red tea at a concentration of 6 g l^{-1} led to a significant increase in number of flower stalks (6) compared to the control.

Number of flower per flower stalk: The spraying of optimus plus at 8 ml l^{-1}, significantly increased number of flower per flower stalk by 9.11 compared to the control (Table 2). Also the spraying of red tea at 6 g l^{-1} resulted in a significant increase of the number of flower per flower stalk (8.22) as compared to control. It seems clear from the overlapping data that the highest values of 10.66 flower stalk^{-1} recorded in plants resulting from spraying of optimus plus at 8 ml l^{-1} and red tea at 6 g l^{-1}.

Floret diameter: There was significant increase in the floret diameter (5.94 cm) by spraying the optimus plus at 8 ml l^{-1} (Table 2). Floret diameter increased by 5.61 cm, when spraying plants with red tea at 6 g l^{-1}, compared to control. The overlapping data shows that plant height resulting from the spraying of optimus plus at 8 ml l^{-1} concentration with the extract of red tea at a concentration of 6 g l^{-1} led to a significant increase in highest value of floret diameter (6.60 cm) compared to non-spray treatment.

Leaf chlorophyll, carbohydrate and flower content of anthocyanin: The optimus plus spraying at 8 ml l^{-1} concentration resulted in a significant increase in leaf content of total chlorophyll, carbohydrate content and flower content of anthocyanin pigment of 25.50 mg100 g $^{-1}$ and 7.98 mg g^{-1} and 9.50 mg 100 g $^{-1}$, respectively, compared to the control treatment (Table 3). The results also showed that the red tea extract at a concentration of 12 g l^{-1} showed a significant increase in the above properties of 23.87 mg 100 g^{-1}, 6.96 mg g^{-1}, and 8.82 mg100 g^{-1} compared to the control. It is clear from the overlapping data that the highest values of 27.53 mg 100 g^{-1} and 8.06 mg g^{-1} and 12.37 mg100 g^{-1} resulting from spraying optimus plus spray at a concentration of 8 ml l^{-1} with the red tea extract at a concentration of 6 gl^{-1} compared to the control.

Table 1. Physical-chemical properties of red tea extract

Property	Red tea extract
Foreign matter (% w/w)	1.2±0.1
Color	Purple-red
Taste	Acidic, stringent
Odour	Floral, berry like
Nature	Hard, not easily broken
pH (10% w/v@ 26 C°)	4.5±0.1
Cold water	Readily soluble
Alcohol (96 %)	Soluble
Chloroform	Slightly soluble
Insoluble matter (100 W/W)	0.4±0.02
Total ash (% w/w)	10.0±0.3
Acid insoluble ash (% w/w)	1.4 ±0.1
Moisture content	11.0±0.4
mineral elements	P, K, Fe, Zn, Ca and Mn
Acids	Aspartic acid, Malic acid and citric acid

Table 2. Effects of optimus plus and red tea extract on vegetative and flowering growth of freesia plant

Treatment			Plant height (cm)	Number of leaves plant^{-1}	Shoot dry weight (g)	Days for flowering (day)	Number of flower stalk (flower stalk plant^{-1})	Number of flower per flower stalk	Floret diameter (cm)
Optimus plus (ml l^{-1})		0	22.08	4.33	1.29	135.56	2.33	6.22	4.51
		4	24.98	5.33	2.05	130.44	4.11	8.00	5.55
		8	30.93	7.11	2.47	126.00	4.78	9.11	5.94
LSD values at p=0.05			0.99	0.49	0.22	1.02	0.56	0.44	0.38
Red tea (g l^{-1})		0	23.72	5.00	1.73	132.56	3.44	7.55	5.15
		6	26,24	6.11	2.07	129.67	4.22	8.22	5.61
		12	28.02	5.66	2.00	129.78	3.56	7.55	5.24
LSD values at p=0.05			0.99	0.49	0.22	1.02	NS	NS	NS
Optimus plus (ml l^{-1}) × Red tea (g l^{-1})	0	0	21.67	4.00	1.09	139.00	2.00	5.66	4.26
		6	22.47	4.33	1.39	135.33	2.33	6.33	4.50
		12	22.10	4.66	1.38	132.33	2.67	6.66	4.76
	4	0	23.13	5.00	1.72	132.33	3.33	7.66	5.10
		6	24.73	5.33	2.19	131.00	4.33	7.66	5.73
		12	27.07	5.66	2.25	128.00	4.67	8.66	5.83
	8	0	30.37	6.00	2.39	126.33	5.00	9.33	6.10
		6	31.53	8.66	2.64	122.67	6.00	10.66	6.60
		12	34.90	6.66	2.37	129.00	3.33	7.33	5.13
LSD values at p=0.05			1.72	0.85	0.38	1.76	0.97	0.76	0.65

Table 3. Effects of optimus plus red tea extract on chemical properties of freesia plant

Treatment			Leaves content of chlorophyll (mg 100 g^{-1})	Leaves content of carbohydrates (mg g^{-1})	Leaves content of anthocyanin (mg 100 g^{-1})
Optimums plus (ml l^{-1})		0	20.77	5.46	4.31
		4	23.10	6.66	7.72
		8	25.50	7.98	9.50
LSD values at p=0.05			0.52	0.50	0.66
Red tea (g l^{-1})		0	22.17	6.36	4.95
		6	23.33	6.78	8.76
		12	23.87	6.96	8.82
LSD values at p=0.05			0.52	0.50	0.66
Optimums plus (ml l^{-1}) × Red tea (g l^{-1})	0	0	19.92	4.98	4.47
		6	20.74	5.37	5.68
		12	21.66	5.66	5.77
	4	0	21.92	6.08	5.43
		6	23.35	6.55	8.23
		12	24.02	7.37	9.49
	8	0	24.66	8.03	4.94
		6	27.53	8.06	12.37
		12	24.31	7.87	11.19
LSD values at p=0.05			0.86	0.90	1.15

Overall, good balance nutrition is essential for plant growth and development. It was observed that the addition of optimus plus and red tea extract significantly increased plant height. This may attribute to effective use of nutrients, which led to increase root system then nutrient uptake. Al-Naami (2012) stated that the fertilization with N increased height of plant and leaf production. It has also been reported that the application of optimus plus and red tea extracts increased plant height and number of leaves per plant and shoot dry weight as stated by Al-Mohamadi et al (2013). This is also supported by the work of Frimpong (2008). Our findings are also in agreement with Al-Zurfi (2016) and Hassan et al (2014).

The number of flowering days decreased significantly with foliar application of optimum plus and in red tea extracts. This decrease in flowering days may be related to organic matter and nutrients availability in optimum plus and organic acids such as ascorbic acid in red tea extracts, which has the same effect to gibberellin in encouraging flowering growth and improving the flowering characteristics (Shalata and Neuman 2001).

The increase in number of flower stalks and floret diameters, and decrease in flowering days, may be because the positive effects of nutrients elements (N, P, K and Fe) and ascorbic acid on physiological processes such as photosynthesis, which is very important to speed up the flowering process. It has been reported by Al-Tohamy et al (2008) that may be attributed to red tea extract includes carbohydrate and amino acids, which strongly influenced the number of flowers. Al-Naami (2012) found that carbohydrate and amino acids increased flowers and flowers diameter. He also observed that the addition of red tea extract increased the leaf Carbohydrate, Chlorophyll Contents. Similar result by Razzaq et al (2014) in (marigold), reported that organic matter positively affected the number of flower per plant. These results are in line with those obtained by Hassan et al (2014), Al-Zurfi (2016) and Bhaiah and Al-Zurfy (2016) where they noted that the addition of organic matter increased flowers parameters such as length of the flower stem, flower number plant^{-1}, and flower diameter. Red tea is also has a very rich red pigmentation due to the presence of anthocyanins (Cisse et al 2012), which is responsible for the intense coloration of red tea extract. Application of red tea extract increased chlorophyll and carbohydrate; this may attribute to the important role of ascorbic acid (Antioxidants) in preventing the demolition of chlorophyll pigment, and then increased the leaf chlorophyll and carbohydrate content. Similar result was obtained by Al-Mohamadi et al (2013). It has been reported by Abbass et al (2015) that foliar application with organic extracts increased total chlorophyll content of plant leaves and total soluble carbohydrates. These increases because the red tea extract contains macro and micro nutrients such as calcium, magnesium, potassium, manganese, copper, iron and zinc. Also may be attributed to considerable amount of nitrogen (3% organic N and 3% in-organic N) as well as organic matter present in optimus plus which makes nutrients readily available to the plant.

Based on the findings of this experiment, it is recommended that optimus plus at 8 ml l^{-1} and red tea at 6 g l^{-1} should be used for better vegetative and flowering growth of Freesia, although further studies may also be carried out with higher doses of these organic matters to test other levels and avoid chemical fertilizers.

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Spatial Mapping of Rice Crop Evapotranspiration in Godavari Command Area

Mahesh Palakuru, Sirisha Adamala[1] and Harish Babu Bachina[2*]

School of Civil Engineering, Vellore Institute of Technology (VIT), Vellore-632 014, India
[1]Natural Resources Management Division, Central Island Agricultural Research Institute (CIARI) Port Blair-744 105, India
[2]Department of Applied Engineering, Vignan's Foundation for Science, Technology and Research (VFSTR) University, Vadlamudi -522 213, India
[*]E-mail: bachina.harish@gmail.com

Abstract: The aim of this paper is determining potential rice crop evapotranspiration (ET_c) using satellite data in Godavari irrigation command area of Andhra Pradesh, India. ET_c was estimated from reference evapotranspiration (ET_o) and crop coefficient (K_c). ET_o estimated using agro-meteorological data (measured maximum and minimum air temperatures) according to FAO-24 modified Blaney-Criddle method. The K_c maps were mapped in Arc GIS software using Normalized Difference Vegetation Index (NDVI). Red (R) and Near Infra-Red (NIR) measurements of MODIS image were used to calculate NDVI. Further, the ET_c map was obtained by multiplying K_c map with the ET_o map. The maximum ET_c computed for Rice crop was 6.04 mm/day, whereas the minimum was 2.22 mm/day for the Godavari command area.

***Keywords*:** Crop coefficient, MODIS, Reference evapotranspiration, Remote sensing, Vegetation index

In arid and semi-arid regions potential crop evapotranspiration is a good index for crop water requirements calculation and for effective water management. Increasing water scarcity has lead to increased pressure on irrigation engineers to utilize water resources for irrigation more efficiently (Adamala et al 2014). Unfortunately, for effective water management, large irrigation schemes need up-to-date real time information on the irrigated area, the crops being grown within the command area of each canal and also the data on the amount of water being used by each crop (crop water requirement or crop evapotranspiration). This information is not easy to obtain as many irrigation schemes are vast, cover hundreds and sometimes thousands of square miles and have vast numbers of farms; their scale severely limiting the effectiveness of data collection. Geographical information systems (GIS) technology in conjunction with remote sensing (RS) has proved to be effective for identification of crops and land use (Palakuru et al 2020). For effective management of water, stressing the need for generation of spatial and non-spatial database by integrating the RS and GIS technologies with ground data is essential. Many researchers have used the integrated RS, GIS and temporal data to map crop evapotranspiration (ET_c) in command areas (Ray and Dadhwal 2001, Hassan et al 2005, Singh and Irmak 2009, Irmak et al 2010, Adamala et al 2016). This study was conducted to estimate the crop evapotranspiration through RS and GIS techniques for Godavari irrigation command area. The present study was undertaken to estimate ET_c of Godavari command area in Andhra Pradesh using RS and GIS techniques.

MATERIAL AND METHODS

Study area description: East and West Godavari districts of Andhra Pradesh are rich in crop production area and are blessed with good water resources. Godavari River is the main source of water for irrigation in the study area. The total geographic area of study area is around 20547 km^2. The study area located in between 80^{0}21'39" E to 82^{0}21'48" E longitude and 16^{0}25'50" N to 18^{0}90'0" N latitude at the seashore of Bay of Bengal. Agriculture is the main source of income to the people and principle crop grown in study area is rice crop. East Godavari and West Godavari are occupied with the highest position in rice production in Andhra Pradesh state. Figure 1 shows the location of study area.

Data used: Since the dominant crop of the study area is rice, multi-spectral and multi-temporal satellite imagery based on crop calendar for *Kharif* season were procured from MODIS. The toposheets of Samalkot, where the Godavari command area falls required for this study were obtained from University of Texas Libraries (http://www.lib.utexas.edu /maps/ams/india/). The topo maps were also used to geo-reference the satellite images. The satellite imageries after being geo-referenced with topo sheets were digitally enhanced to extract appropriate information (Lillesand and Kiefer 2000). Details about various satellites images and climatic data used in this study are mentioned in Table 1. The software used for processing various satellite images and conducting this study were include: ERDAS Imagine 9.1, Arc GIS 9.3, and Google Earth Pro.

Calculation of reference evapotranspiration (ET_o): The collected meteorological data was used to compute ET_o using FAO-24 modified Blaney-Criddle method (Eq. 1). The reason for selecting this method for computation of ET_o because of its simplicity and easy availability of data.

$$ET_o = p\,(0.46 \times T_{mean} + 8) \quad (1)$$

Where, ET_o = reference crop evapotranspiration (mm day^{-1}) as an average for one month, T_{mean} = mean daily air temperature (°C), p = mean daily percentage of annual daytime hours.

Calculation of crop coefficients (K_c): The crop coefficients for various major crops grown in Godavari command area can be estimated empirically from the remote sensing derived vegetation index i.e. normalized difference vegetation index (NDVI) values. The information on spectral radiance and reflectance for Red and Near-Infrared bands of MODIS data are required prior calculation of NDVI. Spectral radiance is the outgoing radiation energy of the band as observed at the top of the atmosphere by the satellite. The four steps in order to calculate K_c is provided in detail below:

Step 1: Conversion from digital number to spectral radiance as:

$$L = \frac{(L_{max} - L_{min}) \times (Q_{cal} - Q_{calmin})}{(Q_{clamx} - Q_{clamin})} + L_{min} \quad (2)$$

Where, L = spectral radiance at the sensor aperture (watt m^{-2} $ster^{-1}$ μm^{-1}), L_{max} = spectral radiance scaled to Q_{calmax} (watt m^{-2} $ster^{-1}$ μm^{-1}), L_{min} = spectral radiance scaled to Q_{calmin} (watt m^{-2} $ster^{-1}$ μm^{-1}), Q_{cal} = quantized calibrated pixel value (DN), Q_{calmin} = minimum quantized calibrated pixel value corresponding to L_{min}, Q_{calmax} = maximum quantized calibrated pixel value corresponding to L_{max}.

Step 2: Conversion from radiance to reflectance as:

$$r = \frac{\pi \times L \times d^2}{E_{sun} \times \cos\theta \times d_r} \quad (3)$$

Where, r = planetary reflectance (dimensionless), L = spectral radiance at the sensor aperture (watt m^{-2} $ster^{-1}$ μm^{-1}), d_r = inverse square of earth-sun distance (astronomical unit)

$$d_r = 1 + 0.033 \cos (D \times 2 \times 3.14)/365) \quad (4)$$

Where, D = day of the year, E_{sun} = mean solar atmospheric irradiances (watt m^{-2} μm^{-1}), θ= solar zenith angle (degree), $\theta = (90 - \beta)$, and β = sun elevation angle.

Step 3: Computing NDVI from reflectance as:

NDVI is a simple numerical index to assess the presence of live green vegetation. NDVI takes the value from -1 to 1. The higher the NDVI, higher the fraction of live green vegetation present in the scene. The model for calculating NDVI for each pixel from classified map is given below:

$$NDVI = \frac{NIR - R}{NIR + R} \quad (5)$$

Where, NIR = reflectance in near infrared wavelength and R = reflectance in red wavelength.

Step 4: Computing crop coefficients (K_c) as:

The method proposed by Brunsell and Gillies (2002) to obtain the K_c values for Rice crop was used here. The method computes the K_c based on fraction of vegetation cover and fraction between the emissivity of bare soil and a full canopy.

$$N = \frac{(NDVI - NDVI_0)}{(NDVI_{max} - NDVI_0)} \quad (6)$$

Where $NDVI_0$ = bare soil NDVI value of the MODIS scene and $NDVI_{max}$ = maximum NDVI of the scene corresponding to full cover dense vegetation.

Then crop coefficient becomes, $K_c = N^2$ (7)

Calculation of crop evapotranspiration (ET_c): The calculated ET_o from FAO-24 modified Blaney-Criddle method is combined with developed K_c maps to compute crop evapotranspiration for the study area.

$$ET_c = K_c \times ET_o \quad (8)$$

Table 1. Data used for this study

Satellite data			
Satellite	Sensor	Row/Path	Date of passing
MODIS	TM	139/44	2018-01-05
CORDEX	-	-	2018
Toposheet			
Samalkot: Scale: 1:2,50,000 (NE-44-11)			
Meteorological data			
Latitude of Godavari command area			
Daily minimum and maximum air temperatures for January, 2018			

RESULTS AND DISCUSSION

Rice crop area maps: The crop acreage for Godavari irrigation command area was estimated from the satellite imageries and this was based on the unsupervised classification in ERDAS Imagine software. It is found that the downstream area of the study area is dominated with more rice crop area as compared to the upstream area (Fig. 2).

Crop coefficient (K_c) maps: The NDVI maps were generated for rice cropped area of Godavari irrigation command, which have monitored for ground truths also. Figure 3 shows the K_c mapped values for rice crop in the study area. The maximum K_c computed was 0.98, whereas the minimum was 0.36. As per FAO guidelines, the K_c values of rice crop for the initial, middle and end of crop stages were 1.05, 1.2 and 0.9-0.6, respectively (Allen et al 1998). The ground truth data revealed that most of rice crop during the

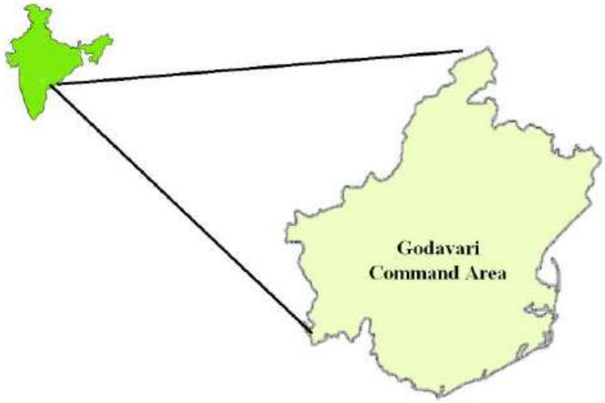

Fig. 1. Location map of study area

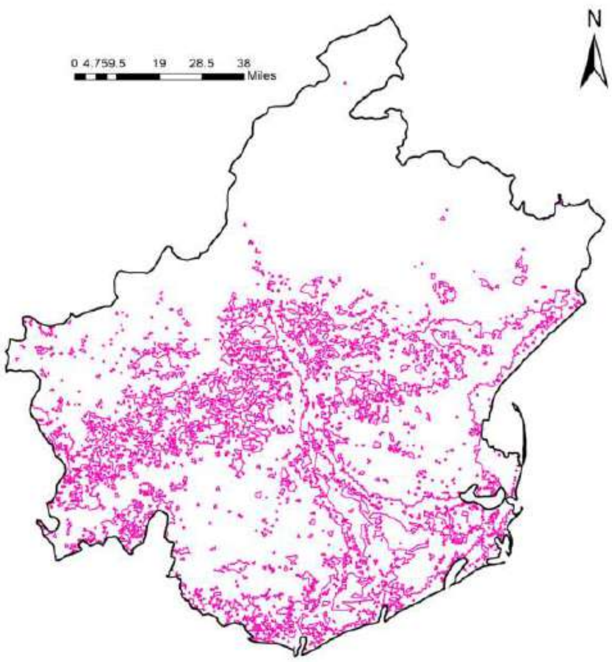

Fig. 2. Rice crop area map generated for Godavari command area

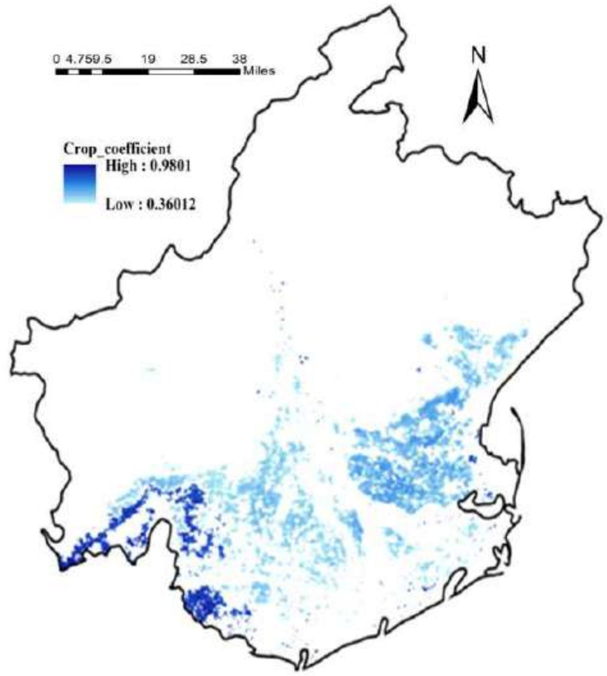

Fig. 3. Crop coefficient map generated for study area

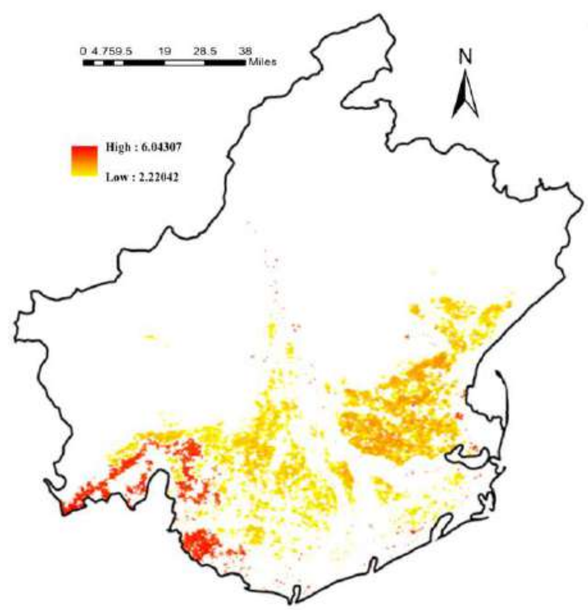

Fig. 4. Crop evapotranspiration map generated for the study area

study period was in middle and end stage. Therefore, it is found that the calculated K_c values for the rice crop for the study area are matching with the FAO guidelines.

Rice crop evapotranspiration (ET_c) maps: ET_o values for January month were computed using FAO-24 modified Blaney-Criddle method (Eq. 1). The output of the pixel-wise K_c map was multiplied with computed ET_o to generate the ET_c maps. Fig. 4 shows the ET_c map generated from the clipped study area. The ET_c map was obtained by multiplying K_c map with the ET_o i.e. 6.17 mm day^{-1}. The maximum ET_c computed for Rice crop was 6.04 mm/day, whereas the minimum was 2.22 mm day^{-1}.

CONCLUSION

The ET_c of the rice crop grown in Godavari irrigation command area of West Bengal, India was estimated based on NDVI vegetation index of MODIS images (K_c maps) and the ET_o for irrigation command area. K_c maps were generated from NDVI values for January 2018 of the rice crop season. The maximum K_c computed was 0.98, whereas the minimum was 0.36. The maximum ET_c computed for Rice crop was 6.04 mm day^{-1}, whereas the minimum was 2.22 mm day^{-1}. Therefore, the information generated can be used to supply an appropriate amount of irrigation water at different locations of irrigation command as per the actual crop water demand. This will save a considerable amount of water supplied in the late growth stage of the crop and improve the application efficiency of the canal system. The study shows new vistas for application of Remote Sensing and GIS in water management of Rice crop.

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Survey of Yield Losses by *Orobanche crenata* in Carrot (*Daucus carota* L.) in Morocco

Toufik Chedadi, Omar Idrissi[1], Mohammed Elhansali and Abdelmajid Haddioui

Laboratory of Biotechnology and Valorization of Plant Genetic Resources, Faculty of Sciences and Techniques, University of Sultan Moulay Slimane, Beni Mellal, Morocco
[1]Laboratory of Food legumes breeding, Plant Breeding and Genetic Resources Conservation Research Unit, National Institute for Agronomic Research (INRA), Regional Center of Settat, Morocco
E-mail : toufik.chedadi@gmail.com

Abstract: The carrot (*Daucus carota* L.) plays important socio-economic role in Morocco. Recently, frequent attacks by the parasitic plant *Orobanche crenata* has been reported and the infestation is increasingly observed in recent years causing huge damages. The results of study show that the parasitic weed attacks reduced root weight, root length and root diameter in carrot. Average reduction was 19.98, 20.04 and 9.10 %, respectively. Furthermore, *O. crenata* affects the end-quality of carrot roots. This causes total yield decrease resulting in significant economic losses and thus reducing growers' incomes. Total yield losses dues to *O. crenata* infestation ranged from 21 to 27 t/ha corresponding to monetary values of about 2600 and 3400 USD ha^{-1}. To overcome this situation, there is an urgent need for effective control methods to limit the infestation and reduce the losses.

***Keywords*:** Carrot, *Orobanche crenata*, Yield, Yield losses, Economic losses

Broomrape is an obligate holoparasitic plant. It lacks chlorophyll and normal roots (Zouhaier et Kharrat 2006) and is present in Europe, the Mediterranean regions, the center of Asia and some African countries (Klein et Kroschel 2002). The genus *Orobanche* contains more than 150 species (Musselman 1980), only five species are the most dangerous for agriculture namely: *Orobanche crenata*, *Orobanche cumana*, *Orobanche aegyptiaca*, *Orobanche ramosa* and *Orobanche minor* (Perez-de-Luque et al 2004). They cause huge damages for crops ranging from 5 to 100 % of losses (Habimanaa et al 2014). They attack several species of dicotyledonous plants worldwide (Punia 2014). The *Orobanche* species attack the families of *Cucurbitaceae*, *Apiaceae, Solanaceae, Fabaceae and Asteraceae*.

In Morocco five species: *Orobanche crenata*, *O. aegyptiaca*, *O. ramosa. O. foetida* and *O. cumana* are documented (Saffour 2003, Naboulsi 2017). The *O. crenata* considered the most dangerous parasite of legumes (Saffour et al 2004, Bouhache et al 2007, El Yousfi 2016). Its first infestation was reported in 1943 on faba bean in the Fez region (northeastern Morocco), afterwards it extended to all major areas of legumes: Zaer and Gharb regions (northwestern Morocco), Sais and Pre-Rif (northern central Morocco), Chaouia-Abda-Doukalas regions (western-northcentral Morocco), Tadla and Haouz regions (central Morocco) (Grenz et Sauerborn 2007). *O. crenata* became after a limiting factor for other legumes especially lentil, chickpea (Saxena 1991, Mabsoute et Saadaoui 1996, Tanji 2003) and pea. Recently, the *O. crenata* is repellent to carrot (*Daucus carota* L.). It infested the Chaouia and Doukkala regions (Chedadi et al 2019) and it causes quantitative and qualitative enormous damages. The carrot is considered among the important crops in Morocco because it plays vital socio-economic role in the region of production and especially in the Chaouia area. It generates incomes for growers and creates an important number of jobs. The crop carrot occupies an acreage in Morocco between 8000 to 9000 ha spread in the regions of: Doukkla (western-central), Chaouia (north-central), Gharb (northwestern), Saïs (northern central) and Souss (western south) (Mojahid 2014). The areas attacked by *O. crenata* increase rapidly and the yields are decreasing due to this parasite. In the absence of such information and study about losses in Morocco, we target to study and to report on how important are yield and its components losses under infestation? And to estimate economic losses dues to this problematic parasitic weed in Morocco.

MATERIAL AND METHODS

Genetic material, experiment and site description: The study related to yield losses in 3 clay soil carrot fields in Chouia (4000 Ha of carrot) located in central Morocco, latitude 33°15'35"N, longitude 7°34'48"W and altitude 221 m. The experimental was in split plot design with 2 treatments (*O. crenata* infested and control treatments) and 3 replications each. Each plot was 1m² with a density of 170 plants m^{-2}. Two hybrid varieties, which are the most grown carrot varieties in Morocco, were used in this study. The previous cultivated crops in the three fields were faba bean for the field 2 and wheat for the fields 1 and 3. The date of sowing was 1 November 2017 (winter carrot). To carry out this study, the root weight, diameter and circumference of healthy and infested plants were measured in each plot. Student T-test was used to compare group means of infested and control treatments for all studied variables. SPSS Statistics (version 22) and Excel Microsoft office were used for data analysis and results presentation.

RESULTS AND DISCUSSION

Yield losses in *O. crenata* infested carrot fields in Morocco: Statistically significant differences were obtained for root weight, root length and root circumference in infested and control (Table 1).

O. crenata attacks decreased the average root weight per plant and was 164.00, 122.00 and 141.83 g for the control plots, while it was 131.67, 103.33 and 107.33 g for three infested plots, respectively (Table 2) correspond to 19.71, 15.30 and 24.32 % as percentages of reduction under *O. crenata* infestation. Carrot yield estimated by the average total root weight in kg per m² was also reduced by the parasitic plant infestation in the three fields (Table 2). The root yield ranged from 21.90 to 24.62 kg/m² and from 17.69 to 20.73 kg/m² for the control and the infested plots, respectively. *O. crenata* damages on yield were higher for the fields 2 and 3 compared to field 1. The percent root yield was reduced by 15.66, 19.22 and 20.67 % in fields respectively. The highest loss in total clean roots (not infected roots) corresponding to the real yield was observed in the field 3 with about 28.08 % of decrease (Table 2).

Root length was higher in control fields being 17.83, 16.76 and 17.58 cm against 15.81, 12.87 and 13.03 cm for the *O. crenata* infested plots respectively. The percentage of reduction was 11.33, 23.21 and 25.88 % respectively (Table 3). The diameter of infected carrot root was reduced (Fig. 1 a). In control plots, the latter was diameter was 14.32, 13.78 and 13.75 cm for the fields 1, 2 and 3, respectively and under *O. crenata* infestation. It was reduced by 9.91, 9.79 and 7.56 per cent. In addition to the decrease of root weight, length and circumference, *O. crenata* infestation causes severe wilting of both carrot roots and shoots (Fig. 1 b, c). The damage to carrot roots was higher when the infestation started at younger plant stages. The holes corresponding to attachment points of *O. crenata* in carrot roots were observed to host other biotic pests and development points of decays and rots. These damage the end-quality of carrot roots reducing their market value and considered as total wastage. The farmers often throw away such infected carrot plants.

Table 1. Student T test for infested and clean check group' means comparison

	Field 1		Field 2		Field 3	
	T score	Sig.*	T score	Sig.*	T score	Sig.*
Root weight (g plant^{-1})	3.14	0.035	2.87	0.045	7.57	0.002
Total root weight (kg m^{-2})	5.80	0.001	2.87	0.045	3.27	0.031
Root length (cm)	5.44	0.006	3.05	0.038	4.82	0.008
Root circumference (cm)	4.78	0.009	5.23	0.006	4.26	0.013

*Sig.: Significance at Pr<0.05

Table 2. Average carrot root weight in *O. crenata* infested and control field plots

Parameter		Average root weight (g plant^{-1})	Average total root weight (kg m^{-2})	Total root weight (kg m^{-2}) not affected
Field 1	Infested	131,67	20,73	17,78
	Clean check	164,00	24,58	24,58
Field 2	Infested	103,33	17,69	16,80
	Clean check	122,00	21,90	21,90
Field 3	Infested	107,33	19,53	17,72
	Clean check	141,83	24,62	24,62

Table 3. Average carrot root length and circumference under *O. crenata* infested and control treatments

Parameters		Average root lenght (cm)	Average root circumference (cm)
Field 1	Infested	15,81	12,90
	Clean check	17,83	14,32
Field 2	Infested	12,87	12,43
	Clean check	16,76	13,78
Field 3	Infested	13,03	12,71
	Clean check	17,58	13,75

Economic analysis of yield losses: The average carrot root yield for control plots ranged from 118 to 133 t ha^{-1} with average of 128 t ha^{-1} with average value of 160000 dh ha^{-1} (≈16000 USD/ha). Yield losses due to *O. crenata* infestation in carrot could be considered in two ways: root weight decrease and quality. When carrot root weight decrease, yield for infested plots ranged from 95 to 112 t ha^{-1} with an average of 104 t ha^{-1} (Table 4) corresponding to total yield losses of about 24 t ha^{-1} compared to the control resulting in an average monetary loss of more than 29600 dh ha^{-1} (≈3000 USD ha^{-1}). This corresponds to around 18.5% decrease in the yield monetary value. When losses as grade-outs (removed infected carrots), the average yield for infested plots was estimated to 94 t ha^{-1}corresponding to average yield losses of about 34 t ha^{-1} which is 26% decrease compared to control plots.

Table 4. Yield losses and corresponding economic values estimation due to *O. crenata* attacks in carrot fields*

Parameters	Field 1	Field 2	Field 3	Mean
Yield estimation for control plots (t ha^{-1})	132.71	118.26	132.92	127.96
Corresponding yield value for control plots (dh**ha^{-1})	165881	147825	166154	159953.33
Assuming yield losses as carrot root weight decrease:				
Yield estimation for infested plots (t ha^{-1})	111.92	95.50	105.42	104.28
Corresponding yield value for infested plots (dh ha^{-1})	139894	119371	131781	130348.66
Total yield losses estimation (t/ha)	20.79	22.76	27.50	23.68
Corresponding value for total yield losses (dh ha^{-1})	25988	28454	34373	29605
Percentage losses of yield value (%)	15.67	19.25	20.69	18.53
Assuming yield losses as removed infected carrots:				
Yield estimation for infested plots (t/ha)	95.99	90.68	95.66	94.11
Corresponding yield value for infested plots (dh ha^{-1})	119981	113348	119579	117636
Total yield losses estimation (t ha^{-1})	36.72	27.58	37.26	33.85
Corresponding value for total yield losses (dh ha^{-1})	45900	34477	46575	42317.33
Percentage losses of yield value (%)	27.67	23.32	28.03	26.34

*Average price of carrot was assumed to be 1.25 dh kg^{-1}; **dh: Moroccan dirham; 1 dh ≈ 0.092 Euro ≈ 0.10 USD

Fig. 1. Infected carrot plants showing *O. crenata* damages on shoots and roots (wilting on shoots and roots: c and b; root length and circumference reduction: a, black and white lines show the reduced root length and circumference, respectively, of the infected plant compared to the two healthy plants)

The average percentages of reduction of 19.98, 20.04 and 9.10 %, respectively for root weight, root length and root diameter were observed. These cause total yield losses ranging from 21 to 27 t ha^{-1} corresponding to monetary values of about 2600 and 3400 USD/ha. Bernhard (1998) reported that the yield loss in carrot fields infested by *O. crenata* and *O. aegyptiaca* reach more than 50 %. Higher loss percentages ranging from 40 to 80% were observed by Donogla et al (2011) in Sudan. Under high infestation rates, total yield loss in carrot could be caused by broomrape (Cochavi et al 2017). Bouhache and Dahan (2008) reported percentages of yield losses due to *O. crenata* infestation in Morocco of 5 to 100 for faba bean, up to 50 for pea and up to 30 for lentil. Host above ground biomass reduction was reported for faba bean, field pea and grass pea by Fernández-Aparicio et al (2016).

CONCLUSION

O. crenata significantly reduced weight, diameter and length of infested roots and consequently penalized the yield in quantity and quality. The reduction in yields has a negative impact on the income generated by growers, which the future of carrot crop in high or medium infested areas is threatened and it will be a limiting.

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Economic Analysis of Carnation under Protective Cultivation: A Study of Mid Hills Zone of Himachal Pradesh

Arshdeep Singh Chahal, Ravinder Sharma and Kapil Dev

Department of Social Sciences, Dr. Y.S Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, India
E-mail: sharmakapil2222@gmail.com

Abstract: Economic analysis of Carnation under protective cultivation in Solan district of mid hill zone of Himachal Pradesh revealed that under Socio-economic indicators majority of the sample households have nuclear families and at overall level the average family size was 5.33 persons, out of which 55 per cent were males and 45 per cent females. The average size of land holding on the overall category was found 3.34 hectares of which 23.01 per cent was cultivated area. It can be referred from the analysis that average cost of production of carnation per cut stem varied between Rs. 0.53 to Rs. 0.55. The net returns from the production of carnation cut stems were Rs. 3,11,348.30 under 500 m^2 polyhouse, whereas, under 2000 m^2 it was Rs. 12,79,504.72. The net present value of carnation was found to vary between Rs. 9,21,328 to Rs. 42,91,301 under different sizes of non-subsidized polyhouses. Whereas, under subsidized polyhouses, it ranged from Rs. 10,31,093 to Rs. 46,80,471 under 20 years life of polyhouse. Benefit cost ratio under subsidized polyhouses of 500 m^2 to 2000 m^2 varied 1.54 to 1.66 with an internal rate of return 31 to 37 per cent. Similarly BCR varied from 1.45 to 1.57 under different sizes of non-subsidized polyhouses with an internal rate of 27 to 33 per cent. Therefore production of carnation cut stems under subsidized and non-subsidized polyhouses is feasible and profitable.

***Keywords*:** Family size, Cost of production, Net returns, Benefit cost ratio

Agriculture is the backbone of Indian economy and experiences during the last 50 years have demonstrated the strong correlation between agricultural growth and economic prosperity. Every Indian farmer faces a unique challenge in undertaking agriculture. Indian farming and nursery are highly dependent on open field seed production because of the low economic status of the farmers; the seedlings are being grown under natural conditions, which are susceptible to sudden changes in climate, affecting their quality and yield is both. The country faces major challenges to increase its food production to the tune of 300 million tons by 2020 in order to feed its ever-growing population, which is likely to reach 1.30 billion by the year 2020. There is a need to have a new and effective technology which can improve continuously the productivity, profitability, sustainability of the farming systems. One such technology is the green house technology, although it is centuries old but it is new to India. Green house protects crops from extreme climatic factors like temperature, high winds, heavy rains, storms, insects and diseases. Green house can provide answers for around the year cultivation under climatic uncertainties and price fluctuations. Greenhouses are framed or inflated structures covered with transparent or translucent material large enough to grow crops under partial or full controlled environmental conditions to get optimum growth and productivity. Greenhouse production is one of the best methodologies which have replaced outdoor plant beds. In some of the temperate regions, where the climatic conditions are extremely adverse and no crops can be grown, man has developed methods of growing some high value crop continuously by providing protection from the excessive cold, which is called as Greenhouse Technology. So, Greenhouse Technology is the technique of providing favourable environment conditions to the crops. It is rather used to protect them from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases. There are more than 50 countries in the world where cultivation of crops is undertaken on a commercial scale under cover. In Asia, China and Japan are the largest users of greenhouses. In India use of greenhouse technology started only during 1980's and it was mainly used for research activities. This may be because of our emphasis, so far had been on achieving self-sufficiency in food grain production. However, in recent years in view of the globalization of market and tremendous boost and fillip that is being given for export of agricultural produce, there has been a spurt in the demand for greenhouse technology. Greenhouses are being built in the Ladakh region for extending the growing season of vegetables from 3 to 8 months. In the North-East, greenhouses are being constructed essentially as rain shelters to permit off-season vegetable production. In the Northern plains, seedlings of vegetables and flowers are being raised in the greenhouses either for capturing the early markets or to improve the quality of the seedlings. India is the second largest producer of vegetable crops in the world. However, its vegetable production is much less than the requirement if balanced diet is provided to every individual. The present production of 90.8 million tonnes (ICAR 2002) is to be raised to 250 million tonnes by 2024-2025. There are different ways and means to achieve this target such as, bringing additional area under vegetable crops, using hybrid seeds and use of improved agro-techniques. Another potential approach is perfection and promotion of protected cultivation of vegetables (Singh 1998, Singh et al 1999).

Agriculture is the mainstay of the economy of Himachal Pradesh contributing around 22 per cent to the state income and engaging 67 per cent of the working population. Because of predominance of hilly terrain, only 11 per cent of total geographical area of 55.7 lakh ha is available for cultivation. Around 86.4 per cent of the land holdings are marginal and small and the average size of holding is around 1.04 ha which is decreasing continuously due to increasing population pressure on limited arable land. Protected cultivation involves protection of from adverse environmental conditions and offers distinct advantages of quality, productivity and favourable market price to the growers (Singh et al 2002). In the times to come, protected vegetable production is likely to be common commercial practice not only because of its potential but out of sheer necessity.

In Himachal Pradesh, the polyhouse technology was popularized among the farmers with the implementation of 'Pandit Deen Dayal Kisan Baagwan Samridhi Yojna' amounting to Rs 353 crore. There are other types of subsidies in Himachal Pradesh, one is Horticulture mission for North-eastern and Himalaya states. It is a center-sponsored scheme and under this 50 percent subsidy is provided to the farmers for greenhouse construction. The second scheme is run by the state government where 80 per cent subsidy is provided to the farmers for greenhouse construction. A significantly large number of playhouses have been constructed in different districts of the state. Therefore, the study was undertaken with the specific objectives to study the cost and return structure of carnation under polyhouse cultivation and to study the financial feasibility of carnation under polyhouse cultivation.

MATERIAL AND METHODS

Polyhouse cultivation is done mostly in every districts of Himachal Pradesh. For the present study Solan district of mid hill zone was selected purposely. Production areas in the Solan district were identified and from a list of polyhouse growers obtained from Directorate of Horticulture and Agriculture, Solan. A sample of 40 polyhouse growers of different sizes was selected for the study. The distribution of the polyhouse growers is presented in Table 1.

Nature and source of data: The data were collected with the aid of structured and comprehensive questionnaire exclusively prepared for the study. The primary data collected included information on age, education, occupation, family size, land holding, etc. The data were collected through a personal interview method from the selected households in the study area during the year 2016-17. Secondary data of polyhouse growers were collected from the Directorate of Horticulture and Agriculture Solan; prices of flowers and different government policies were collected from different offices.

Analytical framework: To fulfil the specific objectives of the study and based on the nature and extent of availability of data, analytical tools and techniques have been employed for the analysis of the data. Simple tabular analysis was used to examine socio-economic status, their resource structure, income patter. Tabular presentation was adopted to compile the general characteristics of the sampled farmers.

Simple statistical tools like averages and percentages were used to compare, contrast and interpret the results. The sex ratio, literacy rate and index were calculated using the following formulas:

$$\text{Literacy rate (\%)} \ \frac{\text{Total number of literate persons}}{\text{Total population} - \text{Population below 5 years}} \times 100$$

$$\text{Literacy Index} = \frac{\sum_{i=1}^{n} W_i X_i}{\sum_{i=1}^{n} W_i}$$

Where; W_i = Weights (0, 1,2,3,4 and 5) for illiterate, primary, middle, matric, secondary and graduate and above respectively.

X_i = Number of persons in respective category.

$$\text{Dependency ratio w.r.t total workers} = \frac{\text{Number of dependents}}{\text{Total workers}}$$

$$\text{Dependency ratio w.r.t average family size} = \frac{\text{Number of dependents}}{\text{Average family size}}$$

$$\text{Cropping intensity (\%)} = \frac{\text{Gross Cropped Area}}{\text{Net Sown Area}}$$

To evaluate the financial feasibility of investment in polyhouse economic indicators, viz., net present value, benefit cost ratio and internal rate of return were used, with the following equation/formulas.

$$\text{NPV} = \sum_{t=1}^{n} \frac{B^t - C^t}{(1+r)^t}$$

Where, NPV = Net present value in period't'

B_t = Benefit from polyhouse cultivation in each year

C_t = Cost of polyhouse cultivation in each year

r = Discount rate

t = 1,2,3…. n, the entire life of polyhouse across the study regions.

n = number of years

BCR

$$BCR = \frac{\sum_{t=1}^{n} \frac{B^t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C^t}{(1+r)^t}}$$

IRR

$$\sum_{t=1}^{n} (B_t - C_t)/(1+r)^t = 0$$

Pay Back Period

$$PBP = \frac{\text{Investment}}{\text{Net annual cash flow}}$$

RESULTS AND DISCUSSION

Polyhouse size wise demographic profile of sampled households: The size and structure of the family, work force and literacy status are among the important factors influencing the polyhouse cultivation. These factors determine the socio-economic well-being of the family that plays a vital role in farm business and marketing activities. The size and structure of sampled households in the study area has been presented in Table 2. The perusal of table shows that at overall level, the average family size was 5.33 persons, out of which 55.00 per cent were males and 45.00 per cent females. It was found that across the different sizes of polyhouse growers average family size was same.

The per cent of literates varied from 75.00 to 90.00 in different categories. The overall literacy rate varied from 91.51 to 97.35 per cent among different farm categories. However, literacy index varied 3.34 to 3.68 among the different categories of the farms with an overall index of 3.50. This highlights the fact that literacy rate in the study areas is higher, along with average level of quality of education, since literacy index lies between 0-5.

Per household occupational structure of the selected households is noted from the table that agriculture is the main occupation as 85.54 per cent of work force practice farming.

Table 1. Polyhouse size wise distribution of sampled households in study area

Category of farmers	Size of polyhouse (m^2)	No. of farmers	Percentage of farmers
Marginal	<500	7	17.50
Small	500-1000	6	15.00
Medium	1000-2000	15	37.50
Large	>2000	12	30.00
Total		40	

Table 1. Polyhouse size wise demographic profile of sampled households

Particulars	Size classes				
	Small	Semi-medium	Medium	Large	Overall
Average size of family (No)	5.71	5.33	5.13	5.33	5.33
Number of males (%)	55.00	59.38	53.25	56.25	55.40
Number of females (%)	45.00	40.63	46.75	43.75	44.60
Structure of family					
Joint families (%)	42.86	66.67	46.67	66.67	55.00
Nuclear Families (%)	57.14	33.33	53.33	33.33	45.00
Educational status					
Illiterate (%)	2.50	6.25	5.19	7.81	5.63
Non School Going (%)	7.50	18.75	16.88	9.38	13.15
Literate (%)	90.00	75.00	77.92	82.81	81.22
Literacy rate (%)	97.35	92.38	93.90	91.51	93.52
Literacy Index of the families	3.68	3.38	3.34	3.60	3.50
Occupational status (%)					
Service	5.88	0.00	5.26	1.96	3.62
Business	11.77	25.00	5.26	9.80	10.84
Agriculture	82.35	75.00	89.48	88.24	85.54
Average no. of workers	4.86	3.67	3.80	4.25	4.10
Dependency ratio w.r.t. total workers	1:5.56	1:2.22	1:2.86	1:4.00	1:3.33
Dependency ratio w.r.t. family size	1:6.67	1:3.23	1:3.85	1:5.00	1:4.35

On an average 10.84 per cent workers population was engaged in business as secondary occupation at overall level followed by services in private/public sectors. Similar trends in occupational distribution were observed on small and large categories. In case of medium category service and business were preferred equally, while members of the semi-medium category were engaged in business (25%).

The overall dependency ratio with respect to total workers was found to be 1:3.33 and among the different categories, it was observed highest in case of semi-medium category (1:2.22) followed by medium (1:2.86) and large (1:4.00) category and lowest in small category (1:5.56). Dependency ratio indicates that on an average one worker has to support more than one member in the family in the sampled area. Dependency ratio estimated with respect to family size was found 1:4.35 on an average level in the study area.

Land use pattern: Land use pattern determines the type of farming system in an area. Polyhouse size wise land use pattern of sampled farmers is summarized in Figure 1 and 2.

The average size of land holding on the overall category was found 3.34 hectares of which 23.01 per cent was cultivated area. The other uses of land in the study area were pastures/ *ghasnis* (45.92%) and barren land (31.07%). The cultivated land varied from 19.91 to 28.17 per cent among the different categories. The average size of holding on small, semi-medium, medium and large categories was found to be 2.51, 3.53, 2.50 and 4.78 hectares respectively which show that there was no relationship between polyhouse size and holding size.

Initial capital investment: Polyhouse farmer is required to have sufficient knowledge about the protective production technology and understanding of the economics of crop cultivation. The initial capital investment for constructing different sizes of polyhouses was estimated and results have been presented in Table 3 that total initial investment on different sizes of polyhouses varied from Rs. 5,53,545 to Rs. 18,63,055 showing a positive relationship with size of polyhouse. Of the total cost 91.62 per cent was cost of polyhouse and 8.38 per cent on major and minor implements in case of 500 m^2 polyhouse. The proportion of polyhouse cost varied between 91.62 to 95.50 per cent among the different sizes of polyhouses. The analysis revealed that polyhouse cultivation is capital incentive and requires higher investments. Government of Himachal Pradesh thus provides subsidies to the farmers to set up polyhouses which varies from 50 to 85 per cent of total cost under different schemes.

Cost and returns of carnation from polyhouse cultivation: Average cost composition of carnation under different sizes of polyhouses was presented in Table 4. The total cost of production varied between Rs. 1,38,309 to Rs. 5,19,123 under different sizes of polyhouses. It is interesting to note that marketing cost was more than the variable and fixed cost because in carnation we found that there was a positive relationship between the production and marketing cost (Table 5).

It can be referred from the analysis that average cost of production of carnation per cut stem varied between Rs. 0.53 to Rs. 0.55. Benefit cost ratio (undiscounted) varied between 3.25 - 3.46 under different sizes of polyhouses. The net returns from the production of carnation cut stems was Rs. 3,11,348.30 under 500m^2 polyhouse whereas under 2000m^2 it was Rs. 12,79,504.72.

Economic feasibility of carnation: The details of economic indicators for carnation under subsidized and non-subsidized

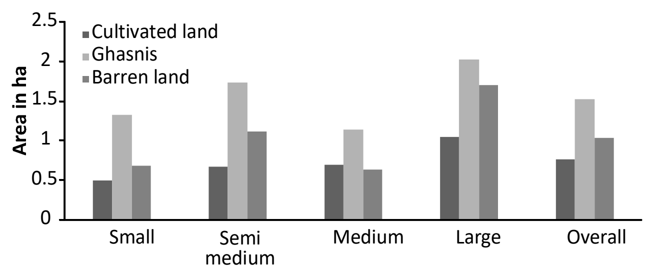

Fig. 1. Polyhouse size wise land use pattern of sampled household

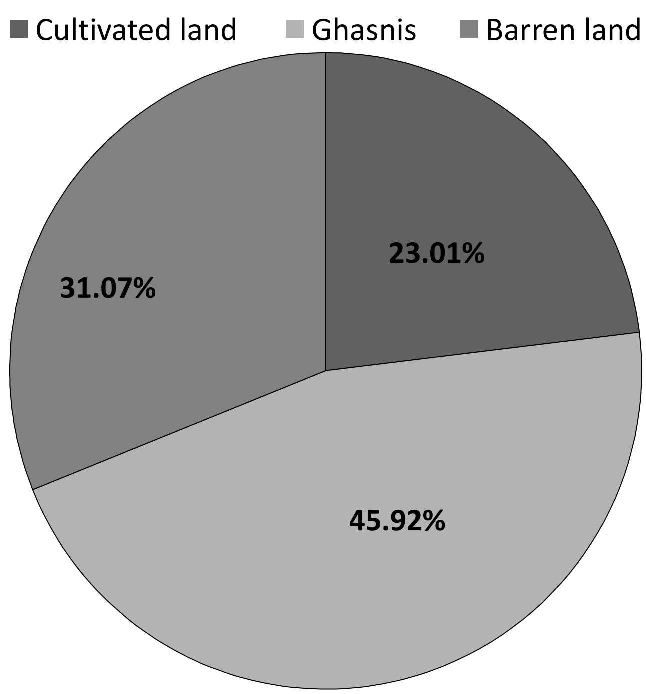

Fig. 2. Land use pattern of the sampled household in overall

Table 3. Initial capital investment on different sizes of polyhouses

Particulars	Size of polyhouse			
	500 m^2	1000 m^2	1500 m^2	2000 m^2
Investment on polyhouse				
Cost of site development	3678.24	5588.00	6484.32	9688.56
Additional infrastructure	18245.00	32220.00	48240.00	62485.00
GI pipes	282282.14	554028.90	780746.68	996296.38
Door and Side frame MS square and other misc	2376.00	2376.00	2376.00	2376.00
Steel work welded	3176.73	5610.00	8298.55	11249.98
Polyhouse sheets	61479.55	104895.57	154680.07	202869.90
insect net	16332.69	23009.56	30218.08	46220.61
Aluminium profiles	30600.00	55170.00	83287.50	113118.75
Shading Net	25300.00	35328.00	55139.28	73524.56
Moulding, processing, fabrication and erection expenses	37500.00	75000.00	112500.00	150000.00
Drip irrigation	14162.00	39661.00	60068.00	80602.00
Fitting and accessories	12000.00	18000.00	24000.00	30000.00
Sub total	507132.35 (91.62)	950887.03 (94.53)	1366038.47 (95.50)	1778431.74 (95.46)
Investment on equipment				
Major implements	44727.61	52818.57	61856.33	81722.92
Minor implements	1685.00	2159.17	2453.00	2900.42
Sub total	46412.61 (8.38)	54977.74 (5.47)	64309.33 (4.50)	84623.33 (4.54)
Total	553544.96 (100.00)	1005864.76 (100.00)	1430347.81 (100.00)	1863055.07 (100.00)

Table 4. Average cost composition of carnation under different sizes of polyhouses

(Rs. $unit^{-1}$)

Particulars	Size of polyhouse			
	500 m^2	1000 m^2	1500 m^2	2000 m^2
A) Fixed cost				
i) Depreciation on polyhouse	31948	59043	85374	111442
ii) Depreciation on equipment	4177	4948	5788	7616
iii) Interest on fixed capital	23000	41732	59388	77403
Subtotal (i+ii+iii)	59125	105723	150549	196462
	(42.75)	(39.11)	(38.12)	(37.84)
B) Variable Cost				
i) Material input	65367	129485	192353	253140
ii) Labour	7557	22605	33510	44850
a) Family labour	3372	3872	5995	6745
b) Hired Labour	4184	9368	13365	20984
iii) Interest on working Capital	6260	12497	18515	24671
Subtotal (i+ii+iii)	79183	164586	244378	322661
	(57.25)	(60.89)	(61.88)	(62.16)
Total cost (A+B)	138309	270309	394927	519123
	(100.00)	(100.00)	(100.00)	(100.00)

Table 5. Average cost and average returns from carnation production under different sizes of polyhouses

Particulars	Size of polyhouse			
	500 m^2	1000 m^2	1500 m^2	2000 m^2
Total variable cost (Rs)	20523.50	164586.25	244377.85	322661.36
Total marketing cost (Rs)	10200.00	233821.59	350732.38	467643.17
Average Selling Price (Rs)	3.00	3.00	3.00	3.00
Gross return (Rs)	449656.90	899313.80	1348970.70	1798627.60
Net return (Rs)	311348.30	629004.81	954043.36	1279504.72
Gross margin (Rs)	439456.90	665492.21	998238.32	1330984.42
Return over variable cost (Rs)	370473.78	734727.55	1104592.85	1475966.24
BCR over total cost	3.25	3.33	3.42	3.46
Cost of production (Rs/cut stem)	0.53	0.55	0.54	0.54
Break even output (cut stem)	23921	43135	61286	79803

Table 6. Economic feasibility of Carnation cultivation under subsidized and non-subsidized polyhouses of different sizes

Measures of investment worth	Non-subsidized				Subsidized			
	500 m^2	1000 m^2	1500 m^2	2000 m^2	500 m^2	1000 m^2	1500 m^2	2000 m^2
Internal rate of return (%)	27	30	32	33	31	34	36	37
Net present Value (Rs.)	921328	2007662	3134502	4291301	1031093	2215742	3433429	4680471
BCR	1.45	1.51	1.55	1.57	1.54	1.60	1.63	1.66
Uniform annual return (Rs.)	123346	268783	419643	574514	138041	296641	459663	626616
Pay back period (years)	5	3	3	3	5	3	3	3

polyhouses of various sizes are given in Table 6. The payback period for polyhouse production of carnation was 3 year under subsidized and non-subsidized polyhouses except for subsidized and non-subsidized polyhouse of 500 m^2 where it was 5 years. The net present value of carnation was found to vary between Rs. 9,21,328 to Rs. 42,91,301 under different sizes of non-subsidized polyhouse. Whereas, under subsidized polyhouses it ranged from Rs. 10,31,093 to Rs. 46,80,471 under 20 years life of polyhouse. Benefit cost ratio under subsidized polyhouses of 500 m^2 to 2000 m^2 varied between 1.54 - 1.66 with an internal rate of return of 31 - 37 per cent. Similarly BCR varied from 1.45 to 1.57 under different sizes of non-subsidized polyhouses with an internal rate of 27 to 33 per cent. At a discount rate of 10 per cent, the present value of Re. 1 received at the end of 20 years, was varied between Rs. 1,45,430 to Rs. 4,19,643 under non-subsidized and Rs. 1,38,041 to Rs. 6,26,616 under subsidized polyhouses of different sizes respectively. Similar result was found by Sharma et al (2014). Therefore production of carnation cut stems under subsidized and non-subsidized polyhouses is feasible and profitable.

Sensitivity analysis was conducted to examine the effect of increase/decrease in cost and return on economic feasibility of rose production under subsidized and non-subsidized polyhouses of different sizes and results have been presented in Table 4.29a and 4.29b. It can be seen from the results that production of carnation was found to be economically feasible under subsidized and non-subsidized polyhouses of different sizes under increasing interest rates and 5 to 10 per cent increase/decrease in cost and returns. The economic indicators remained in the acceptable limits. Hence protective cultivation of carnation is an economically viable option.

CONCLUSION

The analysis that average cost of production of carnation per cut stem varied between Rs. 0.53 to Rs. 0.55. The net returns from the production of carnation cut stems were Rs. 3,11,348.30 under 500 m^2 polyhouse, whereas, under 2000 m^2 it was Rs. 12,79,504.72. The net present value of carnation was found to vary between Rs. 9,21,328 to Rs. 42,91,301 under different sizes of non-subsidized polyhouses. Whereas, under subsidized polyhouses it ranged from Rs. 10,31,093 to Rs. 46,80,471 under 20 years life of polyhouse. Benefit cost ratio under subsidized polyhouses of 500 m^2 to 2000 m^2 varied 1.54 to 1.66 with an internal rate of return 31 to 37 per cent. Similarly BCR varied from 1.45 to 1.57 under different sizes of non-subsidized polyhouses with an internal rate of 27 to 33 per cent. Therefore production of carnation cut

Table 7a. Sensitivity analysis of cost and returns for carnation under subsidized and non-subsidized polyhouses of different sizes (increase in cost)

Measure of investment worth	Non subsidized		Subsidized	
	Increase in costs		Increase in costs	
	5%	10%	5%	10%
500 m^2				
NPV at discount rate of (Rs.)				
a.) 12 per cent	633351.05	546772.99	738838.62	652260.55
b.) 15 per cent	412239.48	335054.91	510323.58	433139.01
c.) 20 per cent	161356.21	95082.7	248937.89	182664.38
Internal Rate of Return (%)	25	23	28	26
BCR at discount rate of				
a.) 12 per cent	1.32	1.27	1.4	1.34
b.) 15 per cent	1.24	1.18	1.31	1.25
c.) 20 per cent	1.11	1.06	1.18	1.12
1000 m^2				
NPV at discount rate of (Rs.)				
a.) 12 per cent	1434420.89	1268071.78	1632212.95	1465863.84
b.) 15 per cent	983933.80	836060.96	1167844.17	1019971.33
c.) 20 per cent	472010.11	345593.14	636228.15	509811.18
Internal Rate of Return (%)	28	26	31	29
BCR at discount rate of				
a.) 12 per cent	1.38	1.32	1.46	1.4
b.) 15 per cent	1.3	1.24	1.37	1.31
c.) 20 per cent	1.17	1.12	1.24	1.18
1500 m^2				
NPV at discount rate of (Rs.)				
a.) 12 per cent	2275208.38	2030655.16	2559355.26	2314802.03
b.) 15 per cent	1593981.12	1376944.72	1858185.63	1641149.23
c.) 20 per cent	819458.50	634380.87	1055373.14	870295.50
Internal Rate of Return (%)	29	27	33	30
BCR at discount rate of				
a.) 12 per cent	1.41	1.35	1.49	1.43
b.) 15 per cent	1.33	1.27	1.40	1.34
c.) 20 per cent	1.20	1.15	1.27	1.21
2000 m^2				
NPV at discount rate of (Rs.)				
a.) 12 per cent	3140530.82	2819037.65	3510458.77	3188965.61
b.) 15 per cent	2220386.46	1935054.56	2564351.65	2279019.75
c.) 20 per cent	1173971.64	930649.33	1481106.52	1237784.21
Internal Rate of Return (%)	30	28	34	31
BCR at discount rate of				
a.) 12 per cent	1.44	1.37	1.51	1.45
b.) 15 per cent	1.35	1.29	1.42	1.36
c.) 20 per cent	1.21	1.16	1.29	1.23

Table 7b. Sensitivity analysis of cost and returns for carnation under subsidized and non-subsidized polyhouses of different sizes (decrease in return)

Measure of investment worth	Non subsidized		Subsidized	
	Decrease in returns		Decrease in returns	
	5%	10%	5%	10%
500 m^2				
NPV at Discount Rate of (Rs.)				
a.) 12 per cent	590581.55	461233.99	696069.12	566721.55
b.) 15 per cent	381470.58	273517.13	479554.68	371601.23
c.) 20 per cent	144351.37	61073.01	231933.04	148654.68
Internal Rate of Return (%)	25	22	28	25
BCR at discount rate of				
a.) 12 per cent	1.32	1.25	1.4	1.32
b.) 15 per cent	1.23	1.16	1.31	1.24
c.) 20 per cent	1.1	1.04	1.17	1.11
1000 m^2				
NPV at Discount Rate of (Rs.)				
a.) 12 per cent	1342074.9	1083379.7	1539866.9	1281171.8
b.) 15 per cent	915899.73	699992.82	1099810.1	883903.18
c.) 20 per cent	431870.36	265313.64	596088.4	429531.68
Internal Rate of Return (%)	28	25	31	28
BCR at discount rate of				
a.) 12 per cent	1.38	1.3	1.46	1.38
b.) 15 per cent	1.29	1.22	1.37	1.29
c.) 20 per cent	1.16	1.1	1.23	1.17
1500 m^2				
NPV at discount rate of (Rs.)				
a.) 12 per cent	2131718.9	1743676.2	2415865.8	2027823.1
b.) 15 per cent	1487157.2	1163296.8	1751361.7	1427501.3
c.) 20 per cent	754701.06	504865.98	990615.69	740780.61
Internal Rate of Return (%)	29	26	33	30
BCR at discount rate of				
a.) 12 per cent	1.41	1.33	1.49	1.41
b.) 15 per cent	1.32	1.25	1.4	1.32
c.) 20 per cent	1.19	1.13	1.26	1.2
2000 m^2				
NPV at discount rate of (Rs.)				
a.) 12 per cent	2944633.7	2427243.5	3314561.7	2797171.4
b.) 15 per cent	2073904.5	1642090.7	2417869.7	1986055.9
c.) 20 per cent	1084180.5	751067.07	1391315.4	1058202
Internal Rate of Return (%)	30	27	34	30
BCR at discount rate of				
a.) 12 per cent	1.43	1.35	1.51	1.43
b.) 15 per cent	1.34	1.27	1.42	1.34
c.) 20 per cent	1.21	1.14	1.28	1.21

stems under subsidized and non-subsidized polyhouses is feasible and profitable. There is need to impart regular trainings to the polyhouse farmers on the technical knowhow of the growing crops under protective technology, since this technology is capital intensive.

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Effect of Salycilic Acid on Antioxidant Enzymes and Biochemical Contents of Date Palm Plantlets (*Phoenix dactylifera* L.) under Salt Stress Conditions

Naji Salim Jasim and Muntaha Abd-A. Ati

Date Palm Research Center-Basrah University- Basrah, Iraq
E-mail: ahmidnaji916@gmail.com

Abstract: The study was conducted to observe the effect of Salicylic acid (SA) on physiological and biochemical changes in date palm plantlets. Plantlets were irrigated water with different concentrations of salt stress (10, 15 and 20 ds m^{-1}), while the control treatment was irrigated by tap water only. The salt concentration significantly decreased chloroplast pigments, total chlorophyll and carotenoid, total soluble carbohydrates compared with increased levels of proline contents and antioxidant activities (catalase and peroxidase). The treatments of date palm plantlets with salicylic acid (1.5 mm) under salt conditions led to increase of leaf chemical composition and antioxidant enzymes activity, catalase and peroxidase compared with treatments under salt stress only and control .

Keywords: Date palm plantlets, Salicylic acid, Salinity, Antioxidant enzymes, Chlorophyll, Carotenoid

Date palm (*Phoenix dactylifera* L.) is one of the Arecaceae family of economic importance typically grown in arid and semi-arid parts of the globe. Various environmental stresses effect the development and productivity (Shao et al 2008). One of the most influencing factors is salt stress which affects the plant growth and production of secondary metabolites (Nikolova and Ivancheva 2005). One-third of the areas of land in the world's cultivated are seriously affected by hight salt stress (Kaya et al 2002). The salts stress of 8-10 ds m^{-1} decreased chlorophyll contents total soluble, carbohydrates and increased proline and accumulation of Na and Cl in *Cassia absus* L. (Hussain et al 2009). Salts increased protein content and antioxidant enzyme activity CAT and POD on *Momrdica charantia* (Agrawal and Shahee 2007) and on sunflower(Ebrahimian and Bybordi 2012).

Salicylic acid (SA) is an endogenous regulators of growth with a phenolic nature, it contributes in regulating the physiological processes of the plants and has a role as natural inductor of thermogenesis (Horva´th et al 2007). One of important strategies to alleviated plants against different stress is use of plant growth regulators (PGR) which regulating many of physio-biochemical processes like protein synthesis, antioxidant enzymes, and photosynthesis, which are involved in the stress tolerance mechanism directly or indirectly (Akram and Ashraf 2011). Under salt stress 8-16 ds m^{-1} plant height, leaves numbers, fresh and dry weights of leaves decreased, while treatments of SA 30 mg l and GA3 on Date palm *Phoenix dactylifera* L. increased these estimations and increased proline, superoxide dismutase (POD), peroxidase (POX) and catalase (CAT) (Darwesh and Mohamed 2009, Darwesh 2014). Many trials have shown that the use of salicylic acid in drought trees enhances the activity of antioxidant enzymes such as POD, SOD and CAT (Hayat et al 2008).

The current study was undertaken to find out whether the application of salicylic acid (SA) on date palm plantlet can alleviate the harmful effects of salinity on chemical contents and antioxidant enzymes CAT and POX.

MATERIAL AND METHODS

This study was conducted in greenhouse and laboratories of Date Palm Research Center, the University of Basra during 2017 to 2018. Three levels of salinity stress 10, 15 and 20 ds m^{-1} alone and application of while salicylic acid at 1.5 mM were evaluated along with control (0 ds m^{-1} salt).

Plantlets of the date palm were ten months old. The different versions mentioned above were applied to the plants for 21 days depending on the soil water content of the study soil. Each treatment consists of three replicates (2plantlets pot^{-1}). The following physiological characteristics measurements were recorded after the completion of the experiment.

Total chlorophyll and total carotenoid: The total chlorophyll was estimated by method given by Arnon (1949) from fresh leaves were determined by U.V. spectrophotometer (CECL 2021, ENGLAND) at wave max 663nm , The total Carotenoid contents from fresh leaves were determined by U.V. spectrophotometer (CECL 2021,ENGLAND) at wave max 470nm (Lichtenthaler and Wellburn 1983).

Proline content: Proline was estimated by Bates et al (1973) method the standard curve (mg g^{-1}DW).

Determination of soluble carbohydrate content: Fales (1951) and Schlegel (1956) method was used for estimation of soluble carbohydrate content in aqueous solution

Measurement of catalase (CAT) activity: The assessment of the activity of the catalase (EC: 1.11.1.6) was according to the method given by Chance and Maehly (1955).

Peroxidase (POX) activity: MacAdam et al (1992) procedure was used to assess Peroxidase (EC: 1.11.1.7) activity.

RESULTS AND DISCUSSIONS

Photosynthetic pigments: Results of photosynthetic pigments (Fig. 1 and 2) indicated significant reduction in total chlorophyll and carotenoid contents under salt stress at 15 and 20 ds m^{-1} which were 9.24 and 7.38 mg 100 g^{-1} FW for chlorophyll respectively and 0.029 and 0.0215 mg 100g^{-1} FW for carotenoid respectively. This reduction of pigments contents could be related to the toxic effects of salinity on the pigments biosynthesis elevating their degradation and/or causing damage to the chloroplast thylakoid. Darwesh et al (2006) observed that salinity from 10000-14000 ppm decreased chlorophyll contents in leaves on date palm. Furthermore, Abd El-Samed et al (2011) found that chlorophyll contents decreased under 30-90 mM NaCl on *Zea mays* and broad bean *Vicia faba*. This inhibition of photosynthesis pigments was recovered by the addition of 1.5mM salicylic acid. Exogenous application of SA at 1.5 mM combination with salt concentration 10, 15 and 20 ds m^{-1} caused an increased in total chlorophyll and carotenoid which were 11.721, 13.238 and 9.762 mg 100 g^{-1} FW for chlorophyll and 0.037,0.039 and 0.033 mg 100 g^{-1} FW, respectively. Al-Mayahi (2015) observed that the chlorophyll content reduction in date palm leaves under salt stress. A decline in the level of photosynthesis pigments were due to the formation of protolytic enzymes such as chlorophyllase which is responsible of destruction of chlorophyll under high stress condition. Schutz and Fangmier (2001) observed that the reduction of chlorophyll owing to stress is due to the increase in reactive oxygen species (ROS) production in the cell. SA application causes ROS scavenging and that can enhance chlorophyll biosynthesis and prevent degradation of chlorophyll and enhanced content in date palm plantlets.

Proline content: Both salt stress and salicylic acid affected significantly proline content. In addition, the interaction effect of both salt and salicylic acid on proline content of plantlelts was significant. The salt increased greatly proline content in treated plants. Proline content of the plantlets under salt stresses concentrations 10,15 and 20 ds.m^{-1} were 18.41, 29.24 and 27.49 µg g^{-1} respectively in comparison with control, which was 17.67 µg g^{-1} FW (Fig. 3). The application of SA in combination with salt concentrations increased proline content which were 37.49, 40.66 and 34.24 µg g^{-1}. Dash and Panda (2001) reported that when NaCl concentration and duration of stress increased proline content in *Phaseolus mungo*. Other study founed that NaCl at 50-150 mM increased proline contents in *Salventia natans* L. (Jampeetong and Brix 2009). The application of SA caused enhancement in the synthesis of proline which might be the adaptive mechanism of date palm plantlets under salt stress condition. These results are in agreement with finding of previous studies (El-Beltagi et al 2017, Agamy et al 2013). The increase in proline content in plants allowed water stressed plants to maintain low water potential, the accumulation of proline involved in osmo-regulation seemed to enable additional water to be absorbed from the environment (Gebaly et al 2013).

Soluble carbohydrate contents: The applying 1.5mM SA on the control plants elevated the content of leaf soluble carbohydrate which was 23.99 mg g^{-1} DW compared to control plant (without SA) which was 15.62 mg g^{-1} DW. With salt stress, the soluble carbohydrate content of plantlet leaves was substantially high with increased salt concentrations (Fig. 4). Exposure plantlets were irrigated with growth regulator (SA) at 1.5 mM in combination with salt stress significant more in leaves content of total carbohydrates in plants which were 26.368, 23.226 and 22.307 mg g^{-1} DW for 10, 15 and 20 ds m^{-1} respectively compared with treated plants at the same concentrations which were 22.153, 22.920 and 19.088 mg g^{-1} respectively. Salt stresses, however, resulted in a significant increase in the content of the soluble carbohydrate of date palm leaves. With increasing salt concentrations the rate of rise in soluble carbohydrate content has been reduced, demonstrating a function for soluble carbohydrate in osmotic adjustment. Pe'rez-Lo'pez et al (2010) indicated that osmotic adjustment could involve the accumulation of soluble carbohydrates in crops under stress circumstances. The accumulation of soluble carbohydrates was commonly recorded as a reaction to salinity or drought (Cheeseman 1988). The carbohydrates constitute one of the dry matter's primary organic constituents were influenced by salt stress. The complete carbohydrate content was decreased by growing salinity concentrations. Reducing the content of carbohydrates may be due to reduced photosynthesis and increased photorespiration under salt stress (Namich et al 2007). The application of SA to date palm plantlets under salt conditions increased the contents of total soluble carbohydrates as compared with untreated stressed plants. Photosynthetic pigments were increased in response to salicylic acid treatments thus enhance the polysaccharides biosynthesis and total carbohydrates significantly which are utilized in the sunflower plants growth (Dawood et al 2012). The application of SA might activate the metabolic consumption of soluble carbohydrates to form new cell constituents as a mechanism to alleviated the growth of date palm plantlets. The high concentration of carbohydrates with its role in reducing water content helps prevent oxidative damages and the preservation of protein structure during water shortage. Carbohydrates also play a molecular role in sugar-responsible genes, which give different physiological responses such as defensive responses and cellular expansion (Simaei et al 2011). Moreover, accumulation of carbohydrate play a key role in alleviating the salinity stress, either via osmotic adjustment, as Ackerson (1985).

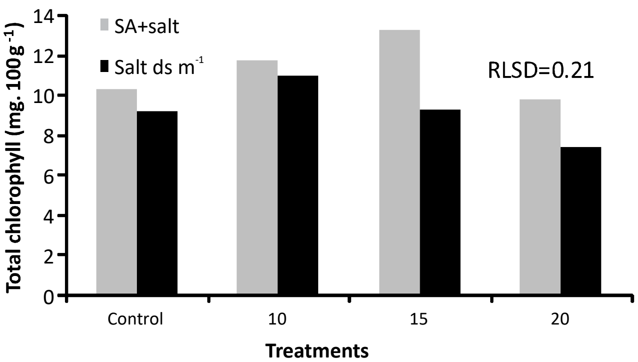

Fig. 1. SA effects on the total chlorophyll content (mg 100 g^{-1}) under salt condition

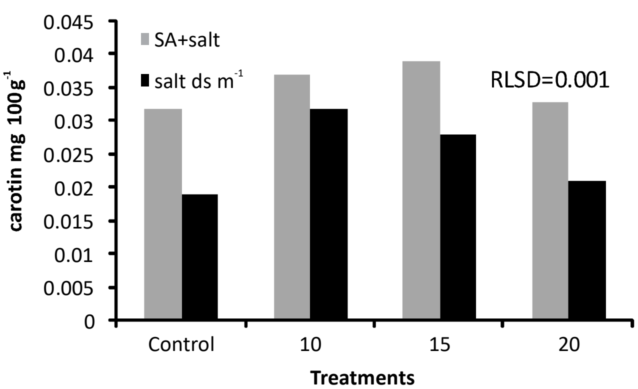

Fig. 2. SA effects on the Carotenoid content (mg 100g^{-1}) under salt condition

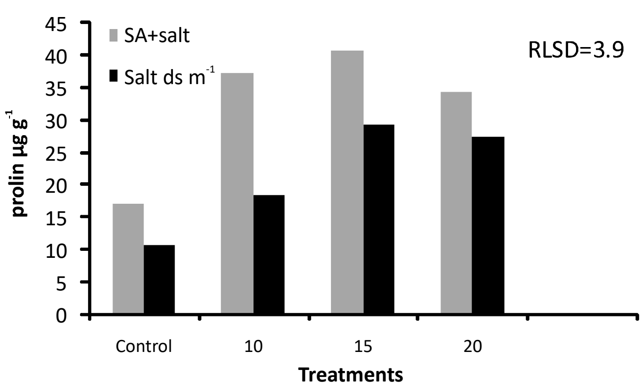

Fig. 3. SA effect on the proline content (µg g^{-1}) under salt condition

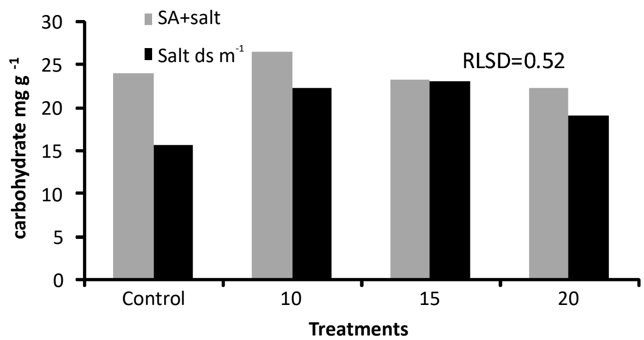

Fig. 4. SA effect on the carbohydrat content (mg g^{-1}) under salt condition

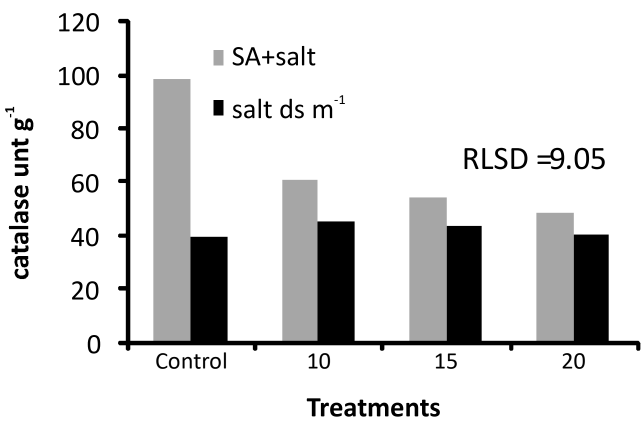

Fig. 5. SA effect on the catalase (unit g^{-1}) activity under salt condition

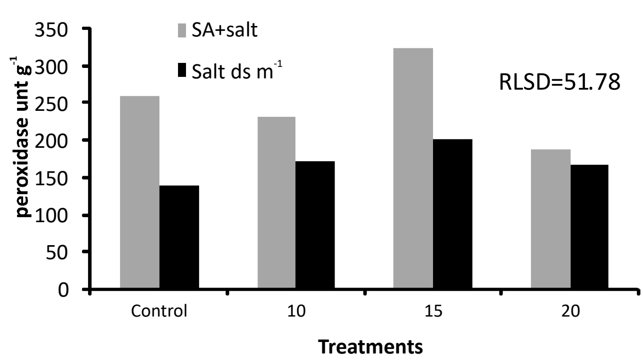

Fig. 6. SA effect on the peroxidase (unit g^{-1}) activity under salt condition

Catalase (CAT) and Peroxidase (POD): The CAT and POD activity increased during salt stress and this increase was positively related to 10 and 15 ds.m^{-1} salt concentrations. Additionally, the results showed that high levels of antioxidant enzymes CAT and POD activity occurred in plants at 10 and 15 ds m^{-1} salt concentrations with SA combination at 1.5mM. Control crops revealed the smallest concentrations of CAT and POD operations. The enzymes of antioxidants include catalase (CAT), superoxide dismutase (SOD), peroxidase (POX) (Zhu 2001, Ashraf 2002). The study of Mittler (2002), showed that salinity induces and increases the activity of these antioxidant enzymes. CAT involving degradation of hydrogen peroxide and prevention of oxidative damage. The resistance to environmental stress may therefore depend at least partially on the production by enhancing the antioxidant defense system (Azevedo et al 2006). CAT and POD markedly increased under salt stress 40-200 mM (Abdulwahid 2012 on date palm). Increasing CAT and POD activities with SA application at 1.5mM was the highest under salt pressure, exogenous application of SA can control the activity of intracellular antioxidant enzymes such as POX, SOD and boost plant sensitivity to environmental stress (Sakhabutdinova et al 2004). Study of Saruhan et al (2012) discovered that the application of SA increased the activity of antioxidant enzymes such as CAT, POD and APX in plants.

CONCLUSIONS

Salt stress was significantly reduced chemical compositions chloroplast pigments (total chlorophyll and carotenoid), total soluble carbohydrate, antioxidant activity (CAT and POD) and increased proline content. The adverse effect of salinity can be alleviated by applying SA, thereby raising all above physiological characteristics.

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Traditional Knowledge of Post-harvest Crop Handling by Tribal Farmers of Northern Andhra Pradesh

S.V.S. Gopala Swamy and B. John Wesley

Post Harvest Technology Centre, Bapatla-522 101, India
E-mail: paulgopal2003@yahoo.com

Abstract: The tribal communities inhabiting the agency areas of Northern Andhra Pradesh grow crops mainly that serve the food requirements besides depending on forest produce. Exploratory surveys were made to document the indigenous food grain preservation practices of these tribal farmers and the information was collected through group discussions and personal interactions with the elders of the ethnic groups. Structures made up of bamboo splits of different sizes and shapes are being used for storage of paddy and finger millet grains. The number of bamboo structures and quantity of grain stored is determined by the size of the family. Maize cobs, pigeonpea and cowpea pods are tied in bundles and suspended in the kitchen area, as the smoke keeps them away from insect pest infestation and moisture. Dried bottle gourds are most commonly used containers for storage of different grains. Finger millet grains are solar dried and processed locally by house wives and the flour is stored in earthen pots. Maize cobs are shelled manually after drying and the kernels are sold in the market or to the middlemen. Integration of these indigenous techniques of storage of food grains with modern scientific knowledge would be more economical and profitable to the tribal farmers.

***Keywords*:** Post-harvest handling, ITKs, Tribals of Northern AP

Tribals constitute an important segment of the population of India, representing about 8.6% of the population (Government of India 2014). Next to Africa, India has the largest tribal population in the world. Indian tribes, spread over the length and breadth of the country, are concentrated mostly in hilly and forest regions. There is a spectacular diversity as the tribes differ considerably from one another in race, language, socio-cultural patterns, traditions, beliefs, and typical food habits. Andhra Pradesh is having considerable population of Scheduled Tribes. On the basis of geoethnic characteristics, the tribal areas of the combined state were divided into Gond-Kolam Region, Koya- Konda Reddy region, Khond-Savara region, Chenchu region and Plain areas (Basic Statistics, Government of Andhra Pradesh 2008). The tribal habitations from forest and hill tracts of Srikakulam, Vizianagaram and Visakhapatnam districts constitute the Kondh-Savara Region with common tribal groups in adjoining Orissa state also. There are 33 scheduled tribes inhabited in the area and the major communities are Savara, Bhagata, Jatapu, Valmiki, Konda dora, Koya, Khond, etc. (Rao 2014). These are extremely backward tribal groups which are identified as primitive groups, due to their pre-agricultural level of technology, low level of literacy and stagnant or diminishing population and also particularly vulnerable tribal group. In addition to shift (*Podu*) cultivation on hill slopes which is the major resource for living, they also depend on collection of minor forest produce, hunting, trapping, gathering, grazing of animals and poultry. Most of them have small or marginal land holdings. They grow crops mainly that serve their food requirements. Along with rice which is the staple food, finger millet gruel (*Ambali*) is also consumed by these people. Maize is also another important food crop. Besides these crops, millets (pearl millet, little millet, foxtail millet), pulses (pigeonpeas [Kondakandulu/hill-arhar], blackgram, greengram, cowpeas, rajmash, lima beans), groundnut, vegetables, turmeric, ginger, pineapple, etc. are also grown under mixed cropping system, generally without using any chemical fertilizers. Being subsistence type of agriculture, grain storage at farm level is normally inter-seasonal that ensures food supplies for the family and also to meet seed requirement for the next season; while the surplus produce may be bartered to neighbours for getting other things or sold for cash. Keeping the produce safely for future use is as important as production itself. Since ancient times, even the primitive farmers might have adopted some sort of methods for storage of food grains. Traditional knowledge is mainly of a practical nature and is transmitted from generation to generation. It refers to the knowledge, innovations and practices evolved out of experience gained over the centuries by the indigenous and local communities in close interaction with environment (Mohapatra 2014). Several authors have reported that a large number of farmers still depend on local resources and traditional practices for storage of various crop produces in several rural and tribal areas (Dhaliwal and Gurdeep 2010, Sinha 2010, Smita et al

2013, Naresh et al 2013). The collection of traditional agricultural knowledge/practices is of great significance in conserving and maintaining sustainability of the environment. Traditional agricultural knowledge/practices were available in the tribal settings but now not at reducing rate (Prakash et al 2016). Keeping this in view an efforts were made to document the indigenous food preservation practices prevailed among the tribal farmers of the agency areas of Northern Andhra Pradesh.

MATERIAL AND METHODS

The study was carried out to document indigenous post harvest knowledge from the tribal farmers of Eastern ghats of Srikakulam and Visakhapatnam districts of High Altitude and Tribal Zone of Andhra Pradesh. Exploratory surveys were carried out during *kharif* and *rabi* seasons of 2017-18 for documentation of farm level grain storage practices followed by the tribal groups inhabited in Seethampet mandal, Srikakulam district (Palakonda forest range) and Chintapalle and Gudem Kothaveedhi mandals, Visakhapatnam district (Alluri Sita Ramaraju forest area). Several Primitive tribal settlements of this area were explored to observe the grain storage practices and the information was collected through group discussions and interpersonal interactions with the elders of the ethnic groups who are the living repositories of these indigenous grain storage techniques. Some descriptions about the practices and facilities for post harvest handling and storage of grain/seed and indigenous food preservation practices being used by the tribals dwelling in these Southern tropical semi ever green forests are included in this paper. In addition, photographed pictures of various indigenous storage structures and methods identified during the survey are presented as they document the incidence authentically without missing anything.

RESULTS AND DISCUSSION

Storage structures and methods: As rice and finger millet are their staple food grains, both are stored in large quantities sufficient to support the family more than one year even if there is a season of crop failure. Structures made up of bamboo splits (locally called as *Gaade*) of different sizes and shapes are being used for storage of paddy and finger millet grains. The number of bamboo structures and quantity of grain stored is determined by the size of the family. In Seethampet area, the bamboo structures of different shapes (rectangular or cylindrical) and sizes are placed on the floor in front verandas of the house with proper dunnage. Stones or bamboo mats or wooden logs are used as palates to protect them from rodents as well as moisture. Where as in Chintapalle area, the same grain filled bamboo baskets are placed on wooden lofts inside the house. After filling the basket with grain, some farmers keep dry paddy straw over the grain, cover with a bamboo mat and create hermetic conditions by plastering with mud and dung mixture or red soil and ash. One or two baskets in which grains are taken for regular consumption are kept open without such sealing. However, this type of sealing is not practiced by all the farmers. Some farmers just keep these bamboo baskets open on the lofts. As they are exposed to smoke and good aeration daily in the house, there is no insect pest problem though rodent activity is found at negligible level. Small basket made of bamboo used for measuring grain is called *Kuncham* (3 kg). Twenty kg is measured as one *Putti* and 30 putties are equal to one *Garise* (600 kg). Depending upon the size of bamboo structures 400 kg to 1600 kg of paddy grain can be stored. The bamboo storage structures last for 10 to 15 years if good quality material *i.e*, along with the bark portion of the bamboo is used and maintained properly by smearing clay and dung mixture regularly. Bamboo is used for making these storage structures with a view that optimal temperatures will be maintained in the grain so that insect infestations and spoilage can be prevented (Kanwar and Sharma 2003).

Maize cobs (husked) are tied to roof top in sufficient numbers inside the house or verandas which may be used for sowing during the next season in 2 to 3 acres and also for consumption after boiling them. Similarly, pigeonpea and cowpea pods are also tied in bundles and suspended in the kitchen area. Regular exposure to smoke keeps them away from insect pest infestation and excess moisture while preserving the viability. Keeping vegetable seeds like gourds and ladies fingers as whole fruit after drying by hanging in the kitchen keep the seeds viable which might be due to low humidity in the kitchen which has also been found in Khasi hill area of Northeast India (Sinha 2010).

For storage of seed material, they use different structures. Small bamboo baskets are plastered with mud and cow dung. After placing sun dried pigeonpeas mixed with fire ash and some black cashew [*Semecarpus anacardium* Linn. (Family: Anacardiaceae)] seeds in the basket, little quantity of straw is placed over the seed, covered with bamboo lid and smeared with mud and dung mixture so that the seed is maintained in hermetic conditions. Black cashew is also called as *Nalla Jeedi* or Bilva seeds of which are used in ayurveda for treating several ailments due to presence of biflavonoids, phenolic compounds, bhilwanols, minerals, vitamins and amino acids. They may also possess insect repellent and fungal growth arresting properties (Srinivasan et al 2016). However, the tribal people use these seeds for medicinal purposes, also believe as magic seeds which can

Table 1. Areas and tribal groups surveyed for the study

Area (Mandal & District)	Villages/Habitations covered	Tribal group
Seethampet, Srikakulam District https://goo.gl/maps/kCpyR8WVEsGtnTtK6	Billaguda, Mamidichettu guda, Marriguda, Kirapa, Nowguda, Woba, Jonaga, Dondamanaguda, Budagarai, Narayanaguda, Manda	*Savara,* *Jatapu*
Chintapalle, Visakhapatnam District https://goo.gl/maps/yjXrS7vFcfyWe9p56	Bayalukinchangi, Boddumamidi, Bowrthi, Charapalli, Chedalapadu, Cheekatimamidi, Chowtapadu, Gaadidalametta, Gadaparai, Kandulagaade, K. Genjigadda, Mallavaram, Pellimamidi, Pinakotturu, Rourinthada, Sallayi, Tekulaveedhi.	*Khond, Kondadora, Bhagatha, Valmiki, Kammara, Nookadora, Poorja, Gadaba.*
G. Kothaveedhi, Visakhapatnam District https://goo.gl/maps/3PxR5ugfU2jovFxy6	Damanavalli, Degalapalem, Duccharipalem, Ebulum, Pedapadu, Kattupalli, Kattuveedhi, Kodisingi, Lingavaram, Madem, Parikala.	

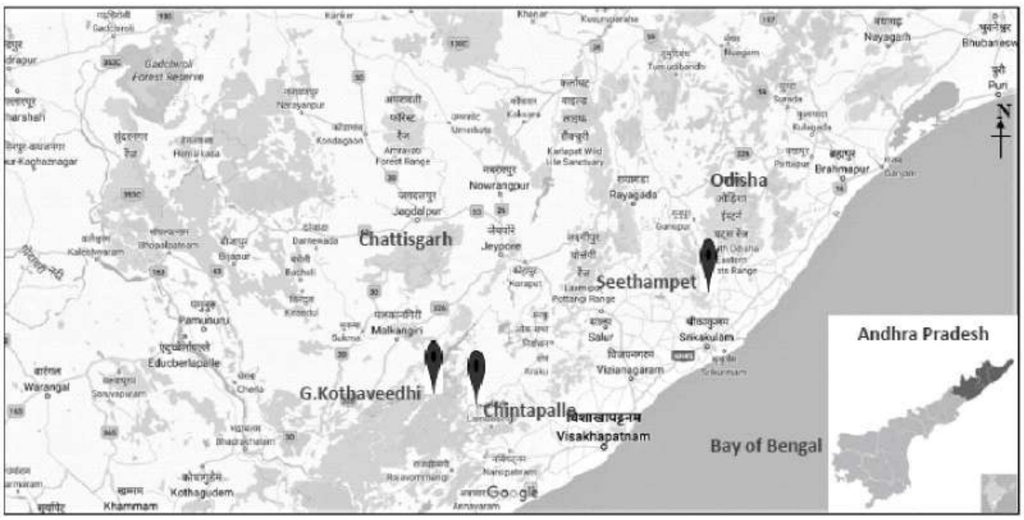

Fig. 1. Map of Northern Andhra Pradesh showing the mandals of tribal areas studied

also prevent all evils and ailments. They tie some of those seeds in a cloth to the thatched roof at the entrance so that they come in contact with the knot while moving in and out. There is a practice of collection of plant twigs of nine different species including *S. anacardium* from the forest and planting them in rice fields by the tribal people in the district of Koraput of Odisha to protect the crop from insect and pest infestations (Smita et al 2013). In the same way, red soil treatment to pulses meant for seed and mixing of grains with ash are also popular indigenous practices among the small and marginal farmers in several states of India (Dhaliwal and Gurdeep 2010, Karthikeyan et al 2006, 2009, Parmar and Jain 2016). As noted in these tribal settings, the simple technologies like sun drying and repeated sieving, use of oils, inert dusts, plant material which have insecticidal or repellent activity have also been practiced for traditional grain storage by a number of small-scale farmers (Mohapatra et al 2015). Dried bottle gourds are most commonly used containers for storage of different grains. Small sized ones are used for storage of millets like variga and bajra for seed purposes while the larger ones are used for storage of pulses like rajmash, lima beans and cowpeas for regular culinary uses. They are provided with a small opening at the top portion and made hermetic, by plugging the opened hole with tightly rolled cloth. Likewise clay pots are used for storage of various grains including castor seeds. There is a structure (locally called as *Burde/Thirre*) made of Adda (*Bauhinia vahlii*) leaves used for storage of seed. Several layers of Adda leaves are pinned together using thin sticks meant for stitching. This structure is of one time use and suitable for one season, hence only at the time of sowing this is opened. This can be of small to larger sizes. *Jolati* is a wide tray like structure made from bamboo which is placed just above the Chula so that food grains and other culinary items kept in the tray are exposed to hot smoke and can be protected from moisture, insects and molds. Storing grains in the kitchen is also common practice by tribals as smoke protects from insects and fungus (Dhaliwal and Gurdeep 2010). Sun drying and mixing of different plant materials with pulse grains are the two predominant practices that are followed in indigenous pulse storage as they are easy and the required plant material is locally available (Reddy 2006).

Fig. 2. Grain storage structures made of bamboo in the verandas at Seethampet area

Fig. 3. Bamboo storage structures on the wooden loft at Chinthapalle area

Fig. 4. Maize cobs and cowpea pods hung to the roof inside the kitchen

Fig. 5. Wild pigeonpeas stored in hermetically sealed bamboo basket along with ash and bilwa seeds

Processing methods: Whenever required, small quantities of paddy grain are taken out from the bamboo baskets and get them milled at rice mills in the nearby towns. Whereas finger millet grains are solar dried and processed locally *i.e.,* pounded with wooden pestle and made into flour using specialized stone mill (*chakki*) by house wives. For storing finger millet flour, earthen pots are being used. Even steel vessels are also used by later generations of tribes simply closing the mouth with a thin cloth. In few villages, power operated small pulverizers were given to encourage women entrepreneurs for making finger millet flour. Yet, the perception of the elders of the community is that the flour made with these mills is not tastier compared to the flour made in traditional method and cannot be stored long as the flour temperature increases while milling.

For curing the turmeric rhizomes, the tribals practice a processing method which is also commonly known as *Bana* method in which the rhizomes are boiled using water in large metal vessel using fire wood till a specific cooked turmeric aroma comes, later they are dried on the floor or roof tops. Though an improved steam boiler was introduced by Integrated Tribal Development Agency (ITDA), the skill for operating the equipment is lacking. The dried rhizomes and turmeric powder is sold in the local sandies which is much valued as organic turmeric and also for their very good aroma. A large number of farmers in Khurda, Ganjam, Kandhamal and Keonjhar districts of Odisha practice the traditional storage system such as pit method and heap method for ginger and turmeric while mesh bags and hanging methods are used for chilli, onion and garlic (Naresh et al 2013). Maize cobs are shelled manually after drying and the kernels are sold in the market or to the middlemen. Hand operated maize shellers may be a great help to these women as they reduce drudgery and conserve time.

During monsoon season, the tribals collect bamboo shoots (*Veduru kommulu*) by digging out from the forest which are split into small pieces, tied to a string and dried by keeping in the kitchen. These dried bamboo sprout pieces are stored in earthen pots or kept on *Jolati* and used for preparation of a traditional curry during off-seasons. Earlier it was reported that the tribes of South Gujarat are also fond of curry made of bamboo shoots and preserve freshly harvested bamboo shoots in earthen pots along with huge amount of salt which will be removed by soaking in water for a day before using them for curry preparation (Patel 2005). Dashrath and Shashi (2016) also observed consumption of bamboo shoots by tribals of Rajasthan.

Earlier the tribal areas had been in virtual isolation except for the contacts with an insignificant number of traders from the plains who used to sell groceries and clothes to the tribals in exchange of their hill produce (Anonymous). The weekly markets (sandies) in tribal junctions play an important role with regard to sale and purchase of goods and also to meet the people. Nevertheless, improvement of communication facilities and road connectivity, increase in contact with non-tribals, exposure to mass media and several beneficiary schemes of Ministry of Tribal Affairs, Govt of India

Fig. 6. Dried bottle gourds used for storage of beans and millets

Fig. 7. Earthen pots and steel vessels for flour storage

Fig. 8. Wooden tray (*Jolati*) above the *chula*

Fig. 9. Seed treatment of pulses with red soil

Fig. 10. Processing of finger millet; drying, dehulling and flour making. A woman entrepreneur with a pulveriser

Fig. 11. Curing of turmeric rhizomes

through ITDA seem to have brought many changes in their socio-economic conditions and traditional cultures. Distance from motorable roads is linked to change in life styles (Livleen and Rita 2019). With the advancement of time traditional storage structures are diminishing and are being replaced by improved metal bins or large sized polythene covers which are easily available in local sandy markets. On the other hand, the traditional bamboo structures require regular

Fig. 12. Maize cobs for sun drying & manual shelling

Fig. 13. Preservation of bamboo shoots for curry preparation during the off season

maintenance like plastering with mud and need local skilled persons for their construction as well as repairs whose number is falling day by day and the young generations do not show interest to learn the works of local artisans (Kanwar and Sharma 2006). For this reason, many of the storage structures that have been used traditionally for several years by the tribal farmers may disappear in the near future.

CONCLUSION

Apart from being eco-friendly, indigenous grain storage structures and practices are designed with cheaper and locally available materials, hence do not pose health hazards. It is imperative to encourage and improve the traditional storage practices as they also fulfil the requirements of organic storage. However, the collection of traditional knowledge/practices on post-harvest preservation of food grains and forest gatherings may offer a great connotation to the sustained nutritional food security for the masses and conservation of the environment as a whole. Integration of traditional practices with modern scientific knowledge would further strengthen the technology for safe storage of food grains in a more economical and profitable way to the tribal farmers.

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Assessment of Tree Diversity in Nithyapoojakona Dry Deciduous Forest of Sri Lankamalleswara Wildlife Sanctuary, Southern Eastern Ghats, India

T. Mastan, C. Ankalaiah, C. Venkata Ramana and M. Sridhar Reddy*

Department of Environmental Science, Yogi Vemana University, Kadapa-516 005, India
**Email: sridharmullangi@yahoo.com*

Abstract: Tree species enumeration was carried out in 5-ha Nithyapoojakona dry deciduous forest of Sri Lankamalleswara wildlife sanctuary. A total of 3406 tree individuals (≥ 30 cm gbh) belonging to 97 tree species,75 genera and 40 families was recorded. The mean and range of tree individuals were 681ha^{-1} and 610 to 738 ha^{-1}, respectively. Shannon-Wiener index (H') was 3.38 and Simpson index was 0.074 and the mean and range of tree species were 60 species ha^{-1}and 32-72 species ha^{-1}, respectively. The mean basal area recorded in the forest stand was 22.9 m^{2}ha^{-1}. The rank abundance curve revealed that these dry deciduous forests were dominated by few tree species. Top five species registered 51.7% tree density, 41 species were recorded with 10-150 tree individuals and 52% of species are with less than ten tree individuals. Species abundance distribution as log normal distribution revealed a normal distribution curve.

***Keywords*:** Dry deciduous forest, Log-normal distribution, Population structure, Southern Eastern Ghats, Tree diversity

In India dry deciduous forests represent the dominant forest type as well highly affected by anthropogenic activities (Agarwala et al 2019). Dry deciduous forests of Eastern Ghats are disappearing at an alarming rate due to anthropogenic activities (Reddy et al 2015). The variation in tree species richness in dry deciduous forests is related to micro-environment conditions (Yadav and Gupta 2006), disturbance levels (Sagar and Singh 2005). Further factors such as topography, aspect, slope, soil texture, soil fertility etc., will affect the forest composition (Sharma et al 2018, Khajuria and Chauhan 2002). Trees form the major structural component and their diversity influence the total plant diversity and functional aspect in the tropical forest ecosystems (Pragasan and Parthasarathy 2010). Forest ecosystem can be characterized by attributes such as tree diversity, tree density, basal area, girth class distribution and species abundance distributions and the effect of disturbance on forests can be assessed by studying these features (Giriraj et al 2008). The number of species of a particular abundance was found related to the logarithm of abundance in a predictable way (Mathews and Whittaker 2015). It is proposed that relatively undisturbed forest community structure follow lognormal distribution model as these forests comprise high number of species and influenced by many independent factors. Thus species abundance distribution curves can be used as effective tool for assessing the success of management and to determine the community structure against the disturbance (Engen et al 2002). Especially lognormal distribution is used for modelling the undisturbed communities and the deviation from the distribution can be used to assess the disturbance effect on the forest ecosystem. The aim of study is to enumerate the tree diversity, population structure and as well to test the hypothesis that the tree species abundance distribution in dry forests of Nithyapoojakona forests which form a part of Sri Lankamalleswara wildlife sanctuary of southern Eastern Ghats fits the lognormal distribution.

MATERIAL AND METHODS

Eastern Ghats are discontinuous hill ranges along the east coast and forests across them represent 9.67% of the country's total forest cover (Kumar et al 2017). The topographical features like plateaus, hills, valleys had made these hill ranges to harbor rich and varied flora (Meher-Homji 2001). Broadly Eastern Ghats can be categorized into Northern and Southern Eastern Ghats and Tirupati-Kadapa-Nallamalai hills of Southern Eastern Ghats represent a minor area of endemic region (Singh et al 2015). The hill ranges of Nithyapoojakona forests lie with an elevation range of 160-620m (N 14^{0} 32'02.2'' E 78^{0} 56'29.9”) and are part of the of Sri Lankamalleswara Wild life Sanctuary of Southern Eastern Ghats (Fig. 1). The study area comprises of shallow red ferruginous loam soil derived from Shales, Quartzites and Sandstone primary rocks. The soil depth is low endowed with pebbles and soil pH is acidic in the range of 5.1-6.8. The study area receives a mean annual rain fall of 690-760 mm and rainfall and the temperature range in the study area is 13°C to 46°C.

Experimental details: A total of 125 (20X20m) quadrat were laid randomly across the hill ranges at different areas to enumerate all the trees ≥30cm gbh girth at breast height (1.37 m). The diversity of tree species at 1-ha level was analyzed by using the Shannon-Wiener index, Simpson index and Pielou's evenness index based on (Magurran 2004). The forest stand structure was assessed by tree density, important value index, girth class distribution and species abundance distribution. Species accumulation curves were drawn by plotting cumulative number of tree species against the cumulative area at 1ha scale. Population structure for the forest study area was drawn by plotting tree abundance values (on 'Y' axis) grouped in the respective increasing girth classes (30-60, 61-90, 91-120 and >120 cm) on 'X' axis. Importance value index of each tree species was plotted against the respective species rank to draw the rank abundance curve. The log normal curve is drawn based on the $\log_2$ scale (1-2, 2-4, 4-8, 8-16 and so on) against the number of species under these abundance intervals. If a set of species has abundance on each side of the border line then 50% of the species are assigned to each side of the border class interval.

RESULTS AND DISCUSSION

Tree diversity: A total of 3406 tree individuals (≥ 30 cm gbh) belonging to 97 tree species, 75 genera and 40 families was inventoried in the five hectares of the study area (Table 1 and 2). The range of tree species was 32-72 species ha^{-1} and the mean value was 60 species ha^{-1}. The mean tree density was 681 individuals ha^{-1} with range of 610 to 738 tree individuals ha^{-1}. Species richness was maximum in family Rubiaceae (9 species) followed by Euphorbiaceae (8 species) Combretaceae (5 species) and Fabaceae, Anacardiaceae (4 species each). The Shannon-Wiener index (H') was 3.38 Simpson index was 0.074, Pielou's evenness index was 0.73 (Table 1). The mean basal area in the forest stand was 22.9

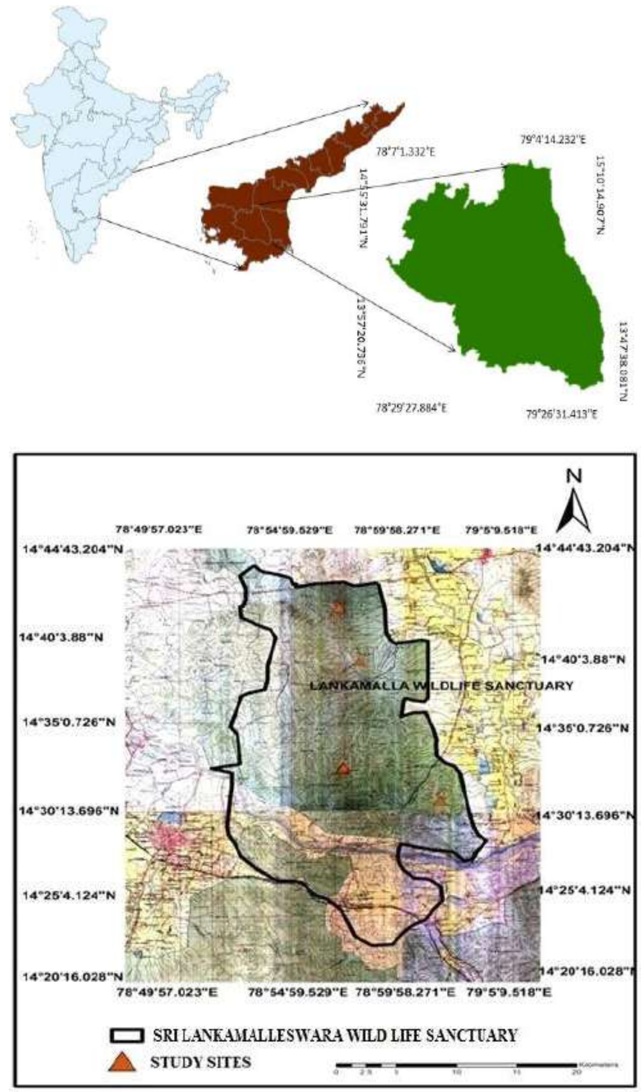

Fig. 1. Study area of showing-Nithyapoojakona dry deciduous forests of Sri Lankamalleswara wildlife sanctuary, Kadapa, Andhra Pradesh

Table 1. Tree diversity indices, tree density, basal area in Nithyapoojakona dry deciduous forests

Forest variables	
Total tree species	97
No genera	75
No of family	40
Tree density	3406
Tree Individuals ha^{-1}	681 tree individuals ha^{-1})
Tree Basal area mean (m^2ha^{-1})	22.87
Shannon index (H^1)	3.38
Simpson index (1-D)	0.074
Pielous Evenness, $E^1=H^1/\ln s$	0.73
Higher gbh tree species	*Stereospermum suaveolens, Sterculia urens, Boswellia serrata, Givotia moluccana*
Higher basal area tree species	*Pterocarpus santalinus*17.87 m^2/5ha, *Anogeissus latifolia*-13.54 m^2/5ha
Forest mean gbh (cm)	57.41cm

$m^2\ ha^{-1}$, respectively. The species accumulation curve was initially steep with a rise of 66 species in the first ha and the graph reached an asymptote featuring the sufficiency of sampling in the study area (Fig. 2). The top five species have accounted for 51.7% of total tree density and 46.12% of total IVI. While top ten species comprised of 63% of total tree density and 59% of total IVI. A total of four tree species such as *Drypetes sepiaria, Haldinia cordifolia, Naringi alata, Walsura trifoliata* were recorded with single individual and 28 species were comprised with 2 to 5 tree individuals. *Pterocarpus santalinus* ranked the most dominant tree species sharing 15.1% of total IVI value followed by *Anogeissus latifolia* with 11.5% of total IVI. In the whole five ha study area, *Pterocarpus santalinus* was recorded in 107 quadrats (85.6%) with 657 total tree individuals. An average of about five individuals occurred in each 20 X 20m quadrat and a maximum of sixteen individuals were represented in five such quadrats.

Log normal distribution: Species abundance distribution of the forest revealed eight octaves; the fifth octave (8-16 individuals) was the modal one with 24.7% of tree species followed by 3rd octave. The one-sample K-S test did not reject the hypothesis and indicated that the distribution was normal (K-S = 0.595, df = 7, p= 0.871), and the lognormal curve corresponded to normal distribution curve (Fig. 3).

Important Value Index (IVI): The rank abundance curve showed a gradual decrease up to seven species (Fig. 4) registering 52% of the total IVI and later the graph declined sharply as 90 species contributed the rest of 48% IVI.

Population structure: The forest stand structure in terms of increasing gbh classes (Fig. 5) has exhibited typical reverse 'J' shape curve. The lower gbh class (30-60 cm) comprised of 88 tree species and has registered 65.5% of total stand density contributing to 36.6% of basal area. Among the 88 tree species, 24 tree species were found to be restricted within the 30-60 cm gbh class itself. The notable species are *Antidesma ghaesembelli*, *Capparis grandis, Ceriscoides turgida, Cordia dichotoma, Drypetes sepiaria* and they are featured only in 1-3 quadrats. The medium gbh class 61-90cm gbh class was represented by 68 species which accounted for 26.9% of total tree density and a higher level of

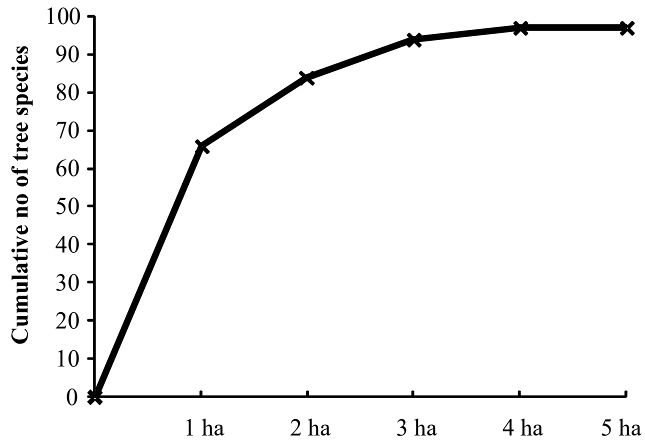

Fig. 2. Species accumulation curve for the total 5 ha obtained at 1 ha study

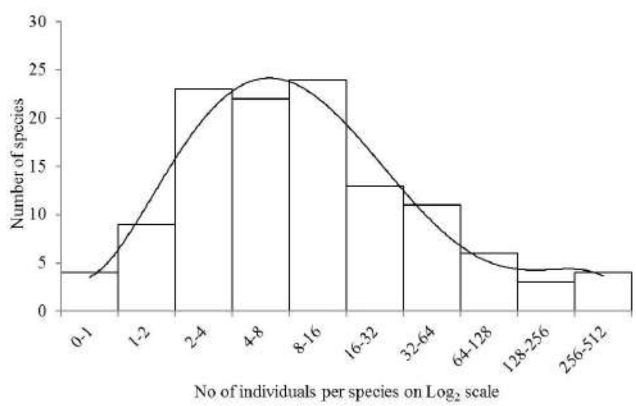

Fig. 3. Species abundance distribution with no of individuals on log 2 scale

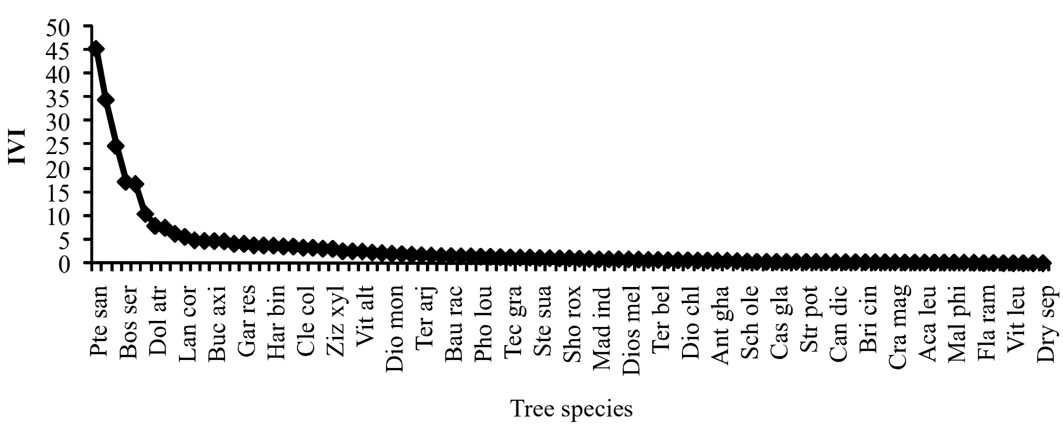

Fig. 4. Rank abundance curve of tree species based on increasing Importance Value Index values

Table 2. Tree species, family, number of tree individuals and Importance value index of all tree species in Nithyapoojakona dry deciduous forests

Name of the tree species	Family	TNI	IVI
Alangium salvifolium (L.f.) Wang.	Alangiaceae	8	0.74
Buchanania axillaris (Desr.) Ramam.	Anacardiaceae	49	4.77
Lannea coromandelica (Houtl.) Merr.	Anacardiaceae	53	5.65
Mangifera indica L.	Anacardiaceae	4	0.38
Semecarpus anacardium L.f.	Anacardiaceae	3	0.26
Polyalthia cerasoides (Roxb.) Bedd.	Annonaceae	75	6.30
Holarrhena pubescens (Buch.-Ham.) Wall.	Apocynaceae	15	1.31
Wrightia tinctoria (Roxb.) R.Br.	Apocynaceae	23	2.00
Wrigthtia arborea(Dennst.) Mabb.	Apocynaceae	2	0.24
Phoenix loureirii Kunth, Enum.	Arecaceae	17	1.49
Dolichandrone atrovirens (Roth) Sprague	Bignoniaceae	89	7.97
Dolichandrone falcata (Wall.exDC.) Seem	Bignoniaceae	9	1.06
Stereospermum personatum (Hassk.) Chatter.	Bignoniaceae	9	1.22
Stereospermum suaveolens (Roxb.) DC.	Bignoniaceae	14	2.62
Ceiba pentandra (L.) Gaertn.	Bombacaceae	8	0.93
Boswellia serrata Roxb.exColebr.	Burseraceae	160	17.24
Commiphora caudata (Wt.&Arn.)Engler	Burseraceae	27	3.63
Bauhinia racemosa Lam.	Caesalpiniaceae	19	1.62
Cassia fistula L.	Caesalpiniaceae	22	2.35
Hardwickia binata Roxb.	Caesalpiniaceae	36	3.81
Capparis grandis L.f.	Capparaceae	3	0.34
Crateva magna (Lour.) DC.	Capparaceae	3	0.31
Maerua apetala (Roth) Jacobs	Capparaceae	10	1.02
Cassine glauca (Rottb.) O.Kuntze	Celastraceae	5	0.42
Cochlospermum religiosum (L.) Alston	Cochlospermaceae	52	4.73
Anogeissus latifolia (Roxb.exDC.)Wall.ex Guill&Perr.	Combretaceae	453	34.46
Terminalia alata Heyne ex Roxb	Combretaceae	198	16.77
Terminalia arjuna Roxb.exDC.	Combretaceae	16	1.81
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	4	0.82
Terminalia chebula Retz.	Combretaceae	14	1.47
Cordia dichotoma Forst.&Forst.f.	Cordiaceae	7	0.31
Cordia macleodii (Griff.) Hook.f.&Thoms.	Cordiaceae	3	0.40
Ehretia aspera Willd.	Cordiaceae	18	1.39
Ehretia laevis Roxb.	Cordiaceae	4	0.42
Shorea roxburghii G.Don.	Dipterocarpaceae	10	1.14
Diospyros chloroxylon Roxb.	Ebenaceae	9	0.73
Diospyros melanoxylon Roxb.	Ebenaceae	23	2.12
Diospyros montana Roxb.	Ebenaceae	10	0.92
Erythroxylum monogynum Roxb.	Erythroxylaceae	7	1.14
Bridelia cinerascens Gehrm.	Euphorbiaceae	3	0.34
Bridelia Montana Roxb.	Euphorbiaceae	6	0.95
Cleistanthus collinus (Roxb.) Hook.f.	Euphorbiaceae	46	3.39
Croton scabiosus Bedd.	Euphorbiaceae	57	3.85
Drypetes sepiaria (Wt.&Arn.) Pax&Hoffm.	Euphorbiaceae	1	0.12
Givotia moluccana (L.) Sreem.	Euphorbiaceae	82	10.47
Mallotus philippensis (Lam.) Muell.-Arg.	Euphorbiaceae	2	0.25
Phyllanthus emblica L.	Euphorbiaceae	61	5.10

Cont....

Table 2. Cont...

Name of the tree species	Family	TNI	IVI
Dalbergia latifolia Roxb.	Fabaceae	27	2.65
Dalbergia paniculata Roxb.	Fabaceae	33	3.66
Pterocarpus marsupium Roxb.	Fabaceae	25	2.25
Pterocarpuss santalinus L.f.	Fabaceae	657	45.16
Flacourtia ramontchi L'Herit.	Flacourtiaceae	2	0.16
Chloroxylon swietenia DC.	Flindersiaceae	294	24.74
Gyrocarpus americanus Jacq.	Hernandiaceae	6	0.89
Strychnos nux-vomica L.	Lauraceae	11	1.31
Strychnos potatorum L.f	Lauraceae	4	0.39
Lagerstroemia parviflora Roxb.	Lythraceae	8	0.26
Soymida febrifuga (Roxb.) Juss.	Meliaceae	1	0.32
Walsura trifoliata (Juss.) Harms.	Meliaceae	1	0.12
Acacia chundra (Roxb.exRottl.) Willd.	Mimosaceae	14	1.20
Acacia leucophloea (Roxb.) Willd.	Mimosaceae	2	0.27
Albizia amara (Roxb.) Boiv.	Mimosaceae	5	0.82
Ficus mollis Vahl	Moraceae	7	1.24
Syzygium alternifolium (Wt.) Walp.	Myrtaceae	42	3.38
Syzygium cumini (L.) Skeels	Myrtaceae	6	0.37
Ochna obtusata DC.	Ochnaceae	65	4.94
Schrebera swietenoides Roxb.	Oleaceae	13	1.91
Ziziphus xylopyrus (Retz.) Willd.	Rhamnaceae	39	3.14
Canthium dicoccum (Gaertn.) Teijsm.&Binn.	Rubiaceae	3	0.35
Ceriscoides turgida (Roxb.) Tirveng.	Rubiaceae	2	0.23
Deccania pubescens (Roth.) Tirveng.	Rubiaceae	37	3.87
Gardenia gummifera L.f.	Rubiaceae	18	1.63
Gardenia latifolia Ait.	Rubiaceae	45	4.80
Gardenia resinifera Roth	Rubiaceae	42	4.20
Haldinia cordifolia (Roxb.) Ridsd.	Rubiaceae	1	0.14
Mitragyna parvifolia (Roxb.) Korth.	Rubiaceae	17	1.57
Morinda pubescens J.E. Smith	Rubiaceae	81	7.56
Aegle marmelos (L.) Cor.	Rutaceae	5	0.43
Atalantia racemosa Wt.&Arn.	Rutaceae	2	0.16
Naringi alata (Wall.exWt&Arn.) Ellis	Rutaceae	1	0.13
Naringi crenulata (Roxb.) Nicolson	Rutaceae	4	0.27
Lepisanthes tetraphylla (Vahl.) Radlk.	Sapindaceae	2	0.69
Sapindus emarginatus Vahl.	Sapindaceae	2	0.27
Schleichera oleosa (Lour.) Oken	Sapindaceae	4	0.47
Madhuca indica J.Gmelina	Sapotaceae	8	0.96
Manilkara hexandra (Roxb.) Dub.	Sapotaceae	6	0.64
Pterospermum xylocarpum (Gaertn.) Sant.&Wagh.	Sterculiaceae	4	0.57
Sterculia urens Roxb.	Sterculiaceae	27	3.18
Antidesma ghaesembilla Gaertn.	Stilaginaceae	12	0.64
Grewia flavescens Juss.	Tiliaceae	2	0.20
Grewia damine Gaertn.	Tiliaceae	3	0.15
Grewia tiliifolia Vahl.	Tiliaceae	19	1.57
Holoptelea integrifolia (Buch.-Ham.) Wall.exDon	Ulmaceae	4	0.66
Premna latifolia Roxb.	Verbenaceae	16	1.73
Tectona grandis L.f.	Verbenaceae	13	1.33
Vitex altissima L.f.	Verbenaceae	14	2.59
Vitex leucoxylon L.f.	Verbenaceae	1	0.13
Total		3406	300.00

IVI -Importance Value Index, TNI- Total number of tree individuals

37% of total basal area. The 34 species in the higher gbh class (91-120cm) featured 5.67% of density, 16.4% of basal area and 15 species in the >120 cm gbh class, represented only 1.88% of tree density and 10% of basal area. Tree species such as *Ficus mollis, Mangifera indica, Terminalia bellirica* and *Vitex altissima* were found to be in the >120cm gbh itself. The population structure curves of five dominant species revealed varied patterns. The four species such as *Pterocarpus santalinus, Anogeissus latifolia, Terminalia alata* and *Chloroxylon swietenia* showed the reverse 'J' shape curve with gradual decrease of tree individuals with increase in gbh classes (Fig. 6). While, *Boswellia serrata* did not featured reverse J shape curve as it had markedly higher girth trees in its population.

The present study tree species richness range of 36-72 tree species ha^{-1} and mean value of 60 tree speciesha^{-1}is on the lower side compared to dry forests of North Eastern Ghats; 46-82 tree species ha^{-1} (Naidu et al 2018) and 52 to 110 tree speciesha^{-1} (Reddy et al 2011) , but greater than tree species recorded in Vindhyan hill ranges 49 tree species (Sagar et al 2003) in Sariska Tiger reserve 38 tree species (Yadav and Gupta 2006) and in Aravali hill ranges of 50 tree species (Kumar et al 2011). The Shannon-wiener index of 3.38 was in the range of Indian dry tropical forests and it was higher than the values reported from Southern Eastern Ghats (2.44; Pragasan and Parthsarathy 2010) and forests in Bannerghatta National Park (1.1-3.5; Gopalakrishna et al 2015) but lesser than the values in north central Eastern Ghats (Reddy et al 2011). Nithyapoojakona forests revealed an average of 681 ha^{-1}tree individuals ha^{-1}indicate that these forests comprise of relatively higher tree density than Mudumalai forests (298 tree individuals ha^{-1}; Sukumar et al 1992) and tree density in southern Eastern Ghats of Tamil

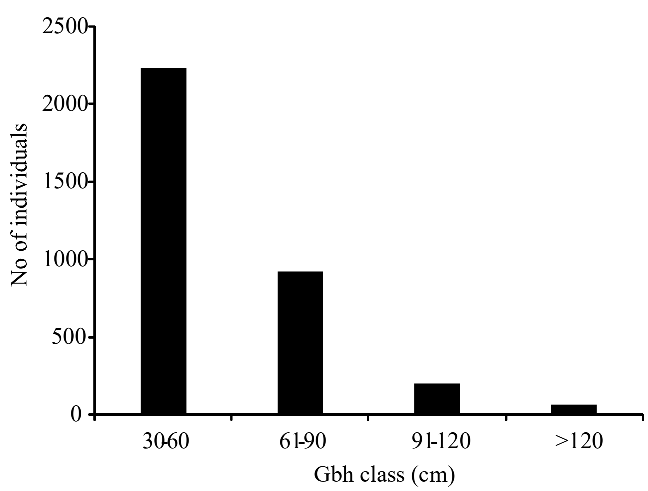

Fig. 5. Different girth class distribution and their respective number of tree individuals

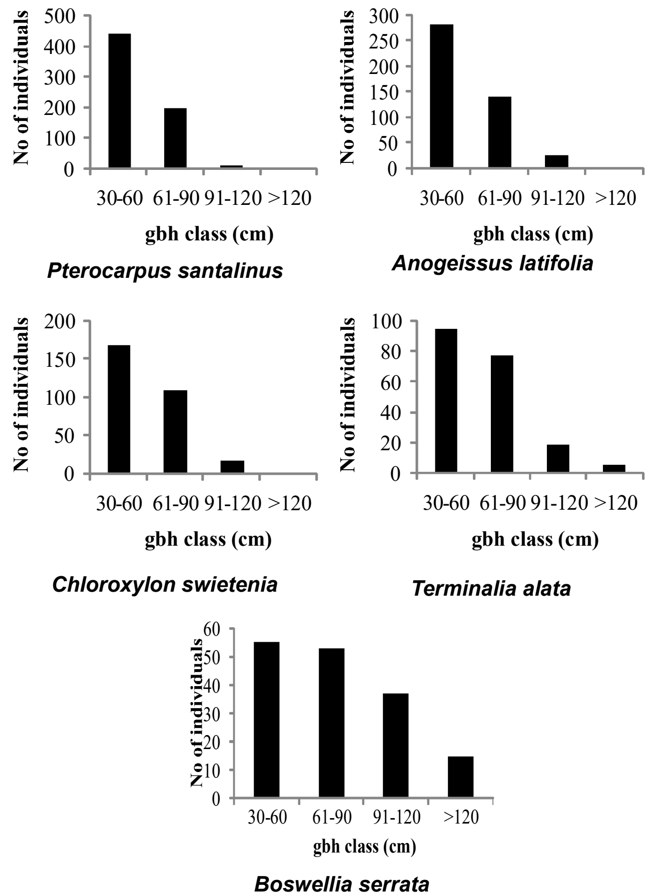

Fig. 6. Number of tree individuals in different girth classes for the top five predominant species

Nadu (457 tree individuals ha^{-1}; Pragasan and Parthasarathy 2010) but lesser than the tree density recorded in tropical dry evergreen forests of Tamil Nadu (935 stems ha^{-1}; Mani and Parthasarathy 2010) and in north central Eastern Ghats of Andhra Pradesh (726 trees ha^{-1}; Reddy et al 2011). The three dominant trees, *Pterocarpus santalinus, Anogeissus latifolia and Chloroxylon swietenia* shared >25% of the total IVI values indicating their dominance. Such kind of trees with wide ecological amplitude like *Shorea robusta, Hardwickia binata, Acacia catechu* (Sagar et al 2003), *Anogeissus latifolia, Xylia xylocarpa, Cleistanthus collinus* (Naidu et al 2016), *Xylia xylocarpa, Pterocarpus marsupium, Schleichera oleosa* (Reddy et al 2011), *Albizia amara, Euphorbia antiquorum, Canthium dicoccum* (Pragasan and Parthasarathy 2010) were reported in other dry forests.

CONCLUSIONS

The quantitative assessment of the dry deciduous forests reveal that they harbor moderate tree species richness and the forest stand structure is dominated by few tree species. A typical reverse "J" shape population curve showing gradual decrease of the total number of individuals with increase in gbh class suggests that forests possess regeneration potential as younger tree individuals can replace the mature tree individuals in future. Further, tree species abundance distribution curve of Nithyapoojakona forests indicating a normal distribution curve strengthens the view point that protected areas should remain a central component of conservation strategies.

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Seedling Mortality and Timing of Phenological Events in *Quercus semecarpifolia* Dominated Forests in Kumaun Himalayan Region

Arti Verma and Ashish Tewari

Department of Forestry & Environmental Science
DSB Campus, Kumaun University, Nainital-263 001, India
E-mail: artiverma60@gmail.com

Abstract: Phenology and population dynamics of *Quercus semecarpifolia* Smith. (Kharsu) in Nainital district of Kumaun region of Uttarakhand were observed during 2009-10 and 2010-11. The results revealed that the leafing occurred in the pre-monsoon period which peaked in July. Full leaf expansion was completed in August. The leaf expansion period in Yr1 was 10-15 days longer than Yr2 on both the sites. Leaf drop occurred throughout the year with a peak in June, while flowering was seen in July. Similarly, flowering was one week later in Yr2 in comparison to Yr1. The period between pollination and the ripening of acorns in *Q. semecarpifolia* was 12-14 months. Seed fall started from August and continued till September. The germination rate varied between 50-65% between the sites. The seedling emergence ranged from 35-45%. Across the study period seedling mortality rate was very high on both the sites. The regeneration was poor. At the end of observation the mean seedling density ranged from 0.3 to 0.6 seedling m^{-2}. Seedling mortality was high in the first year of recruitment between December and June.

***Keywords*:** Leafing, Leaf drop, Seed fall, Himalaya, Population dynamics

Himalayan forests play an important role in controlling the climate, conserving soil on slopes and building up huge reserves of soil nutrient. Himalayan forest degradation coupled with a global warming is imposing severe threats to the existing environment. Recent modelling studies suggest that the forest ecosystem can be seriously impacted by future climate change. Even a rise in 1-2°C, much less than the most recent projections of temperature during this century would impact most ecosystems and landscapes through changes in species composition, productivity and biodiversity (Ravindranath et al 2006). This will also impact the people who depend upon the forests for their livelihoods. Phenology and regeneration of any particular species are the most important phases in tree life history. *Quercus semecarpifolia* is common and much utilized broad-leaf oak species, but remarkably understudied in relation to its importance. The timing of growth onset and senescence also determines growing season length, thus driving annual carbon uptake in terrestrial ecosystems (Gu 2003). The phenological studies are important from the point of view of the conservation of the tree genetic resources and forestry management as well as for a better understanding of ecological adaptations of the plant species and the community level interactions. Regeneration is a key process for the existence of species in the community. The germination rate and the seedling survival rate constitute biological and ecological advantages for the population dynamics of species, which is characterized by effective regeneration strategies.

Quercus semecarpifolia Smith. (Brown oak), family Fagaceae, a late successional species, which forms climax vegetation between 2200-3500 m elevations in the northern hemisphere. It is naturally long lived (>300 yrs) and requires small gaps for survival and regeneration of seedlings. The species has viviparous seeds with short seed viability and it synchronizes its seed maturation and germination with monsoon rains (Verma et al 2012). The benefits of the oak forest include large biomass returning large amount of nutrient annually, retaining water, providing moisture etc. We hypothesize that warming would impact the timing of phenological events and population dynamics of this high-altitude species *Q. semecarpifolia*. The main aim of the present study was to observe the pattern of phenological events and study the population dynamics of the species in view of changing climate and compare the changes in the timing of the phenological events if any with the current studies to estimate the impact of climatic irregularities and warming on this high elevation oak species over a period of time. Biological clock is more authentic reason to observe the changes in climate, though one year information cannot depict the change but serves as source of base line information for future observations.

MATERIAL AND METHODS

Two representative sites were selected in Nainital district of Kumaun Central Himalaya, China peak and Kunjakharak. China Peak is located between 29° 27' to 29° 29' N latitude and 79° 23' to 79° 25' E longitudes with an altitude varying between 2500 and 2610 m and Kunjakharak site is located between 29° 30' to 29° 27' N latitude and 79°19' to 79°20' E longitude with an altitude varying between 2400 to 2500m above mean sea level. Both sites are dominated by *Quercus semecarpifolia* and under canopy species *Rhododendron arboreum.* There are three main seasons, winter season (December - March) a relatively dry summer (April to mid June) and a warm, humid rainy season (mid June to September) which accounts for approximately, 70 % of the annual rainfall. Severe frosts are usual throughout the winter season and snowfall is frequent with snow persisting for months in the northern pockets. The total rainfall recorded in the year 2009-10 was 2175.6 mm and in 2010-11 3739.2 mm in Nainital. The maximum temperature recorded in the year 2009-10 was 29.0°C and 27.3°C in 2010-11. The minimum temperature recorded in 2009-10 was 3.0°C and 3.9°C in 2010-11.

Methods: At each forest site a permanent plot of 1.0 ha, was established. Ten, 5.65 m radius circular permanent plots at each site were established within the 1.0 ha area. Vegetational parameter was determined as (Mishra 1968, Muller-Dombios and Ellenberg 1974). Frequency, density, total basal area, relative values and IVI (Important value index) were calculated (Ambasht and Ambasht 2002).

Phenological observation: Phenological observations were made for four major phenophases viz. leafing, leaf maturity, flowering and fruiting of *Q. semecarpifolia* from January 2009 (Yr1) to December 2010 (Yr2) at both the sites from, 25 marked individuals of *Q. semecarpifolia* of similar size. The observations were made at weekly intervals from the 1st week of January to last week of August, the period of high phenological activity. During the remaining part of the year observations were made at 3-4 week intervals.

Leafing: On the marked 25 Individuals for *Q. semecarpifolia*, 3 branches of each individual tree were selected and approximately 15 vegetative buds of each branch were marked just prior to bud break. From these marked trees, 5 leaves from each selected branch were collected randomly on each of the sampling dates; samples were taken at weekly intervals at the peak time of phenological activity in spring and at fortnightly interval in other months. Leaf area was calculated. Collected leaves were brought to laboratory in polythene bags and . fresh weight was taken. Thereafter, leaves they were oven dried at 50°C to constant weight. On the basis of leaf dry weight, SLA was calculated (Evans 1972).

Specific leaf area SLA ($cm^2 g^{-1}$) = A / LW (A= leaf area (cm^2), LW = leaf dry weight (g))

Specific leaf mass SLM ($g\ cm^{-2}$) = LW /A

The observations were made for flowering and fruiting at weekly interval from April to August for *Q. semecarpifolia* at both the sites.

Population Dynamics

Seed fall density: 10 seed traps of 50X50cm size were placed randomly on the forest floor with side extending upwards = 5cm. Seeds were collected from the traps every week from July to August (the season of seed fall). The seeds were counted to calculate the yearly variation in seed fall density (Joshi and Tewari 2009).

Seedling survival: An experiment area of 0.1 ha was demarcated and 10 permanent quadrat of 1X1 m^2 were randomly laid during 2008. The newly recruited seedlings of *Quercus semecarpifolia* in each quadrate were tagged with aluminium foil in the 1st week of October and their survival was monitored at monthly intervals until March 2011. The age-specific mortality rate (Q_x) of the seedling populations was calculated on the monthly basis for 2 years using the following expression (Poole 1974).

$$Q_x = d_x / l_x$$

Where l_x is the number of individuals at the beginning of the month and d_x is the number of individuals that died during the 1-month period.

RESULTS AND DISCUSSION

Vegetation parameters: The total tree density on China peak site was 640 tree ha^{-1} and the total basal area of all the tree species was 54.57 $m^2 ha^{-1}$. On the other hand, the total tree density on Kunjakharak site was 390 trees ha^{-1} and the total basal area of all the tree species was 43.26 m^2 ha^{-1} (Table1).

Table 1. Vegetational parameters of tree species in *Quercus semecarpifolia* dominated forest on China peak and Kunjakharak site

Sites	Species occurs	Density (ind ha^{-1})	MBA ($m^2 tree^{-1}$)	TBA ($m^2 ha^{-1}$)	IVI
China Peak	*Quercus semecarpifolia*	630	0.086	54.49	289.32
	Rhododendron arboreum	10	0.008	0.086	10.65
Total		640		54.576	299.97
Kunjakharak	*Quercus semecarpifolia*	320	0.124	39.68	252.3
	Rhododendron arboretum	40	0.084	3.36	32.72
	Cornus macrophylla	30	0.0076	0.22	14.88
Total		390		43.26	299.9

At both sites, *Quercus semecarpifolia* was the dominant tree species, the total tree density at China peak and Kunjakharak oak forest ranged from 390-640 tree ha^{-1}, which was within the range (280-1680 ind ha^{-1}) as reported by earlier workers for different Himalayan oak, pine and oak-pine mixed forest (Kharakwal 2009, Raikwal 2009, Singh 2009)

Phenological events: The phenological events for each month were recorded as the sum of fractions of species with different phenological activities (leaf drop, leafing and maturity, flowering and fruiting and litter fall) in that month.

Leaf drop and initiation: Leaf drop started in 4^{th} week of October and was maximum in June in Yr 1 but in Yr 2, the leaf drop commenced from 1^{st} week of November and was highest in May on both the sites.

Leafing commenced when trees had reduced their canopy cover by 75% in May-June. At full developed stage in August at China Peak site, full leaf size in Yr1 was lower (22.7 cm^2) than Yr2 (28.81 cm^2). Conversely, specific leaf area (SLA) and specific leaf mass (SLM) were greater in Yr1 (13.27 $cm^2\,g^{-1}$and 0.075 g cm^{-2}) than Yr2 (11.89 $cm^2\,g^{-1}$ and 0.083 g cm^{-1}). Similarly, the leaf expansion period in Yr1 was 8-10days longer than the leaf expansion period in Yr2. The leaf size and period of enlargement were significantly related (r = 0.930,) and there existed a negative correlation (r = 0.836) between leaf area and specific leaf area. At Kunjakharak site, full leaf size in Yr1 was lower (27.53 cm^2) than Yr2 (30.99 cm^2). On the other hand, SLA and SLM was greater (16.09$cm^2 g^{-1}$and 0.069 g cm^{-2}) in Yr1 than Yr2. Similarly, the leaf expansion period in Yr1 was 10-15days longer than the leaf expansion period in Yr2. The leaf size and period of enlargement were significantly related (r = 0.927) and there existed a negative correlation (r = 0.671) between leaf area and specific leaf area.

In the present leafing started in pre-monsoon season and leaves matured in rainy season. In Yr2, leaf flushing was 3weeks later than Yr1 on both the sites. The shift in the time of leaf flushing in Oak species has also been reported by the Singh et al (2000). Similarly, leaf drop started in *Q. semecarpifolia* one week later in Yr2 than Yr1, when the canopy had thinned by 60-75%. However, in other oaks of the region, the new leaves become fully developed before the old leaves were shed; consequently the thinning of the canopy is not conspicuous. The duration between leaf initiations to full expansion of leaf was approximately 6 weeks in *Q. semecarpifolia.* In Yr2, the vegetative buds appeared three week later than Yr1 and time between leaf initiation and full expansion of leaves was also 15days earlier than Yr1 at both the sites. The shift in bud formation and leaf maturity in two consecutive years was due to the variation in temperature at the peak time of the phenological activity; in May-June 2009, the mean average day temperature was 28.5^{0}C and in 2010 the mean average day temperature in May-June was 25.9^{0}C. The temperature in 2009 was higher than the temperature in 2010 during leaf expansion time.

Singh and Negi (2018) have reported that the commencement of the leaf flushing in *Quercus semecarpifolia* was 4 week earlier (Table 3) than our reported time. In recent years, however, some progress has been made on the growth response of plants to ongoing global warming (Gaire et al 2014, Cui et al 1999, Shrestha et al 2012). At high altitude the short growing season, snowfall, low air and soil temperature, high exposure to wind, increased exposure to frost and lower availability of nutrients are some of the common features of high altitude regions, which greatly influence plant phenophases and vegetation growth (Korner 2012, Germino 2014).

Flowering: The flowers were in clusters and one cluster had at least 6-7 catkins. Flowering occurred after the culmination of leaf expansion. The duration of flowering ranged between

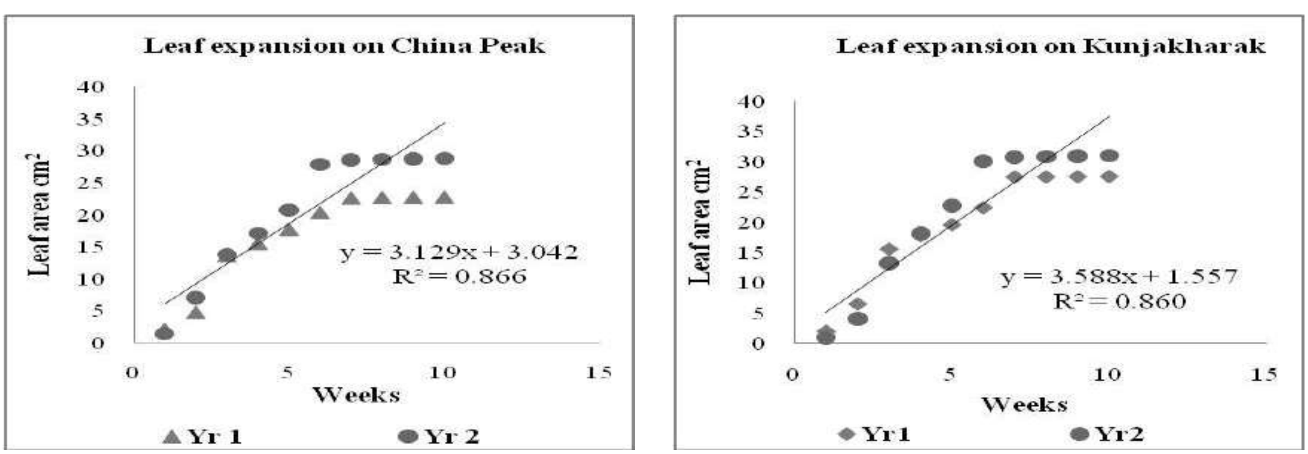
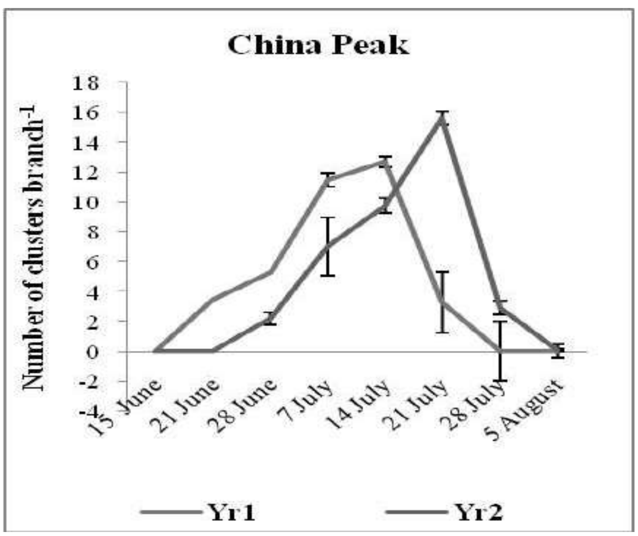


Fig. 1. Period of bud bursting and leaf expansion in *Quercus semecarpifolia* on China peak and Kunjakharak site

3-4 weeks. The flowering in Yr1 started from was on 3rd week of June, the maximum flowers were observed in 1st week of July and then declined. Similarly, in Yr2, the flowering started in June last week and maximum flowering appeared in 2nd week of July and after that declined on both the sites. Start of flowering in *Q. semecarpifolia* was a week later in Yr2 in comparison to Yr1. (Fig. 2)

Fruiting: The period between pollination and the ripening of the acorn was 14-15 months. Acorn development was observed from July. At China Peak site, the acorn size in 3rd week of July was 0.55 long and 0.60±0.03 cm wide and colour was green. The maximum acorn size was 3.45±0.15 cm long and 4.07±0.12 cm wide in 3rd week of August and colour was dark brown. In Yr2, the fruit ripening was delayed and was observed from 1st week of August on the both the sites. The acorn size in 1st week of August was 0.64 long and 0.8 cm wide and colour was green. The maximum size of acorn was 3.78±0.1 long and 4.07±0.26cm wide in 1st week of September and colour was dark brown on China peak site. On Kunjakharak site, the acorn size in 3rd week of July was 0.57 long and 0.72±0.02 cm wide and colour was yellowish green. The maximum size of acorn was 3.52cm long and 4.00 cm wide in 3rd week of August and colour was yellowish brown. In Yr2, the acorn size in 1st week of August was 0.78 cm long and 0.95 cm wide and colour was yellowish green. The maximum size of fruit was 3 cm long and 4.09 cm wide in 4th week of August and colour was yellowish brown. Fruiting in Yr2 was 2 week later than Yr1 (Table 2). In *Q. semecarpifolia*, the flowering in Yr2 was 1week earlier than Yr1 on both the sites. Similar, trend in flowering phenology has been reported by Menzel, et al (2006) and Hegland et al (2009) in Europe, which concur with findings from other parts of the northern hemisphere (Miller-Rushing, et al 2006, 2007). Earlier study however, have shown significant



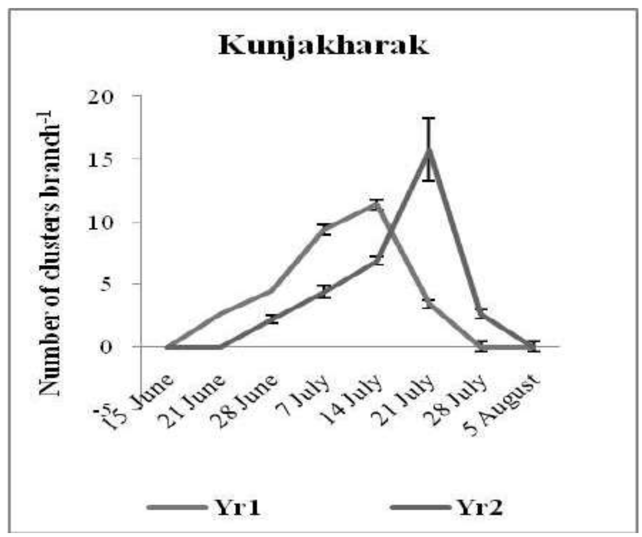


Fig. 2. Flowering in *Quercus semecarpifolia* at China peak and Kunjakharak site

Table 2. Period of acorn enlargement in *Quercus semecarpifolia* on China peak and Kunjakharak site (Mean +_SD)

Year	Time period	China peak		Kunjakharak	
		Average length (cm)	Average width (cm)	Average length (cm)	Average width (cm)
Yr 1	3rd week of July	0.55±0.02	0.60±0.03	0.57±0.02	0.72±0.02
	4th week of July	1.57±0.12	1.75±0.15	1.87±0.15	1.92±0.23
	1st week of August	2.57±0.06	2.61±0.05	2.25±0.06	2.57±0.22
	2nd week of August	2.89±0.08	2.97±0.09	2.92±0.12	3.06±0.18
	3rd week of August	3.45±0.15	4.07±0.06	3.52±0.16	4.00±0.06
Yr 2	1st week of August	0.64±0.01	0.82±0.06	0.78±0.02	0.95±0.05
	2nd week of August	1.25±0.12	1.52±0.02	1.78±0.10	1.98±0.12
	3rd week of August	2.64±0.07	2.52±0.56	2.85±0.15	2.67±0.16
	4th week of August	2.90±0.08	2.67±0.07	3.80±0.06	4.07±0.02
	1st week of September	3.78±0.19	4.07±0.26	3.88±0.20	4.09±0.01

variation (advanced or delayed) in onset dates of flowering (Fitter and Fitter 2002) and fruiting responses (Chapman et al 2005) in tree species as a result of climate change.

Tewari et al (2019) reported that the acorn maturation time in Kharsu oak was the 2nd week of August, which was approximately 15 days earlier than reported in our study. Maturation time of many tree species with short seed viability synchronized with the rainy season. Due to global warming seeds of such species might mature earlier breaking their timing of seed maturation with monsoon rains severely affecting germination Tewari et al (2019).

Population Dynamics and Regeneration

Seed fall density: Seed fall started from last week of August and continued till mid September. At China Peak site, the seed fall density ranged between 4.30 to 14.50 seed m^{-2} with 15-30% seed showed vivipary. At Kunjakharak site, seed fall density ranged from 4.93 to 11.20 seed m^{-2} and 15-25% seed showed vivipary. Across the sites, China peak had higher seed fall density than Kunjakharak. The seed fall density varied significantly in Yr1 and Yr2 and across the sites. These values were closer to reported values by Joshi and Tewari (2009) for *Quercus floribunda* in non-mast seed year which ranged from 0.0 to 19.6 seeds m^{-2} and that in winters the study areas have become warmer by 1.5°C and can severely effect seed production and germination (Joshi and Tewari 2009). Tewari et al (2019) also reported for *Quercus semecarpifolia* in bad seed year, the seed fall density ranged between 4.15±0.78 and 9.45±2.7 seed m^{-2}. No long term seed bank exists for oaks because acorns do not survive from year to year and this *Quercus* species being viviparous coincide its seed maturity with monsoon rains.

Seed germination and recruitment: On China peak site, mean seed germination varied between 60 and 65% and on Kunjakharak site, between 50-55%. Germination in

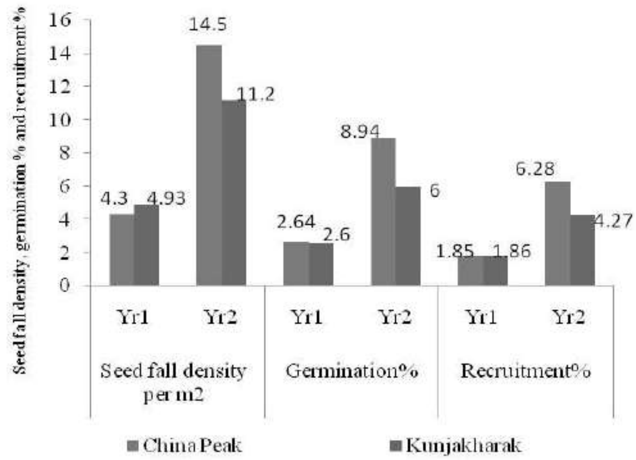


Fig. 3. Seed fall density, germination and recruitment in *Quercus semecarpifolia*

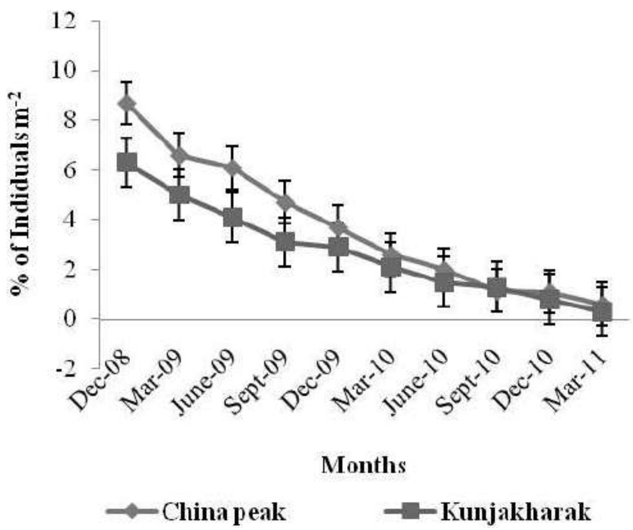


Fig. 4. Comparative diagram of survival rate in *Quercus semecarpifolia* on China peak and Kunjakharak site

Table 3. Comparative table of phenological activities of dominant tree species in Kumaun Central Himalaya

Species	Leaf drop (month)	Leaf flushing (month)	Flowering (month)	Fruiting (month)	References
Shorea robusta	3-4	3-4, 6-7	4-5	5-7	Ralhan (1985)
Pinus roxburghii	1-12/5-6*	2-4, 7	2-3	2-3	Ralhan (1985)
Quercus leucotrichophora (mixed oak-rianj dominated forest)	1-12/4-5*	3-4, 8, 10	4-5	10-2	Ralhan (1985)
Quercus leucotrichophora(mixed oak-tilonj dominated forest)	1-12/5-6*	4,8,10	4-5	10-2	Ralhan (1985)
Quercus leucotrichophora	-	-	-	12	Negi (1989)
Quercus floribunda (mixed oak-rianj dominated forest)	1-12/6-7*	4, 8, 10	4	8-10	Ralhan (1985)
Quercus floribunda (mixed oak-tilonj dominated forest)	1-12/5-6*	4, 8,10	4	8-10	Ralhan (1985)
Quercus floribunda	-	-	-	8	Nagi (1989)
Quercus semecarpifolia (oak forest)	1-12/5-6*	6-7	6-7	7-8	Present study
Quercus semecarpifolia	1-12/5-6*	5-7	7-8	-	Singh and Negi (2018)
Quercus semecarpifolia	-	-	-	7-8	Tewari et al (2019)

Numerical values represent the months in numeric form as 1=January,2=February and so on ungerminated seeds started within the 5-7th days after falling and was completed within 30 days of seed fall. Germination was however, rapid between 10th and 20th days. Seedling emergence from the viviparous seeds was significantly higher than non-viviparous seeds. The seedling emergence ranged from 45-40% on China peak and 35-40% on Kunjakharak site.

Seedling mortality and growth: Across the study period seedling mortality ranged from 90-95% on both the sites. After 30 months observation, on China peak site, the total mean seedling density was 0.6 seedlings m^{-2} and on Kunjakharak site it was 0.3 seedling m^{-2}. The maximum mortality of seedlings was in first year of recruitment 57.15% and 36.26% in rest of the months. At the end of observation the average height of existing seedlings ranged from 5 to 8 cm. Seedling mortality was high in the first year of recruitment from the winter to spring season (December to May) and in rainy season it was low. The relationship between survival rate and month was significantly variable but insignificant between survival rate and site.

The relative proportion of population of seedlings, young trees and mature trees in a given species population indicates the status of regeneration of the species. Nath et al (2005) suggested that main cause responsible for increase mortality rate of seedling and sapling is the below ground competition of mature trees with seedlings and anthropogenic activities imposed by local inhabitants. The seedling mortality rate after 30 months observation, in *Q. semecarpifolia* ranged from 36.26% to 57.15% and survival rate of seedling was 6.59% at China peak. The seedling mortality rate ranged from 40% to 55.08% and survival rate of seedling was 4.34% at Kunjakharak. The germination and recruitment percentage were close to value reported for *Q. floribunda* in non-mast seed year and seedling mortality rate by present study was comparable lower value reported by (Joshi and Tewari 2009). In present study, after 30 months observation, the seedling density ranged between 0.3 and 0.6 seedlings m^{-2} in *Q. semecarpifolia*. The seedling density of present studies was lower than reported by (Joshi and Tewari 2009) after 15 years observation the total mean seedling density was 6.1 seedlings m^{-2} in *Q. floribunda* forest.

CONCLUSION

There appear to be shift in the timing of leaf initiation and fruiting time of *Q. semecarpifolia* when compared with the current studies. The shift in fruiting time can severely influence the regeneration of *Q. semecarpifolia* which has viviparous seeds and short viability. This is preliminary study to assess time the phenological events of a major high-altitude forest forming tree species which can be severely impacted by the rising global temperature. Evidences from the seedling dynamics study indicate that even after 30 months the new populations of the species do not stabilize and mortality continues. This indicates that regeneration of the species is under threat.

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Anthropological Understanding of Climate Change: A Review Essay

Gurinder Kaur and Neetu Gaur

Centre for Research in Rural and Industrial Development, Chandigarh-160 019, India
E-mail: gurinderkaur1725@gmail.com

Abstract: Anthropocene is fast developing as a concept and a theoretical paradigm and linked to climate change exigencies of today. This brought *anthropos*, humans, at the centre of climate change debates. Humans are being considered as the largest contributors towards the existing realities and challenges of climate change. This brings in focus the question of responsibility because anthropos is not a homogenous category and defines, it the diversity and subjectivity of this entity. Therefore, fixing the responsibility over cause and effect of climate change would not be uniform. In this focus, the present review attempts to present how anthropology as a discipline can contribute towards alternative narratives of living with climate change based on its theoretical and methodological tools that are embedded in the local everyday lives of the people.

***Keywords*:** Climate change, anthropocene, anthropos, anthropology

The term anthropocene and climate change have almost established a conjugal relationship with one another in recent times. Anthropocene is being defined as a geological era in earth's history where human impact is most profound rather than natural climatic phenomenon (Sayre 2012). Anthropocene is fast developing as a concept and a theoretical paradigm and "with astonishing speed, dislodging familiar terms like nature and environment from their customary pre-eminence" (Howe and Pandian 2016). Even though International Commission on Stratigraphy is yet to declare its views on confirming it as a distinct era within the geological history of earth, it has gained prominence in and beyond popular, academic, research and bureaucratic discourses. Anthropocene being established as a distinct geological era or not, there is no deniability that *anthropos*, humans, are the largest contributors towards the existing realities and challenges of climate change. Human factor bringing about climate change is an established fact. Bruno Latur (2014) remarked anthropocene, as a concept, has the ability to claim that human agency has become the main geological force shaping the face of earth, and is to immediately raise the question of responsibility (139-AAA4). Accordingly it seems that anthropocene and climate change are two sides of the same coin, the basic material of which is composed of human agency. In the attempt to fix responsibility, multiple approaches and counter-approaches surrounding climate change are being attempted. This fixing of responsibility makes it an issue of not just scientific and scholarly enquiry but also problematises it by raising concerns of politics, power, control and ethics. Thus, calling for acceptance of current climate change as human induced and for taking relevant actions in mitigating its effects. As a result of all the debate surrounding anthropocene and climate change, anthropos is marked as moral, political and ethical subject. However, as Latur remarks, "the 'anthropos' of anthropocene is not exactly anybody, it is made of highly localised networks of some individual bodies whose responsibility is staggering" (138-AAA7). Even though anthropocene has brought anthropos at the centre of climate change debates, it is not a homogenous category. Anthropocene has garnered human agency as consuming giant and at the apex of existence of all life forms. Human agency, however, has never been bereft of its diversity and subjectivity.

The politics over climate change has been made amply clear two camps debating its existence, also dividing the nations and their policies towards climate change. On the one side are many individuals, groups and organisations which deny the existence of human accentuated climate change. They argue on the basis that changing climatic conditions like global warming is a naturalised phenomenon with no causation by human interference (Sayre 2012). These groups tend to support their claims stating that changing climatic conditions from ice ages to interspaced warmer periods have been the natural phenomenon of earth's history. The other side are researchers, scientists, social scientists, activists, organisations like United Nations Climate Change Commission (UNCCC), Inter-governmental Panel on Climate Change (IPCC) which have established human induced climate change as a fact. Within this debate emerge the three tropes of climate change around which policy debates, formulations and implementation revolve, viz., vulnerability, resilience and adaptation. Studies and reports on the three tropes have established that the effect of climate change is not going to be uniform, in terms of physical effect as well as socioeconomic implications. Fixing the responsibility over its cause and effect, thus, also would not be uniform. Goodman (2018) refers to climate change as climate crisis and reflects on it as a dialectical subject produced by society's own contradictions. Scientists, social scientists, activists, researchers, etc. across spatial and temporal formations have attributed the fact that the regions which have contributed in highest configuration towards climate change are not likely to be the worst sufferers of its impact (Sayre 2012). As a result there has been a constant failure over the years ever since the debate on climate change was initiated to translate and transform it towards effective policy measures (Demeritt 2001).

Considering this background, the centrality of human agency, anthropos, into the debates around climate change calls for an increased attention towards what and how anthropology has contributed and can further add towards development and understanding of this issue. Anthropology calls for attention towards the local effects of a global phenomenon, to locate that which is universal to human experience yet unique in its existence to the particular. It attempts to present newer forms of understanding about living beyond the homogeneity of anthropos which has come to define and identify anthropocene (Howe and Pandian 2016). It places diversity and subjectivity at the core of its methodology and attempts to locate the tropes of vulnerability, resilience and adaptation by documenting and presenting these as lived experiences of the people. By knowing the alternate ways for understanding about climate change helps in deciphering how risk and vulnerability is lived with. There alternatives become essential, for identifying ways and methods to help develop resilience and adapt to changing conditions, as policy measures or to understand how communities depict resilience and adaptability towards changing conditions.

Anthropology and Climate Change

"Large scale natural events can cause significant impact on agriculture and human settlemen. In many cases, the impacts will be felt most severely in regions already under stress, mainly developing countries. Human-induced climate change due to continued uncontrolled emissions will accentuate these impacts" (Climate Change Report IPCC 1992). "Several modelling studies have linked some specific responses in physical and biological systems to anthropogenic warming". Additional adaptation measures will be required to reduce adverse impact of projected climate change and vulnerability to climate change can be exacerbated by other stresses. These arise from, current climate hazards, poverty and unequal access to resources, food insecurity, trends in economic globalisation, conflict and incidence of disease such HIV AIDS" (IPCC, Climate Change Synthesis Report 2007). Between 1992 and 2007 climate change become a concretised reality and impact of human imprint on this large scale global phenomenon well established. The unequal impact of climate change has been documented through climate change reports of IPCC over the years. The earlier reports gave a piecemeal coverage to importance and significance of social factors in terms of adaptation and resilience of communities, but not countries as a whole, the 2014 climate change report recognised, "the value of social (including local and indigenous), institutional, and eco-system based measure and of the extent of constraints to adaptation" (IPCC, Climate Change Report 2014).

The increasing focus on social paves path for bringing in the local to the centre of climate change discourse. The top-down homogenised policies failed to reflect upon the local experience of climate change except for the passing reference to the some of the regions and indigenous populations of those regions represented as symbolic to the effects of climate change. Anthropological studies have over the years contributed directly and indirectly to creating a nuanced understanding about the forces of climate change and its impact on human populations. The human-environment interaction has been well documented and the ways in which both have impacted one another is recorded in fossilised evidences. A number of disciplines have studied these interactions in details, including anthropology. Beginning with prehistoric archaeological studies, these have over all these years presented recorded evidences of climatic changes and the impact it has had on human evolution and spread of human population over eras and epochs of geological time scale. These studies have also presented the means and methods through which humans adapted to climate change and developed innovative ways for survival and therefore depicting resilience for survival (Crate 2011).

The AAA statement on humanity and climate change reflects that "archaeological record shows that diversity and flexibility increase resilience to stress in complex adaptive systems" (AAA 2014) and present the ways in which past human populations adapted to changing climatic patterns to increase their chances of survival and proliferation. The changes in the distant past in the climate of earth were more or less attributed to natural causes. However, if anthropocene is established as a hard fact and a geological epoch following Holocene in progression, this would mark the damaging footprint of human interference on climate with larger spread and greater impact than in the past. These studies on prehistoric and historic past provide relevant information and framework towards understanding and dealing with human, climatic and systemic variations in the present day complexities.

The second significant contribution of anthropology is its focus on the local grassroots level through embedded fieldwork and ethnographic approach. The physical changes taking place in climate and its implications on biology and ecology on the whole is well established. Anthropology has come a long way in its journey from documenting how different cultures developed technological innovations and progressed in evolutionary scale depending upon the environmental variation towards specificity of how communities relate to their environment and live, experience and describe climate change as part and parcel of their existence and their world. The culture and ecology school of anthropology, propounded by Julian Steward and Leslie White, has well conducted studies which depict human-environment interdependency in terms of technological progression and energy consumption. Anthropology has now begun to incorporate domains that have started exploring human and non-human spaces of interaction. Kohn (2013) in his book How forests thinks, talks about “post humanities... focusing on the zone beyond the human as a space for critique and possibility” (7). This focus, according to him, helps in understanding the relationship between place and people who live there. These approaches help to decipher an understanding of environment as different form the Western notions of environment as a resource. These provide an account of environment as part of culture and society.

The current debates and focus of anthropology is on how climate change has started to impact how people developed their own worlds, how they perceived it and lived in it and their relationship with environment and ecology. It focuses on the social and cultural implications of life's existence in era of large scale climate change and it is acknowledged that the impact is neither uniformly felt not distributed, implicating factors which are anthropogenic, structural and institutional. Baer and Singer (2018) express, humans and their cultures as being one within and not separate from nature and focus on how power plays impact the cause and effect of climate change differentially and how economic and consumerist expansion, historical and social injustice(s) “can push ecological systems beyond the coping capacity of special, including our own” (12). They argue that various life forms have shown varied degrees of resilience in face of ecological adversities, the change has been slow and adaptable. However, in the present case scenario the change is large scale, unequal and fast paced. Rather than putting lives to the threat of extinction the most profound effect would be on the way life exists as of now. Loss of meaning, of cultural associations, of man-nature dependence and reliance all would face the threat of being altered even more than they already are.

This aspect gains significance given the three tropes of climate change that focus increasingly on how communities are and would ensure their survival in context of climate change. Oliver-Smith (2013) provides an anthropological conceptualisation of vulnerability, resilience and adaptation. Vulnerability bares the social factors that increase the chances of death and other forms of damages due to climate related hazards. It also implicates economic dimension of human-environment relation, where environment serves the purpose of a resource for exploitation. Resilience depicts how communities are stable in their historical and socio-cultural existence which ensures their material and developmental growth. Adaptation refers to the changes that take place and become part of culture enabling people and communities to survive and proliferate without threat to existence. Bolig (2018) called for attention towards how capitalist practices, adaptation to climate change and governance techniques are and would be linked to each other and highlighted that anthropology has contributed through thick ethnographic descriptions on how changes in climate are lived with and how these impact cultural meanings of sociality and existence. In the irreversibility of climate change effects, anthropology could focus on anticipated practices for adaptation based on the observation that market based adaptive strategies would be more pronounced in near future. These strategies would not merely entail profit for global players but would also benefit local elites. The new power dynamics involving political economy and ecology would provide a new paradigm for anthropological focus.

Crate (2008) argues that focus on the social aspect of climate change has been missing in the climate change research. The focus primarily is on the quantitative techniques and results often neglecting the social and cultural realities. Even IPCC recognises the urgency of research into how human systems would adapt to climate change but research explicitly focusing on the cultural implications of global climate change need to be addressed. Crate (2008) in her study among the Viliui Sakha in north-eastern Siberia, explained the effect of changing ecosystem and the grassland of the region on existence of cows and reindeers. Both the animals represent central cosmology for the people of this region. Such localised effects would “play out in forms of a people's cultural predilections, the restacking and appropriating of their belief systems, and their cognitive orientations- their perceptions of and assumptions about home"(Crate 2008). At the same time, anthropological enquiry also raises the question of equity and equality in terms of effects of climate change on certain communities. de Wit et al (2018) emphasise that anthropological focus must not solely rely upon what people perceive of environment through their observations alone. The mechanics involved in diffusion of knowledge on climate change includes media in various manifestations, NGOs, scientific research, political set up at both national and international level and climate change activism must also be studied. They termed this approach as climate change traveling idea. Hofmann (2018) presented a case study of the islanders from Micronesia and expanded on the concept of climate change as a travelling idea. This presents the western notion of islands as insular and highly vulnerable to climate change. The island communities are put on display to the world as epitomising climate change. However to the islanders climate change remains a non-issue in face of other exigencies that they face for their survival owing to political economy of the region.

Farboto and Lazrus (2012) in study among the Tuvalu in the Pacific problematise the conceptualisation of climate refugees. Furthering the importance of group specific studies to understand the felt impact of climate change, the authors object that the abstractions of time, space and belonging which dominate climate change narratives often assume are not universally shared. They argue that rather that climate change it is the already prevailing situations of structural and institutional conditions leading to forms of structural violence that cause vulnerability and susceptibility towards climate change.

Climate change is not the dominant cause of vulnerabilities of communities, rather it accentuates them further in addition to already existing causes like poverty, violence, persecution, political instability, lack of access to resources etc. The need is to focus on everyday practices rather than breaking the practices like migration out of context from the everyday lives of the people and putting it in the boxed context of climate change alone. Lazrus (2012) and Oliver-Smith (2013) have attempted to contextualise adaptation, vulnerability and resilience anthropologically and emphasised on the need to reconceptualise these concepts based on local everyday lives of the people affected by climate change. For example Lazrus (2012), mention that more than the loss of land and resources it is the loss of cultural and national identity that makes the Tuvalu feel more vulnerable towards climate change. Migration emerges to be a key response towards current and future aspects of climate change. The current international political paradigms accorded to refugee status became redundant for those termed as "climate refugees". Compensations in present day context for people impacted by climate change do not address the structural forces that cause systematic vulnerabilities of people.

Anthropology presents different strains through climate change and presents climate change as felt by the local communities in terms of changing weather patterns over decades. Along with this change, ethnography contributes to foretell how cultural symbolism and meaning change and how the change is reflected, accepted and adapted to and presents the change in man-nature interaction. Multi-species ethnography is an addition to this, whereby human and non-human interactions in changing environment become focus of study.

In second anthropological focus is on structural and institutional forces like economy, polity, inequality, inequity, globalising effects of capitalism and consumerism. The basic paradigm of these studies is on political economy and political ecology. These multiple institutional factors accentuate the adverse impact of climate change on local communities, thus, manifold increasing their vulnerabilities. Climate change in these studies is not the sole factor of community vulnerability. Hans and Singer (2018) attempt to define this impact through the concept of pluralea interactions. The multiple ecological risks or hazards synergise causing increased impact on health of ecology, including that of humans. They quote multiple examples correlating increased pollen in the air, forest fires, air pollution, oil exploitation, human health and survival. Cartwright (2019) also emphasises the significance of medical anthropology in documenting how climatic changes are impacting human health. Exemplifying on the role that green revolution has played in Mexico, she reflects on the side effects of this revolution particularly in terms of increasing desertification and abuse of soil and ground water and the concurrent health problems prevalent in the region owing to this.

The other anthropological studies attempt to unfold how climate change discourse travels from higher echelons of research and policy at global level and embeds itself in the local communities. In this climate change has been identified as travelling idea, where the local understandings of climate change with differing experience on interpretations change in expression due to percolation of techno-scientific activism and may start identifying themselves with the language of global discourse on climate change and measuring their vulnerability on differing scales and range accordingly. In all the different anthropological approaches to climate change, vulnerability, resilience and adaptation remain core concepts. These concepts are overlapping and braided within the everyday lived experiences. Given the emphasis that anthropological approaches have put on the everyday lives of the people, lived experiences become pertinent for understanding the felt effects of climate change.

Anthropology, Everyday/Ordinary and Climate Change

Even though the aspects of everyday have been explored in anthropology as a discipline but Veena Das"s work in recapitulating, re-defining and theorising this concept has been exemplary. She identifies everyday as space where the ordinary and the extraordinary are weaved into one another. For her it is not the eventuality that comes to define trauma, struggle and survival. Rather she brings into focus how critical events in history fold themselves into the ordinary and everyday life of the people. She seeks to present "what happens to the subject and world when the memory of such events is folded into ongoing relationships" (Das, 2006). Her work was situated in two critical events of Indian nation-state and contextualised violence within everyday life of people and entangling the eventful and the ordinary. Her approach provides a framework for theorising everyday in other forms of breaches in taken for granted social world and existence of people. It would help in understanding how such events are "... are not likely to be fixed thing that erupts unchanged into people's thoughts and experiences but, rather something malleable that is sucked and stitched into ongoing lives and deaths over the long duration" (Martin, 2007:744). Her theorisations on everyday, ordinary and eventful, however, could be explored in anthropological understanding and contextualisation of climate change. The proposition here is to view how anthropological underpinnings relate to emerging questions on climate change and not just addressing the already revealed quandaries and queries.

Emergence of or approaching any discourse from social science perspective is bound to raise the issue of subjectivity. Revolving around climate change at the core, Das's approach helps us to understand how "slow shifts in subjectivity are very important for understanding what is happening to politics today."Climate change is a highly politicised discourse where paradigms of development, economy, survival and ethics are implicated alongwith. This approach towards climate change helps in unlayering how different subjectivities are formed.

CONCLUSION

The change that occurs in formation of subjectivities regarding climate change is slow and gradual but not sudden and drastic. It is gradual enough to become a part of ordinary and everyday life of the people. In this sense the temporal frame for climate change not only reflects the before and after effect comparison but also how it gets contained within the everyday lives of people. Anthropology with its scope of embedding itself into this everyday of people's lives has the capacity to render visible they felt effects of climate change on people and communities. Such an approach would provide a nuanced projection of the tropes of climate change on vulnerability, resilience and adaptation. Climate change presents an opportunity for anthropologists to make a contribution more so importantly from a collaborative aspect with other disciplines.

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Primary Productivity of Phytoplankton in Kosi River at Bhagalpur and Katihar district of North Bihar

Rashmi Kumari and Arvind Kumar

Environmental Biology Research Laboratory, T.N.B. College, Bhagalpur-812 007, India
E- mail: akarvindkumar863@gmail.com

Abstract: The primary productivity of phytoplankton in the river Kosi has been analysed both spatially and seasonally in year 2017 and 2018 at three sites. The maximum Gross Primary Productivity (GPP) was noted during pre- monsoon season in all the study sites. Net Primary Productivity (NPP) of phytoplankton varied from 11.25 g $Cm^{-3}day^{-1}$ to1.35 g $Cm^{-3}day^{-1}$ in the first year and 5.62 g $Cm^{-3}day^{-1}$to2.7 g $Cm^{-3}day^{-1}$in the second year of observation. The community respiration (CR) showed a systematic seasonal pattern where the maximum value was observed during pre-monsoon and minimum during winter. Respiration as per cent of GPP was higher in pre monsoon in 2018.The ratio between NPP and GPP was highest in winter and Production Respiration Ratio (P/R ratio) was observed higher in winter in both the years. Physico-chemical parameters of water were analysed concurrently. Production Respiration Ratio (P/R ratio) determination is a good measure of new organic matter created in the water body. This study provides base line information to find out influence of water quality on primary productivity.

***Keywords*: Phytoplankton, Primary productivity, Kosi river, Organic matter, Water quality**

Primary productivity is the rate at which radiant energy is stored by the photosynthetic and chemosynthetic activity of producer. Primary productivity is the most important biological phenomenon in nature on which the entire diverse array of life depends, either directly or indirectly. Measurement of primary productivity gives information regarding the photosynthetic production of organic matter in an area per unit time and the functional aspects of ecosystem. The basis of ecosystem functioning the biological production of autotrophs is manipulated by primary productivity of a water body (Mohanty et al 2014). There is a main role of primary productivity in providing energy and organic matters to the entire biological community (Ahmed et al 2005). Light (solar energy) and nutrients are the main limiting factors to primary production in an aquatic ecosystem (Guildford and Hecky 2000), though distribution of phytoplankton (algae) are also affected by temperature and seasonal variations in light intensity. Most of the organic matter of an aquatic ecosystem is produced by phytoplankton. The Kosi river is one of the major tributaries of river Ganga situated on the northern plain of Bihar state. In the present study, gross primary productivity (GPP), net primary productivity (NPP) and community respiration (CR) of the river Kosi were determined at three sites in Bhagalpur and Katihar district (Bihar) on seasonal basis. The ratio of net and gross primary productivity (NPP/GPP) and community respiration as percent of gross primary productivity were also computed.

MATERIAL AND METHODS

The present investigation has been carried out in the 44 km long stretch of Kosi River flowing through Bhagalpur district to Kursela in Katihar district of north Bihar from three locations. Site-I is situated at side channel of Kosi river at Hario village which is located 23 km north from Bhagalpur city and lies at 25° 26′ 08″ North latitude and 86° 55′ 50″ East longitude. Site-II is situated at main channel of river Kosi at Vijay Ghat located north from 25 km from Bhagalpur city and lies at 25° 25' 16″ North latitude and 87° 05' 04″ East longitude. Site-II is approximately 19 km downstream of site-I.Site III is situated at Kosi-Ganga confluence zone which is near the town of Kursela in Katihar district and lies at 25° 24' 46″ North latitude and 087° 15' 00″ East longitude. Site-III is approximately 25 km downstream of site- II.For estimating the rate of primary production of phytoplankton, light and dark bottle method was employed .After the incubation period, dissolved oxygen in both light and dark bottles was measured by Winkler's volumetric method.

The water sample was collected from the study sites of river Kosi for 2017 and 2018. Various physico-chemical parameters like temperature (air and water), pH, dissolved oxygen, electrical conductivity, free carbon dioxide and total dissolved solids were determined on the spot immediately. Three BOD bottle (300ml)were selected and water sample were collected in sampling bottle from the littoral zone of the sampling sites from 8.00 am to 12.00 am carefully excluding air bubbles for the estimation of initials Dissolved Oxygen (DO) concentrations was measured, then the two bottles, one was covered by black cloth while the other without any covering. Both the bottles were suspended in water at the same depth and fixed with an incubation period of 4 hours. After the incubation period dissolved oxygen in both light and dark bottles was measured .The dark bottle gives the oxygen concentration used in respiration by plankton, bacteria etc. while the light bottle gives the amount of oxygen in photosynthesis.

RESULTS AND DISCUSSION

Gross primary productivity: This ranged from 12.6 to 2.25 g Cm^{-3} day^{-1} (2017) and 7.53 to3.15 g Cm^{-3} day^{-1} (2018). The maximum GPP value was during first year in pre-monsoon and minimum during post-monsoon season at site-III. In the second year the GPP was higher during pre-monsoon season sites-III and lower in winter in site-I. Higher GPP may be due to solar radiation and high temperature and lower during winter season could be attributed to the reduced photoperiod coupled with low light intensity, temperature and scarce phytoplankton (Chinnaiah and Madhu 2010). Same observations were reported by many workers (Kumar and Singh 2006, Kumar and Choudhary 2007). The high GPP values indicated the influence of organic pollution. GPP showed negative correlation with TDS and positive correlation with DO.

Net primary productivity: The NPP of phytoplankton ranged from 11.25 to 1.35 g Cm^{-3} day^{-1} (2017) and 5.62 g Cm^{-3} day^{-1} to 2.7 g Cm^{-3} day^{-1} (2018). The maximum NPP was observed during first year during pre-monsoon at site-III and minimum during post-monsoon season at sites-III. In the second year the maximum value was observed during pre-monsoon season and minimum during winter season at site-I. NPP showed positive correlation with air temperature, DO and negative correlation with conductivity.

The higher value of NPP and GPP is due to penetration of more light intensity which facilitates the higher rate of photosynthesis and ultimately the productivity (Sharma et al 2018). The amount of gross production available to the consumer is evaluated by the ratio of the net and gross primary production. Decreased value of NPP and GPP during the post- monsoon and winter season might be due to the reason that high suspended solids in the flood water restrict light penetration into the water and thereby results in less photosynthetic activities and productivity.

Community respiration: This varied from 3.6 to 0.45 g $Cl^{-1}d^{-1}$ (2017) and 2.02 to 0.45 (2018). The maximum CR values was observed during pre-monsoon at site-I and minimum value was observed during winter season at sites-III. In the second year the maximum value was observed during pre-monsoon season at site-III and minimum value was observed during winter season at site-I. Higher values were obtained during pre-monsoon. High rate of community respiration during warmer season was probably due to increase in the mineralisation rate of organic matter, caused by the quick warming of water and due to enhanced O_2 consumption by animals and plants. Respiration rate exhibited seasonal variability, high in pre-monsoon might be due to greater microbial metabolisms, while low during winter could be due to the low temperature and poor sun's light affects rate of photosynthetic efficiency (Singh et al 2018). Statistically CR showed positive correlation with air temperature.

NPP/GPP ratio: This varied from 0.93 to 0.5 g Cl^{-1} d^{-1} in first year (2017) and 0.85 to 0.73 in second year 2018. The maximum NPP/GPP values was observed during first year in winter season at site- II and minimum value was observed during post-monsoon season at sites-II. In the second year (2018) the maximum value was observed during winter at site-I and minimum in pre-monsoon season at site-III. Similar ratio was reported from floodplain lakes of Bihar (Palui and Jha2003).NPP/GPP ratio was generally less than one

Table 1. Seasonal variation in Phytoplankton primary productivity in Kosi river (2017)*

Parameters	Site-I			Site-II			Site-III		
	Winter	Pre-Monsoon	Post-Monsoon	Winter	Pre-Monsoon	Post-Monsoon	Winter	Pre-Monsoon	Post-Monsoon
Gross primary productivity(GPP) g Cm^{-3} day^{-1}	3.15 (3.15)	9.45 (6.97)	4.95 (5.40)	7.2 (3.37)	11.02 (6.63)	4.5 (6.07)	6.75 (4.61)	12.6 (7.53)	2.25 (5.85)
Net primary productivity (NPP) g Cm^{-3} day^{-1}	2.25 (2.70)	5.85 (5.62)	4.05 (4.50)	6.75 (2.81)	9.00 (5.28)	2.25 (5.17)	6.3 (3.60)	11.25 (5.51)	1.35 (4.50)
NPP/GPP g Cm^{-3} day^{-1}	0.71 (0.85)	0.62 (0.83)	0.818 (0.83)	0.94 (0.83)	0.82 (0.79)	0.50 (0.85)	0.93 (0.78)	0.893 (0.73)	0.60 (0.76)
Community respiration (CR)	0.90 (0.45)	3.60 (1.35)	0.90 (0.9)	0.45 (0.56)	2.35 (1.35)	2.25 (0.9)	0.45 (1.01)	1.35 (2.02)	0.90 (1.35)
Respiration (R) as % of GPP	28.57 (14.28)	38.09 (19.35)	18.18 (16.66)	6.25 (16.66)	18.36 (20.33)	50 (14.81)	6.66 (21.95)	10.71 (26.86)	40.00 (23.07)
P/R ratio	0.02 (0.06)	0.01 (0.04)	0.04 (0.05)	0.15 (0.05)	0.04 (0.03)	0.01 (0.05)	0.14 (0.03)	0.08 (0.02)	0.01 (0.03)

*2018 in parentheses

Table 2. Pearson's correlation among the primary productivity of phytoplankton and water quality parameters of surface water from (2017-2018)

Variable	NPP/Day	GPP/Day	CR/Day	NPP/GPP	R as % of GPP	P/R ratio	Air Temp	Water Temp	Water depth	pH	TDS	Cond	Fco_2	DO
NPP/Day	1	0.956**	0.212	0.574	-0.582	0.334	0.696**	0.71	-0.361	-0.482	-0.461	-0.567*	0.25	0.618*
GPP/Day	0.956**	1	0.491	0.323	-0.335	0.095	0.781	0.79	-0.439	-0.415	-0.562*	-0.55	0.349	0.758**
CR/Day	0.212	0.491	1	-0.627*	0.614*	-0.673**	0.536*	0.524	-0.386	0.048	-0.499	-0.148	0.421	0.69
NPP/GPP	0.574*	0.323	-0.627*	1	-0.999**	0.846**	0.035	0.046	-0.059	-0.37	0.062	-0.248	-0.191	-0.134
R as % of GPP	-0.582*	-0.335	0.614	-0.999**	1	-0.845**	-0.053	-0.062	0.057	0.362	-0.06	0.236	0.191	0.131
P/R ratio	0.334	0.095	-0.673	0.846**	-0.845**	1	-0.148	-0.116	-0.111	-0.394	0.188	-0.183	-0.239	-0.467

* and ** significant at 5 and 1 per cent

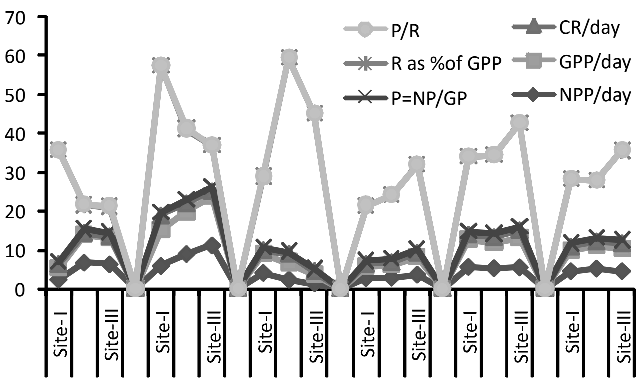

Fig. 1. Seasonal variation in primary productivity of Phytoplanktons in Kosi river at site I, II and III (2017-2018)

reflects that both lakes were productive (Singh et al2018).NPP/GPP ratio was low in post-monsoon might be due to the rainfall and floodwater dilutes phytoplankton density. The NPP/GPP ratio reflects productivity potential of water body because it remains low in productive ecosystem.

Respiration percentage: The value of respiration as percentage of GPP varied from 50 to 6.25 g $Cl^{-1} d^{-1}$ in the year 2017 and 26.86 to 14.28 g Cl^{-1} d^{-1} in 2018. The maximum respiration as % of GPP value was observed in post-monsoon at site-II and minimum value was observed during winter season at sites-II during first year of study. In the second year study period, the maximum value was observed during pre-monsoon season at site-III and minimum value was observed during winter season at site-I. Respiration as percentage of GPP may be as a measure of eutrophic nature. Respiration higher than 40% of gross production is characteristic of eutrophication. Respiration as percentage (%) of GPP was positive correlation with air and water temperature, total dissolved solid, dissolved oxygen and water depth.

Production respiration (P/R) ratio: This varied from 0.15 to 0.01g Cl^{-1} d^{-1}in 2017 and 0.06 to 0.02 g Cl^{-1} d^{-1} in 2018. The maximum P/R ratio values was observed during first year study period in winter season at site-II and minimum value was observed during pre-monsoon and post-monsoon season at sites-I. In the second year study period the maximum value was observed during winter season at site-I and minimum value was observed during pre-monsoon season at site-III. The biological balance between photosynthesis and respiration is necessary for maintaining the chemical balance in the water. P/R ratio always exceeds one at unpolluted section of the aquatic system where as polluted sites generally expresses values less than one. P/R ratio is an excellent functional index of the relative maturity of the system (Jana et al 1982). P/R ratio indicated positive correlation with air and water temperature and pH (at 0.01 % significant level).

Phytoplanktons: Primary productivity of phytoplanktons were affected by the interactions of a number of factors like light, photoperiod, temperature (air and water) and erosion, whereas surface runoff is a seasonal phenomenon, largely affected by non-point source pollution which seems to be climatic conditions within the river basin (Singh et al 2005). The river is currently facing heavy soil erosion at its river sites and at some places it becomes shallow. Due to high sediment load, the Kosi river has a history of course shifting. The run-off from the agriculture area within the catchment of river basin further aggravates the problem (Adhishwar and Choudhary 2014, Kumar et al 2011). Person's correlation analysis on phytoplankton primary productivity and water quality parameters revealed that all parameters are more or less correlated with each other.

CONCLUSIONS

The study highlighted phytoplankton productivity status and water quality in Kosi river at Bhagalpur and Katihar district of North Bihar. Due to the addition of various products in water due to many anthropogenic activities the physiochemical parameters of river water changes. The low productivity could attribute to the low nutrient levels. This decreases the primary productivity of the rivers and directly or indirectly affects many aquatic plants and animals. NPP/GPP ratio tends to approach unity in a healthy aquatic ecosystem. The range of this ratio in the river Kosi indicates the presence of a healthy phytoplankton population. This is also supported by the values of respiration expressed as percentage of the GPP. Water quality variables were interrelated and have profound effects on primary productivity. So, it is necessary to treat the water to maintain the primary productivity so that the aquatic plants and an animal can survive in it.

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Population Status of Hollock (*Terminalia myriocarpa* Heurck & Muell. Arg) in the Eastern Hollock Forest Type of North East India

Lyngdoh, N, Kumar Mukul[1], M. Bishwapati Devi[2], R. Vasudeva[3] and A.K. Pandey[4]

Department of Tree Improvement, [2]Department of Basic Sciences, College of Horticulture and Forestry
Central Agricultural University, Pasighat-791 102, India
[1]Department of Genetics and Plant Breeding, College of Agriculture, Banda University of Agriculture and Technology, Banda-210 001, India
[3]Department of Forest Biology and Tree Improvement, College of Forestry, Sirsi-581 401, India
[4]College of Horticulture and Forestry, Rani Lakshmi Bai Central Agricultural University, NH -75, Near Pahuj Dam Gwalior Road, Jhansi-284 003, India
E-mail: lyngdoh@gmail.com

Abstract: The study aims to ascertain whether Hollock trees (*Terminalia myriocarpa* Heurck & Muell. Arg) still retain their dominant status in the Eastern Hollock Forest type ($3/_{I}S_{2}$) of Arunachal Pradesh. This forest type is an edaphic formation under North Indian Moist deciduous forests. We primarily assessed its population status and compared its various population parameters with overall community indices, and inferred future population status based on its existing regeneration pattern. The study was carried out during 2015-16 in Pasighat Station reserve and Poba reserve forests of $3/_{I}S_{2}$ forest type under Pasighat Forest Division of Arunachal Pradesh. In both reserves a total of 74 tree species was recorded. Out of the total number of individual stems enumerated Hollock represented 26.67% and 18.60%. Stem density was the highest for Hollock with 95 and 73.12 individuals/ha with a relative density of 35.22% and 19.33% in Pasighat Station and Poba reserve forest, respectively. Complete dominance was observed for basal area contributing 95.90% of the total at Pasighat Station reserve forest while it was 41.94% in Poba reserve forest, only lower to *Gmelina arborea*. The density of seedlings of Hollock in Poba reserve forest was also lower than seedling density of *Gmelina*.

Keywords: Basal area, Density, *Gmelina*, Pasighat, Regeneration, Reserve Forest

India is home to four of the thirty four biodiversity hotspots of the world-Western Ghats, Andamans-Nicobar Islands, Himalayas and Eastern Himalayas. The Eastern Himalayas which is a part of the Indo Burma hotspot comprises eight states of north east India. It represents 7.98% of the country's total geographical area and accounts for nearly one fourth of its forest cover (Anonymous 2015). There are fifty one forest types in the region, which are broadly classified under the six major groups. Underneath these array of vegetation types ranging from tropical rain forest in the foothills to alpine meadows and cold deserts lies more than one third of the country's total biodiversity. The Eastern Hollock Forest type (3/IS2) is an edaphic formation under North Indian Moist deciduous Forests. It is found only in the sub Himalyan tracts of Assam and Bengal extending south of the Brahmaputra to the foothills of Naga and Patkai hills in north eastern region of the country (Champion and Seth 1968). In this forest type, hollock pioneers in the silt deposits along the Bhramaputra river and its tributaries and occurs in close association with *Dillenia indica, Terminalia belirica, Albizzia lucida, Artocarpus chaplasa, Lagerstroemia speciosa, Canarium resiniferum, Dysoxylum binectiferum* and *Bischofia javanica.* It yields valuable timber (AIV class) for furniture and house construction in the form of scantlings, beams, rafters and for heavy packing cases; it is also suitable for manufacture of plywood for general purposes and also for tea chests. Timber is suitable for making jute-mill rollers and for construction of lorry bodies. The plant is often cultivated as an avenue tree and is also diuretic, cardiac stimulant and antioxidant used in various drug preparations (Singh et al 2000). Its bark has medicinal importance, bark extract is given on chest pain (Deb et al 2009). However, the species along with its habitat is under tremendous anthropogenic as well as abiotic pressure. Human habitation along the river banks has resulted to rampant encroachment, large scale deforestation and removal of prime hollock trees from the forest. In addition periodic inundations (Tewari 2004) may have affected the regeneration potential of hollock as well as many other species. Yet very little is known about the status of these forests and particularly that of the hollock trees. In a study dating back to 1930s, hollock was shown to represent 42% of the tree density in such forest type at Pasighat, Arunachal Pradesh (Purkyasta 1932). To this end there is almost a century old gap in the information about this forest type and status of hollock trees. The region during the last century has witnessed rapid land transformation and was once a centre of lucrative timber trade. Therefore, it is suspected that hollock may have been indiscriminately felled and consequently its dominant status in the Eastern Hollock Forest compromised.

In this study we have assessed the status of hollock trees in the Eastern Hollock Forest type (3/IS2) found in the foothills of Pasighat, under East Siang district of Arunachal Pradesh by comparing various population parameters of the species to community diversity values. We have further looked into the regeneration trend of hollock in these forests to ascertain future possible changes in their population structure.

MATERIAL AND METHODS

The study was undertaken in two Reserve Forests, Pasighat Station reserve (28o03'06.7''N, 95o 21'12.7''E) and Poba (27o 54'34.0''N, 95o 16'51.1''E) reserve, under Pasighat Forest Division, East Siang District, Arunachal Pradesh during the year 2015-16. The two reserves fall under the Eastern Hollock Forest type which is an edaphic formation group 3/IS2 (b) of the Champion and Seth forest type classification. The Pasighat station reserve is spanned over an area of 159.2 ha while Poba reserve is 10,007.6 ha in area, separated by a road distance of 25 km. The region experiences hot and humid pre-monsoon climate from March to May, followed by wet season which lasts upto September with mild winter accompanied by strong winds from December to February. Monthly average maximum and minimum temperature ranges between 24.4 and 32.8°C, and between 12.1 and 24.6°C, respectively. The soil type ranges from loamy sand to sandy loam and devoid of any humus due to heavy rains. The major perennial river is Siang which is fed by innumerable seasonal rainfed streams and streamlets.

The Pasighat Station reserve forest is located nearby Pasighat town with some human settlements along the fringes of the reserve while the Poba reserve is located in the outskirts of Ruksin town bordering Assam along national highway No. 52. Human and domesticated animal activity is higher in the Pasighat reserve and therefore more disturbed. In addition the Pasighat reserve lies along the bank of the mighty Siang river and therefore vulnerable to the river dynamics. In the year 2000 flood waters submerged major portion of the Eastern Hollock Forests type in Pasighat Forest Division of Arunachal Pradesh and devastated prime hollock forests (Dasgupta and Mukhopadhyay 2014). Subsequently in recent years hollock forests located by the banks of river Siang under Pasighat Division have encountered periodic submergence during the monsoon seasons.

Population survey: Tree diversity assessment was carried out in the year 2015-16. Using Nested random sampling method trees were sampled using 20m X 20m plots within which four 5m X 5m and eight 1m X 1m plots each were laid for enumerating saplings and seedlings, respectively. In Poba reserve 40 plots of 20m X 20m sizes were laid while 30 plots of the same dimension were laid in Pasighat reserve. The distance between two neighbouring plots was atleast 50m. Under a sampling unit, trees of all species (>15 cm gbh) were considered for calculating relative density, relative frequency, relative abundance and relative basal area of target species. Saplings (5–15 cm girth) and seedlings (<5 cm girth) of hollock were enumerated within each sample plot to calculate their density in each reserve. For hollock species, regeneration status was quantified by calculating the density of seedlings and sapling. The tree data was quantitatively analyzed for frequency, density and abundance (Curtis and McIntosh 1950). The importance value index (IVI) for tree layer was determined as the sum of relative frequency, relative density and relative dominance (Curtis 1959).

RESULTS AND DISCUSSION

A total of 74 tree species was recorded in both the reserves, out of which 19 species occurred only in Pasighat station reserve, 29 recorded only in Poba reserve and 26 common to both. The number of tree species recorded was 47 in Pasighat and 55 in Poba (Table 1).

The tree species richness recorded in the present study is comparable to the species richness of some of the tropical forests in the region. Fifty-four species were reported in a tropical wet evergreen forest of Arunachal Pradesh (Bhuiyan et al 2003), 31-61 species in different moist deciduous forests of Tripura (Majumdar et al 2014) and 34 species in a Sal dominated moist tropical forest of Assam (Dutta and Devi 2013). Our values are also comparable to the 50 tree species recorded in the core area of Namdapha National Park of Arunachal Pradesh (Nath et al 2005). However, the figures were lower than those reported for some of the tropical primary forests of Meghalaya (Tripathi and Uma Shankar 2014) and that of tropical moist deciduous forests of Nayagarh Forest Division, Odisha (Sahoo and Panda 2015) and tropical moist community reserve forest of Mizoram (Devi et al 2018).

The total number of individual trees enumerated in Poba was 688 in 1.6 ha sampling plot and 401 in a 1.2 ha sampling plot in Pasighat reserve out of which 18.60% were hollock

Table 1. General tree community parameters in Pasighat and Poba Reserve Forests of Pasighat Division

Variables	Pasighat	Poba
Total no. of species	47	55
Family	23	28
Total density (individuals ha^{-1})	291.67	378.12
Total basal area ($m^2 ha^{-1}$)	3338.39	4032.40

trees in the former and 29.67% in the latter. In both the reserves the frequency distribution of individuals of all tree species having more than 15cm girth was in an inverted 'J' form (Fig. 1) depicting high proportion of individuals in the lower girth classes and a gradual decrease towards the higher girth classes. In other words, it indicates good reproduction and recruitment status within the reserve forests in general. At Poba reserve 71.08% of the hollock trees were between 50 and 150cm girth class, while only 32.77% of the trees were in the same girth class in Pasighat reserve (Fig. 1), the rest being large sized trees. The dominance of large sized hollock trees in Pasighat reserve can be explained by the high biotic pressure such as illegal felling which would probably target medium sized trees for ease in felling, conversion and transportation, animal population pressure and also abiotic pressure in the form of periodic inundations, as compared to the other reserve.

Total stem density for trees >15cm girth was 291.67 and 378.12 individuals per ha in Pasighat and Poba reserve, respectively (Table 1). Higher total basal area of trees was also observed in Poba (4032.40 m2 ha-1) compared to Pasighat reserve (3338.39 m2 ha-1). The values reported here are much lower than values reported in some of the tropical moist deciduous forest of India such as that of Nayagarh Forest Division, Odisha (Sahoo and Panda 2015), Eastern Ghats area (Naidu and Kumar 2016) and of Tripura (Majumdar et al 2014). In both the reserves stem density was the highest for *Terminalia myriocarpa* (95 and 73.12 individuals ha-1) with a relative contribution of 35.22% and 19.33% to total tree density in Pasighat and Poba reserve, respectively (Table 2). These values are reportedly lesser than tree species which are dominant for a forest type such as sal in a sal dominated forest (Tripathi and Uma Shankar 2014, Kapkoti et al 2016) or teak in a teak dominated forests (Pande 2001). Unlike hollock, sal and teak trees are known for their gregarious growing habit and would therefore have dense populations wherever they are found (Troup 1986).

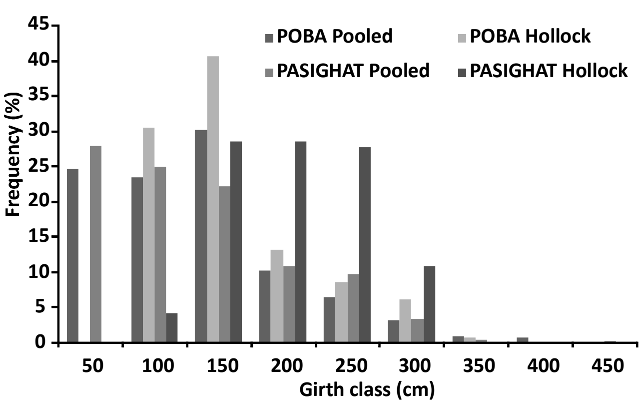

Fig. 1. Frequency distribution of tree girth of all trees and of Hollock in Pasighat Station and Poba Reserve Forests of Pasighat Division

Complete dominance of *T. myriocarpa* was observed in Pasighat reserve (3202.50 m2 ha-1) contributing 95.90% of the total basal area while it was shared between *T. myriocarpa* (41.94%) and *Gmelina arborea* (40.13%) in Poba reserve. Although the relative density of hollock in the Pasighat reserve was 35.22%, high proportion of large sized trees has contributed to this huge basal area. The dominance of hollock in Pasighat reserve can also be confirmed by its IVI value which was 144.81 after which there was a sudden drop in IVI rankings for other species (Fig. 2) On the other hand, IVI value of hollock (71.78) is closely followed by *Gmelina arborea* (65.45) in Poba reserve. *Gmelina* is a species indigenous to the region but is not a natural associate in such forest types. It is fast growing, with profuse regeneration potential, wide adaptability and marketability. It is therefore one of the favorite plantation species of the state forest department and has been planted on several occasion at the Poba reserve creating good stands of *Gmelina*. The species has also been more successful in establishing itself within the reserve by having higher seedling density (718.75 individual ha-1) as compared to the dominant hollock species (343.75 individual ha-1).

The two reserve forests are categorized as the Eastern Hollock Forest type (3/IS2), and clearly hollock has still remained a dominant species inside Pasighat reserve. The regeneration status of the species is good and much higher than the second most dominant species which was *Leea indica* (Fig. 3). Yet the scarcity of individuals in the low girth class of less than 100 cm and low density of saplings may create a vacuum in the demographic structure of the species in future. In this regard, the existing regeneration should be given adequate protection and steps for increasing the density of young individuals should be taken up. In the Poba reserve, hollock seemed to be losing its dominance to *Gmelina*, There is also evidence of higher regeneration status of *Gmelina* as compared to hollock in Poba reserve (Fig. 3) which has occurred without any record of assisted

Table 2. Population parameters of *Terminalia myriocarpa* in Pasighat and Poba Reserve Forest

Variable	Pasighat	Poba
Density (individuals ha^{-1})	95	73.12
Relative density (%)	35.22	19.33
Basal area ($m^2 ha^{-1}$)	3202.50	1691.24
Relative basal area (%)	95.90	41.94
IVI	144.81	71.78

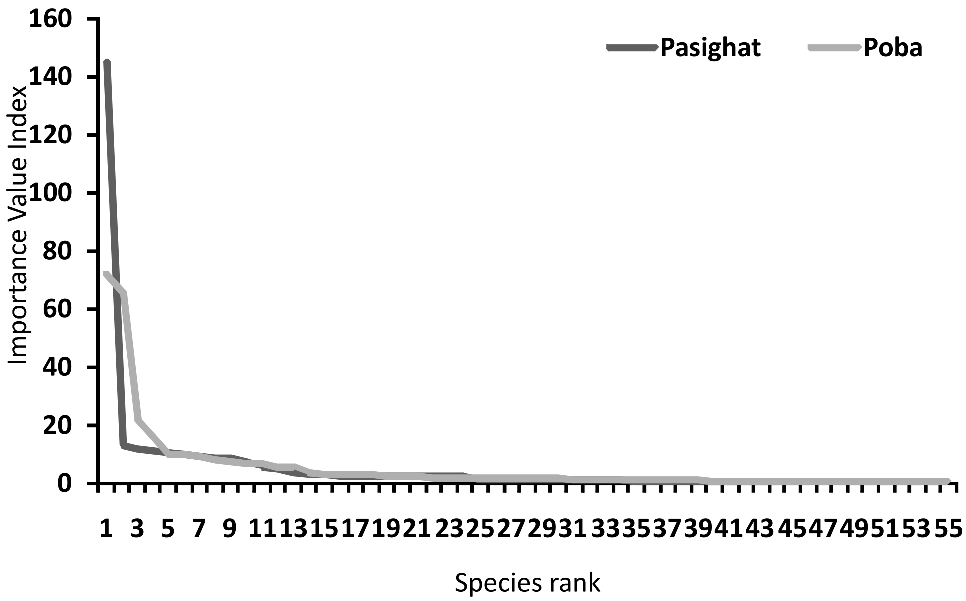

Fig. 2. IVI ranking of species in Pasighat and Poba Reserve Forests of Pasighat Division

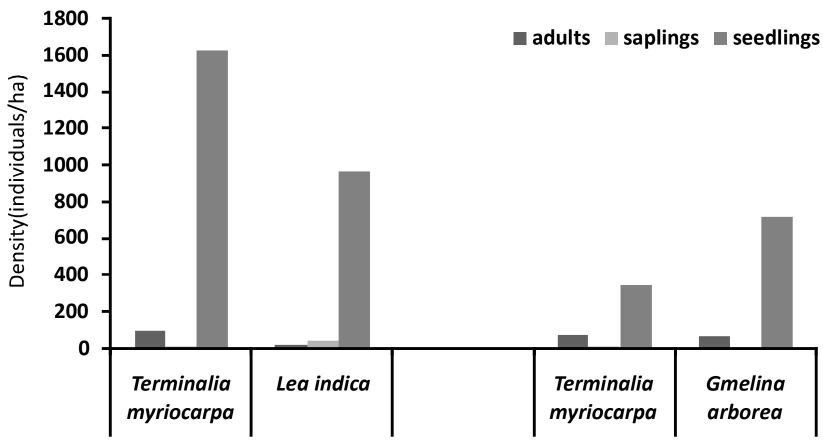

Fig. 3. Density of species with top two IVI in Pasighat and Poba Reserve Forests of Pasighat Division

artificial regeneration in the recent years. If the same trend persists hollock would ultimately become a secondary species in this reserve which could alter overall community structure. Dominant tree species are central for maintaining forest stability and community structure. Therefore, although the benefits and local preferences weigh more towards *Gmelina*, adequate population sizes of Hollock should be maintained in the reserve and assisted regeneration of the species should be encouraged to circumvent any break in the community composition and its overall integrity.

CONCLUSION

This study has after almost a century reported the status of hollock trees in their natural distributional range. Hollock still remains the dominant species in both the reserve forests studied with an overwhelming dominance in the Pasighat Station reserve. Yet the future status of the species is a matter of concern due the non-uniform regeneration pattern and the competition from more aggressive species such as *Gmelina*. Further, future plantation programmes may want to include some exotic fast growing species. Therefore, in order to maintain the integrity of this forest community, efforts should be directed to increase the population size and regeneration status of hollock by protecting its natural regeneration and supplementing with assisted artificial regeneration. The Forest department should realize that the presence of hollock in large number is an asset to them in terms of economic as well as ecological wealth. Further more scientific information should be generated for this species for more public acceptance and demand.

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Succession of Microfungi on Leaf litter of *Anogeissus pendula* in Datia, Madhya Pradesh, India

B. Kumar, T. K. Sharma and S. Dassani

Department of Botany and Industrial Microbiology, Bipin Bihari College, Jhansi-284 001, India
E-mail: tirtheshk@gmail.com

Abstract: Plant-microbial interactions are recognized as important drivers of terrestrial ecosystem functioning. Colonization and decomposition of leaf litter in forest ecosystem is mostly governed by microfungi. Present study has been carried out to understand the biology and diversity of leaf litter fungi and their colonization during decomposition. After removing litter bags from pits at 15, 30, 45, 60, 75, 90, 120, 150, and 180 days of intervals, isolation and identification of fungi was done following serial dilution method. A total of 16 fungal species belonging to seven genera were isolated and identified from decomposed leaf litter of *Anogeissus pendula*. Among these three species belonged to Zygomycota and thirteen species are belonging to Ascomycota and their anamorphs. Species namely *Mucor varians, Mucor hiemalis, Rhizopus stolonifer, Aspergillus niger* and *Aspergillus japonicus* were early colonizers and *Aspergillus flavus, Aspergillus fumigatus, Aspergillus nidulans, Aspergillus versicolor, Aspergillus flavipes, Geotrichum candidum, Penicillium chrysogenum, Penicillium aurantiogriseum, Trichoderma reesei*, *Trichoderma viride* and *Chaetomium osmoniae* were regarded as late colonizers. In all stages of decomposition, fungi belonging to Ascomycota were predominant. The present investigation provides valuable information about diversity of leaf litter fungi of tropical forest.

***Keywords*:** Litter, Microfungi, Colonization, Decomposition

Plant litter is the main source of carbon, energy and nutrients for heterotrophic microbial communities in the terrestrial ecosystems. Litter, not only assists in maintenance of soil fertility, but also contributes in conservation of soil organic matter on long term basis. Most of the plant litter is composed of polysaccharides i.e. cellulose, hemicelluloses and aromatic polymer lignin which is being considered as the most recalcitrant compound (Steffen et al 2000). Colonization and decomposition of the litter in soil is carried out by a variety of soil microorganisms but fungi are known to be the chief colonizers and decomposers of plant litter. Fungi contributes substantially to this complex phenomenon of nutrient cycling in forest ecosystems as they elaborate an array of extracellular enzymes that deconstruct the different types of organic compounds in the litter (Baldrian and Lindahal 2011, Tifcakova et al 2011). This is vital for the growth of new plants and other organisms in forest ecosystem.

Studies on litter fungi of tropical ecosystems are limited as compared to those in temperate ecosystems (Sayer 2006, McGuire et al 2012, Xu et al 2013). Studies on litter fungi in the tropics pertain to fungi occurring in the litter of plant species such as *Manglietia garrettii* (Promputtha et al 2002), *Ficus pleurocarpa* (Paulus et al 2006), *Magnolia liliifera* (Kodsueb et al 2008), *Pandanus* sp. (Thongkantha et al 2008), *Ficus* sp. (Wang et al 2008), *Hevea brasiliensis* (Seephueak et al 2010), *Anacardium occidentale* and *Pavetta indica* (Shanthi and Vittal 2010a,b), twelve Dicotyledonous tree species (Prakash et al 2015), Salcete forest (Amisha et al 2016), Loyola college campus (Raja et al 2017), Mattavara forest (Chandini and Rajeshwari 2017), *Nothofagus* forest (Vivanco et al 2018), forest of Northwest Arkansas (Alanbagi et al 2019). For the present study, a tropical deciduous forest ecosystem was chosen in Datia, Madhya Pradesh, India. The forest of study area was dominated by *Anogeissus pendula* and *Acacia catechu* trees. This investigation has provided an account of different fungal species (fungal diversity) involved in various stages of leaf litter decomposition of *Anogeissus pendula* in an Indian tropical forest as well as their changes (succession) which occurred during the decomposition.

MATERIAL AND METHODS

Study site and collection of samples: For sampling purpose, the forest area of Ratangarh (Fig. 1a) in Seonda block is selected. The site is 65 Km away from Datia city of Madhya Pradesh state. Datia is located in the north eastern part of the state of MP, India ($25^0$28' to 26^0 20'N latitude and 78^0 10' to 78^0 45'E longitude). Freshly fallen and senescent leaves of *Anogeissus pendula* (Fig. 1b) were collected from the forest floor in sterile polythene bags from January to June, 2017 at monthly intervals. The collected leaves were returned to the laboratory in sealed plastic bags within four hours. By using litter bag method (Crossley and Hoglund 1962), approximately 20g of leaves were enclosed in each nylon mesh bag (with mesh size 2 mm) and placed randomly in each of the nine 60 x 60 x 60 cm^3 pits (Fig. 2a) (one bag in each pit) for contact of soil and decomposition. One litter bag (Fig. 2b) from each sampling pit was randomly removed at each sampling time (15, 30, 45, 60, 75, 90, 120, 150 and 180 days) after the placement. Each bag was placed in a separate paper bag and transported to the laboratory for isolation work.

Methods for isolation: The isolation of fungi was carried out following serial dilution method of Waksman (1916). The decomposed litter (20g) was suspended into 100 ml of sterilized distilled water and thoroughly shaken for 15 min. on a horizontal mechanical shaker for fungal suspension. The suspension was further diluted to 10^3 and 10^4 times. One ml of this aliquot was inoculated separately into each of five Petri plates containing 20 ml potato dextrose agar medium i.e. PDA (Potato 200g, Dextrose 20g, Agar 15g, pH 5.5, Distilled water 1000 ml) for the isolation of fungi. Five replicates of each were incubated at 28± 2ºC for a week and development of fungal colonies was noticed from third day of incubation. The heterogeneous or mixed fungal colonies appeared (Fig. 3 a,b) after 5 days of incubation. From these heterogeneous or mixed fungal colonies, desired colonies were transferred to freshly poured petri plates containing PDA media in order to obtain pure and mono culture. The pure cultures were preserved on PDA slants and maintained at 4ºC for further studies.

Identification of fungi: Colony characteristics such as growth, shape and colour were observed with the help of standard texts and keys (Gilman 1957, Barnett and Hunter 1972, Nagmani et al 2006). A portion of mycelium of the representative colony was picked up with the help of a pair of needles and mounted on a clean slide with 0.05% solution of cotton blue in lactophenol. The slide was gently heated over a spirit lamp flame to remove air bubbles. The excess stain was removed using tissue paper and then the cover slip was sealed with transparent nail polish for semi-permanent. The microphotographs of the individual fungal species were taken. Fungi were identified and assigned to respective genera and species.

RESULTS AND DISCUSSION

Altogether 16 fungal species belonging to seven genera are found associated with leaf litter samples during six month of observation (Table 1). Three species belonged to the Zygomycota and remaining thirteen to Ascomycota and their anamorphs. These species were divided into early and late colonizers according to their occurrence. Five species namely *Mucor varians, M. hiemalis, Rhizopus stolonifer, Aspergillus niger* and *A. japonicus* were initially highly frequent on available substrate and decreased over time and were regarded as early colonizers. The other fungal species such as *Aspergillus flavus, A. fumigatus, A. nidulans, A. versicolor, A. flavipes, Geotrichum candidum, Penicillium chrysogenum, P. aurantiogriseum, Trichoderma reesei*, *T. viride* and *Chaetomium osmoniae* were increased in 3-6

Table 1. Periodicity of fungal taxa recorded from leaf litter of *Anogeissus pendula* during decomposition

Fungi identified	Period of decomposition (days)								
	15	30	45	60	75	90	120	150	180
Mucor varians Povash, Bull	+	+	+	+	−	−	−	−	−
M. hiemalis Wehmer	+	+	+	−	−	−	−	−	−
Rhizopus stolonifer Ehrenberg	+	+	+	−	−	−	−	−	−
Aspergillus niger Tiegh	+	+	+	+	+	+	+	+	+
A. japonicus Saito	+	+	+	+	+	+	+	+	+
A. flavus Link	−	−	+	+	+	+	−	−	−
A. nidulans Fennell and Raper	−	−	+	+	+	+	−	−	−
A. fumigatus Fresen	−	−	−	+	+	+	+	−	−
A. versicolor Vuill	−	−	−	+	+	+	−	−	−
A. flavipes Bainier and Sartory	−	−	−	+	+	+	+	−	−
Geotrichum candidum Link	−	−	−	−	+	+	+	−	−
Penicillium chrysogenum Thom. Bull	−	−	−	−	+	+	+	+	−
P. aurantiogriseum Dierekx	−	−	−	−	+	+	+	−	−
Trichoderma reesei E. G. Simmons	−	−	−	−	+	+	+	+	−
T. viride Pers	−	−	−	−	+	+	+	+	+
Chaetomium osmoniae Rama Rao and Ram Reddy	−	−	−	−	−	+	+	+	+

Note: Serial dilution method, (+) = Presence, (−) = Absence

Fig. 1a. Studied forest area

Fig. 1b. *Anogeissus pendula*

Fig. 2a. Sampling pit

Fig. 2b. Decomposed litter bag

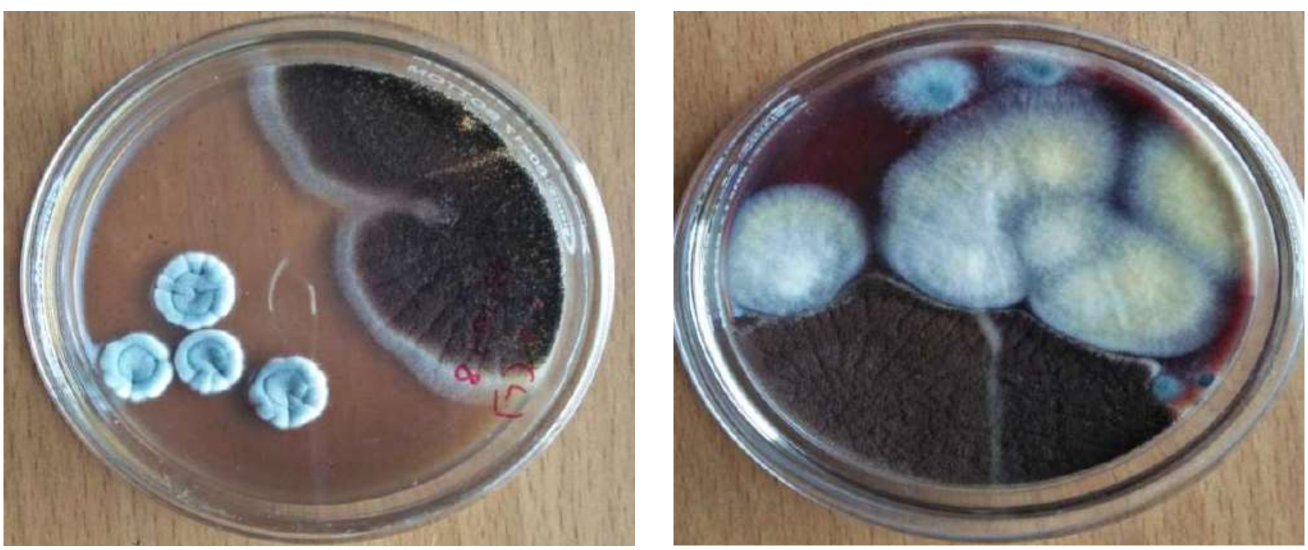

Fig. 3a,b**.** Isolation of Fungi (mix culture)

months and decreased as the litter decomposition progressed and regarded as late colonizers. *Aspergillus niger* and *A. japonicus* dominated the overall litter assemblages throughout the 180 days of decomposition.

The number of species recovered from the decomposed leaf litter of *Anogeissus pendula* increased initially and started to fall later. In all stages of decomposition fungi belonging to the Ascomycota were predominant and co-dominated by Zygomycota. During the entire decomposition process, species richness ranged from 5 to 13 species with the highest value found at 90 days of decomposition. After 120 day of decomposition, the numbers of fungal species decreased and were replaced by new colonisers.

Leaf litter fungi of Datia forest: *Mucor varians* Povash, Bull (I): Colonies growing well, white at first later olive buff to brown, sporangia globose or subglobose, smooth, at first yellow or pale orange, later dark grey tinged with green; sporangiospores not uniform, oval, elongate oblong to subelliptical, oval and elongate spores found in about equal numbers, yellow to orange.

***Mucor hiemalis* Wehmer (J):** Colonies white, later grey; reverse pale olivaceous grey both in light and dark; sporangiophore with large sympodial branches originating from a short distance below the previous sporangia, sporangia globose, blackish brown, wall diffluent, leaving a basal collarette; columellae globose or oval, sporangiospores variable in shape, cylindrical-oblong.

***Rhizopus stolonifer* Ehrenberg (K):** Colonies white at first, turning brownish black, stolons spreading, internodes brown, with well branched brown rhizoids at each node; sporangiophores in clusters of 3-10, unbranched, white, becoming pale to dark brown at maturity; sporangia globose, hemispherical, granular, olivaceous, black; sporangiospores irregular, round to oval, angular, straight, grey.

***Aspergillus niger* Tiegh. (D):** Colonies with abundant mycelium, conidial heads carbon black or sometimes deep brownish black; conidiophores arising directly from the substratum, conidia globose, spinulose with colouring substance, black, globose to subglobose sclerotia produced in some strains, at first cream to buff, later vinaceous buff in age.

***Aspergillus japonicus* Saito (B):** Colonies spreading rapidly producing purple brown to black conidial heads; conidiophores arising from the substratum, conidia mostly globose, sometimes subglobose, strongly echinulate, bright coloured at first, becoming purplish brown.

***Aspergillus flavus* Link. (A):** Colonies growing rapidly; conidial heads yellow when young, becoming dark yellow-green in age, in older cultures deep grey-green, conidiophores arising separately from the substratum, conidia globose to subglobose, conspicuously echinulate, yellowish green, sometimes elliptical when young.

***Aspergillus nidulans* Fennell and Raper (F):** Colonies growing well at room temperature, dark cress green in some strains from abundant conidial heads, conidiophores light brown, sinuous, smooth, phialides biseriate, conidia globose to subglobose, green in mass.

***Aspergillus fumigatus* Fresen (C):** Colonies spreading dull blue-green, velvety to floccose; white at first becoming reverse colourless to varying in shades; conidiophores short, smooth, light green, septate, gradually enlarging into a flask shaped vesicle; conidia globose to subglobose, green in mass, echinulate, sclerotia and cleistothecia absent.

***Aspergillus versicolor* Vuill (E):** Colonies growing slowly, in two weeks, compact, closely crowded, at first white, changing to yellow to pea-green, conidiophores colourless or yellowish or strongly pigmented conidia globose, delicately to strongly echinulate, usually born in loosely radiating chains.

***Aspergillus flavipes* Bainier and Sartory (G):** Colonies growing moderately, white at first, turning to bright wheat colour later, velvety conidiophores smooth, sometimes smaller, old colonies yellow to light brown, conidia subglobose nearly colourless, smooth.

***Geotrichum candidum* Link (L):** Colonies spreading creamy white, somewhat yeast like texture, pasty; conidiophores lacking; arthrospores variable in dimension; hyaline or subhyaline, cylindric (barrel shaped) with truncate ends.

***Penicillium chrysogenum* Thom. Bull (M):** Colonies sometimes smaller, often centrally umbonate, commonly moderately deep and floccose; margins usually deep, conidia blue-green; conidiophores borne from surface or subsurface hyphae, conidia ellipsoidal to subellipsoidal, less commonly spheroidal, smooth, borne in long irregular columns.

***Penicillium aurantiogriseum* Dierekx. (N):** Colonies growing moderately, radially sulcate, moderately deep, surface texture smooth to granular, fascicles seen in young growth at low magnifications; margins usually entire, deep and white; mycelium white, usually inconspicuous, occasionally dominating the colony appearance in floccose isolates; conidiophores borne singly or in fascicles, mostly from substrate hyphae, with stipes, bearing terminal terverticillate or less commonly biverticillate penicilli; conidia subspheroidal to ellipsoidal, smooth, usually borne in long well defined columns.

***Trichoderma reesei* E.G. Simmons (P):** Colonies growing moderately, aerial mycelium appressed to agar surface, cottony aerial mycelium not forming, white with radial lines and scant conidial production after one week; conidiophores

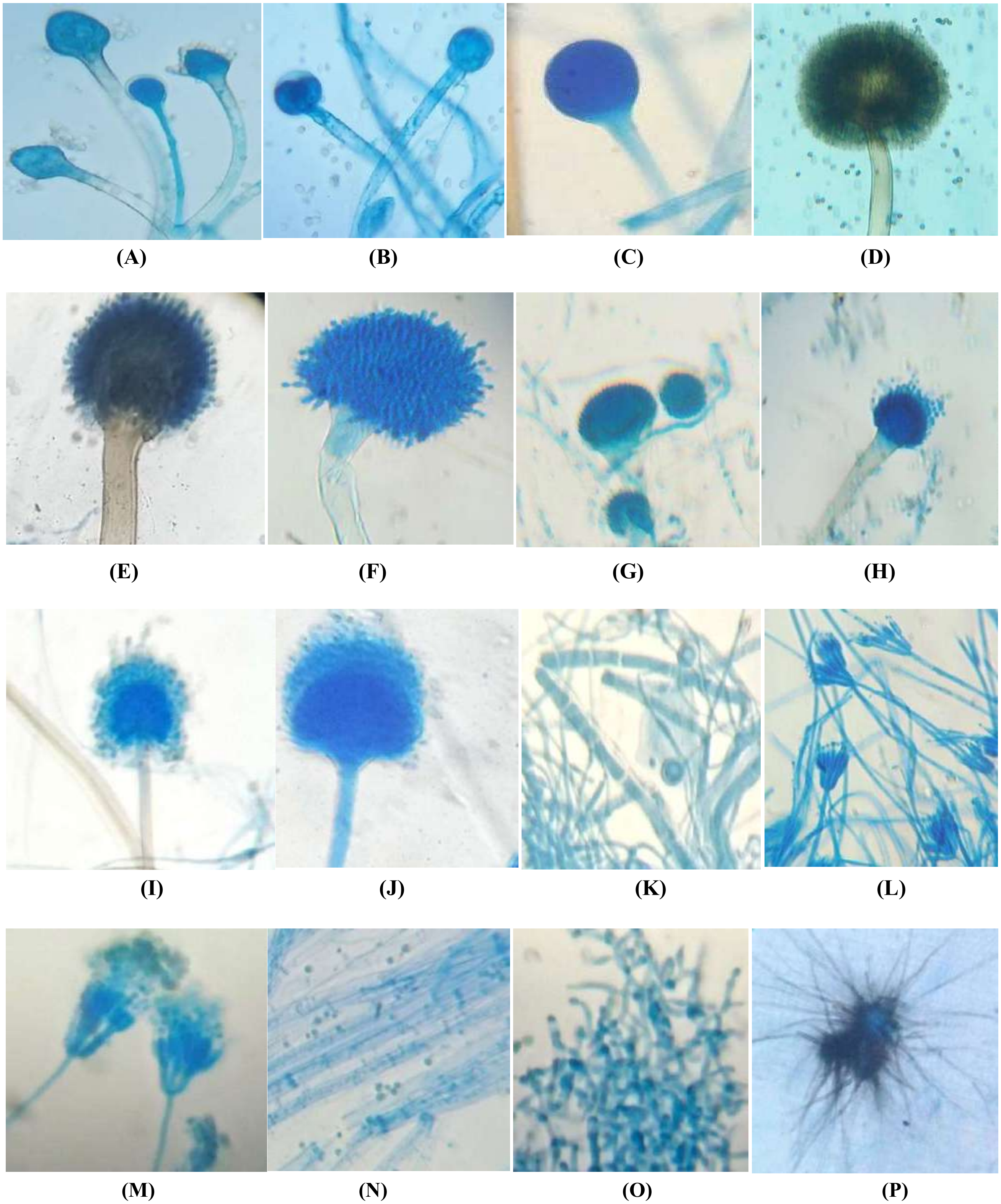

Fig. 4. Schematic diagrams of fungal species observed during study

A *Mucor varians;* B. *Mucor hiemalis;* C. *Rhizopus stolonifer;* D. *Aspergillus niger;* E. *Aspergillus japonicas;* F. *Aspergillus flavus;* G. *Aspergillus nidulans;* H. *Aspergillus fumigatus;* I. *Aspergillus versicolor;* J. *Aspergillus flavipes;* K. *Geotrichum candidum;* L. *Penicillium chrysogenum;* M. *Penicillium aurantiogrieseum;* N. *Trichoderma reesei;* O. *Trichoderma viride;* P. *Chaetomium osmoniae* forming on aerial mycelium, tufts minute, only primary branches infrequently branched, phialides arising singly before first branch, side branches producing more than one phialide; conidia obovoid to ellipsoid, smooth, and light green.

***Trichoderma viride* Pers. (O):** Colonies watery white becoming hairy from the formation of loose scanty aerial mycelium, glaucous to dark bluish green; conidiophores may be formed on the aerial or creeping hyphae, main conidiophores producing smaller side branches, ultimately a conifer-like branching system is formed, conidia globose or short obovoid, or broadly ellipsoidal, sometimes with distinct apiculus- like base because of distinct minute roughening on their walls, bluish green to dark green.

***Chaetomium osmaniae* Rama Rao and Ram Reddy (H):** Colonies growing slowly in two weeks, some vegetative hyphae forming a mat in the substratum, perithecia dark brown, subglobose to ovoid, attached to substratum by olive-brown rhizoids, the hairs becoming denser at the ostiolar region, basal portions of the hairs getting detached in old perithecia, terminal and lateral hairs alike, myceloid, unbranched, obscurely septate or rarely with a septum at the swollen base, olive-brown, coarsely roughened, becoming paler and smooth at the tip.

The results of present investigation show that the tropical leaf litter is colonized by numerous fungi and the types of fungal species changes as the decomposition progresses. *Mucor varians, M. hiemalis, Rhizopus stolonifer*, *Aspergillus niger* and *A. japonicus* appears first on the available substrates and they give way to the other colonizers with greater ability to degrade the leaf litter. The appearance of *Aspergillus flavus, A. fumigatus, A. nidulans, A. versicolor, A. flavipes, Geotrichum candidum, Penicillium chrysogenum, P. aurantiogriseum, Trichoderma reesei*, *T. viride* and *Chaetomium osmoniae* increased with the progress of degradation. This study also indicates that *Aspergillus niger* and *A. japonicus* were dominant in all stages of litter decomposition. This indicates the higher survivability of these species in tropical deciduous forests. In our study most of the fungal species which occured in the later stages of decomposition were efficient degraders of cellulose. The species of *Aspergillus, Chaetomium* and *Trichoderma* are found to be main utilizers of cellulose as a source of carbon for their growth and multiplication.

The result of present investigation was very similar to previous work carried out by many workers**,** Parungao et al (2002), Promputtha et al (2002), Tokumasu and Aoiki (2002), Tang et al (2005), Paulus et al (2006), Duong et al (2008), Shanthi and Vittal (2010 a,b), Seephueak et al (2010) and Osono (2011). Promputtha et al (2002) observed the fungal succession on senescent leaves of *Manglietia garretti* for 56 days and recorded 22 fungal taxa with the fungal community composition differing at each stage of succession. Greater fungal communities were recorded from the mature stage of decomposition. Similar trend was observed by Kodsueb et al (2008) on succession of the woody litter of *Magnolia liliifera* for 35 months at bimonthly samplings, where the number of fungal species was higher during the mature stage of decomposition. The species diversity tends to be richest and the number of fungi usually highest during the early and middle stages of colonization, thereafter the number of species begins to decline (Seephueak et al 2010). Borkar and Thakre (2014) observed that most of the fungi isolated from degrading biomass are the members of Ascomycetes whereas very few fungi belong to other groups like Zygomycetes and Basidiomycetes.

CONCLUSION

The present study provides valuable information of fungal diversity associated with the leaf litter of tropical deciduous forest of district Datia. The fungal communities were entirely dominated with Ascomycota and co-dominated with Zygomycota. The identified fungal strains of *Aspergillus niger*, *Aspergillus japonicus, Aspergillus flavus, Chaetomium osmoniae*, *Trichoderma* and *Penicillium* may contribute to future searches for fungal bio-indicators as biodiversity markers of a specific site. Fungi are key component of nutrient cycling in forest ecosystems, so their community composition is important for determining the nutrients present in the soil that are available for plant use and growth.

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Anatomical Features a Moth Orchid , *Phalaenopsis deliciosa* subsp. *hookeriana* (O. Gruss & Roellke) from Tripura, Northeast India

Biswajit Baishnab, Koushik Majumdar and Badal Kumar Datta

Plant Taxonomy and Biodiversity Laboratory, Department of Botany
Tripura University, Suryamaninagar-799 022, India
E-mail: biswajit.baishnab540@gmail.com

Abstract: *Phalaenopsis deliciosa* subsp. *hookeriana* a moth orchids, is reported for the first time from Tripura. Present study deals with its anatomical description of the aerial root and leaf internal structure. The collateral vascular bundle in leaf which is surrounded by homogenous mesophyll, epidermis and cuticle were examined. The anomocytic type of stomata are present in this species and estimated stomatal density was 2.1/92.9 mm^2 and stomatal index was 3.71%. The root anatomical study revealed that it having uniseriate velamen as additional adaptive feature. Pelotons of mycorrhzia were also identified in the root cortex. This species blooms in Agust to September in moist deciduous forest of Atharomura at an altitude of 145m amsl on the trunk of *Artocarpus chama* Buch. Ham.

***Keywords*:** Orchidaceae, Uniseriate velamen, Mycorrhiza, Distributional extension

The genus *Phalaenopsis* was first described by Carl Ludwing Blume in 1825. The generic name *Phalaenopsis* is derived from the Greek word '*Phalaena'* (moth) and '*opsis*' (resemblance) and thus they are commonly called 'moth-orchids'. The genus represents by 62 species (Christenson 2001) and is widely distributed throughout the world. In India the genus is represented by 14 species (Misra 2007) distributed throughout the Himalayas, Peninsular India and Andaman and Nicobor Islands. Gogoi (2012) reported five species from Assam and earlier one species also reported from Goa, Western Ghats (Jadhav et al 2015). *Phalaenopsis* are mostly epiphytic, shade loving, monopodial orchids and some are lithophytes. The species have adapted to moist and humid forest and grow below the canopy to avoid direct sunlight. Only thirty one orchid species belonging to twenty two genera were mentioned in the state flora of Tripura (Deb 1983). Recently, few orchid species were reported as new for the flora of Tripura (Baishnab et al 2017, Baishnab and Datta 2019). *Phalaenopsis deliciosa* subsp. *hookeriana* (O.Gruss & Roellke) Christenson has not been reported by earlier worker from Tripura (Deb 1983) and thus, this is the first report on the occurrence of this epiphytic orchid from Tripura, North East India. So far, this species has also been recorded from Sikkim, Arunachal Pradesh, Meghalaya, Assam, Jharkhand, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Andaman Island. The single distributional record and population scarcity of the orchid might be associated with its rarity. As it has already been listed in CITIES Appendix II (CITES 2019; ENVIS 2019), hence proper conservation measure should need to take to restore its wild population. Tripura is a small hilly state of North Eastern region of India, with a geographical area of 10491sq.km and is situated between 22°57' and 24°33' North latitudes and 91°10' and 92°20' East longitudes, surrounded by Bangladesh on three sides. The total forest area is 6294 km^2 which is 60.02% of the total geographical area of the state. There has not been much addition to the earlier reported number of orchids due to lack of proper exploration and documentation.

Maximum numbers of orchid of the family are from epiphytic habitat (Benzing et al 1982, Benzing 1986). The studied orchid species grows in epiphytic habitat with an average temperature of 30℃ to 35℃ and 50% to 74% relative humidity and exposed to full sunlight during summer. During the dry season this habitat becomes more susceptible to draught due to low humidity. Usually they have to overcome these difficulties for survival through some changes in their morphological parts and anatomical structures. Mycorrhizal fungi are in symbiotic relation with orchid roots from the very begining of orchid seed germination. Therefore, the aim of the present study was to examine the anatomical features of leaf and root to know any anatomical adaptations of this species if available which helps the species to survive in a wide range of climatic and edaphic conditions, and to describe with its additional distribution record from Tripura.

MATERIAL AND METHODS

During the floristic survey of Atharomura region in August 2018, one epiphytic orchid was collected in flowering condition. Geographical data, field photo, habit and habitat and other ecological data were recorded during the field study. Taxonomical enumeration was done by complete study of orchids flowers i.e., reproductive as well as vegetative parts and identity of the species was confirmed based on consultation of available literature (Christenson 2001, Misra 2004, Kumar and Manilal 2004, Gogoi 2012, Jadhav et al 2015). Standard methods for collection and preservation of the plant specimens were used (Jain and Rao 1977), and the voucher specimen (TUH 2075) has been deposited at the Herbarium in the Department of Botany, Tripura University.

The median regions of the mature leaves, roots were fixed in 50% FAA and preserved in 50% alcohol). To study internal structure, free hand sections were first stained and stained samples were examined under compound microscope (Magnus-016408). Stomata were studied from the epidermal peel of the mesophyll tissue of leaf which was then stained with acetocarmine solution diluted with 50% acetic acid. Stomatal density were calculated by observing the number of stomata in the microscopic circular view field in terms of mm^2 in 40X of compound microscope (Magnus-016408).The area of the microscopic field calculated (πr^2) by measuring the diameter of the view field by ocular scale, where r is the radius of the view field (Mallick et al 2016). For calculating the total cross sectioned area and area percentage same method were used. Stomatal index were calculated by the formula Stomatal index (%) = (S/S+E) ×100, where S and E are the number of stomata and epidermal cells in a microscopic field (Mallick et al 2016).

RESULTS AND DISCUSSION

The species was identified as *Phalaenopsis deliciosa* and by further observation it was found as *Phalaenopsis deliciosa* subsp. *hookeriana* (O. Gruss & Roellke) Christenson as its sepal and petals are yellow ground colour. A further scrutiny of literature (Deb 1983) and other new report of orchids from Tripura revealed that this species was unreported from Tripura.

Identification: *Phalaenopsis deliciosa* subsp. *hookeriana* (O. Gruss & Roellke) Christenson, is a epiphytic plant with very short stem, 1.0-1.5 cm long; roots compressed, long, grey, smooth, strongly attached to the host substratum; leaves 3 to 4, deep glossy green, thick, persistent, elliptic, 7.0-14.5 × 3.0-5.4 cm, acute, margin undulate, papery and slightly curved. Inflorescence was 10-15 cm, branched, densely flowered. Flowers are 1 cm across in size, yellowish green with pale purple stripes or markings. Dorsal sepal were sub elliptic, 6-7 × 3.0-3.5 mm, obtuse; lateral sepals obliquely ovate, 5.5-6.0 × 3.5-4.0 mm, base adnate to column foot, apex obtuse. Petals were sub-obovate, 5.0-5.5 × 2.7-3.0 mm, obtuse; lip not clawed at base, 3-lobed; lateral lobes erect, obliquely elliptic-obovate, 4.0 × 2.5 mm, rounded, with tooth like flaps, base forming a broadly conic spur with base of midlobe, midlobe spreading horizontally, pale yellow with longitudinal violet colour rays, disc with a white oblong callus, dilated nearly from the base of the midlobe and then bifurcated to form two antennae, midlobe obovate-cuneate, 6 × 5 mm, apex deeply emarginate, with a thickened central longitudinal ridge. Column 3 mm, foot 2 mm. Pollinia 4, two in each pair, hyaline, 2 mm long, viscidium small orbicular (Fig. 1).

Flowering and fruiting: August to September.

Habitat and Ecology: The epiphytic orchids grow in semi evergreen moist deciduous forest of Atharomura hill region of Tripura. The forest area is dominated by *Artocarpus chama* Buch. Ham., *Careya arborea* Roxb., *Shorea robusta* Gaertn., *Syzygium cumini* (L.) Skeels., *Litsea monopetala* (Roxb.) Pers., *Schima wallichii* Choisy. Individuals of *Phalaenopsis deliciosa* subsp. *hookeriana* was found growing in this forest below the tree canopy, protected from direct sunlight at 146 m elevation on tree trunk of *Syzygium cumini*.

Fig. 1. Photographs of *Phalaenopsis deliciosa*. A. Habit; B. Root; C. Inflorescence; D. Flower & buds; E. Flower; F. Sepal, petal & lip; G. Lateral & Midlobe of lip; H. Column & anther cap; I. Midlobe extended; J. Column; K. Pollinarium; L. Ovary; Illustration by Biswajit Baishnab

Anatomy

Leaf: Leaf anatomical structure of the *Phalaenopsis deliciosa* subsp. *hookeriana* showed the features of ideal monocot leaf organized with cuticle, epidermis, hypodermis, mesophyll and vascular bundles. Transverse sections of the leaf have upper (45 µm) and lower (30 µm) uniseriate elongated epidermis cell layer covered with striated cuticle of 7.5 µm and 5.0 µm thick respectively. The single layered hypodermis of 60 µm thick. Homogenous, 9-10 layers (765 µm thick) mesophylls are consists of round shaped thin walled parenchymatous cells. Large, oval-shaped, midrib vascular bundle lies in the centre, whereas the small and large laminar vascular bundles were seated on either side of it, 10-11 number of vascular bundles archs were present in a single row in mesophyll cells. Collateral vascular bundle was consists of xylem and phloem surrounded by thin walled bundle sheath cells. Stomatal organizations are of anomocytic type and observed only on upper surface of leaf. Epidermal cells were characterized with low stomatal density (2.1/92.9 mm^2) and stomatal index (3.71%).On the mesophyll cells of lower surface needle shape raphides also found (Fig. 2).

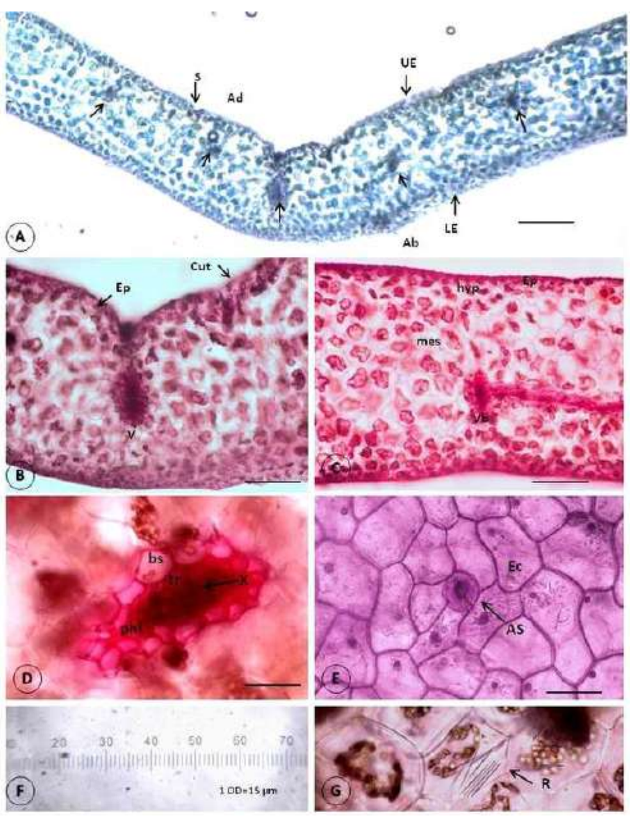

Fig. 2. Transverse section of leaf blade; A. Section showing single row vascular bundle (Ad-Adaxial part, Ab-Abaxial part, UE-Upper epidermis, LE-Lower epidermis, S-stoma, Arrow-Vascular bundles); B. Section through main vain (Ep-epidermis, Cu-cuticle, V-vain); C. Vb-vascular bundle, ms-mesophyll cells, hyp-hypodermis; D. Vascular bundle (X-xylem, phl-phloem, bs-bundle sheath, tr-tracheid); E. Stomata, (AS-anomocytic stomata, Ec-Epidermal cell), F - Scale (1 OD=15 µm); and G-Raphides; Bars=A=500 µm; B=C=100 µm; D=E=50 µm

Root: Transverse sectioned of the aerial roots of the species showed three different regions, velamen with rhizodermis, parenchymatous cortex and vascular cylinder. The total cross sectioned area of root was 264937.5 $µm^2$. The outermost single layer of large cells, radially arranged, root anatomical structure was rhizodermis followed by the uniseriate velamen formed of polygonal and elliptical cells. The cortex was made of exodermis just below the velamen, cortex and endodermis. Below the single layer exodermis, 9-11 cell layer cortex was present. The exodermis cells were little large compare to the cortex layer. Inside the exodermis cells or near in cortex cells mycorrhizal peltons were observed. After cortex, uniseriated elongated cell layers, the endodermis, surrounds the inner pericycle layer of vascular cylinder. The vascular cylinder was intact with xylem, phloem central pith and parietal 10 number of protoxylem pole and hence the root was poliarch (Fig. 3).

This study described the orchid the genus *Phalaenopsis*

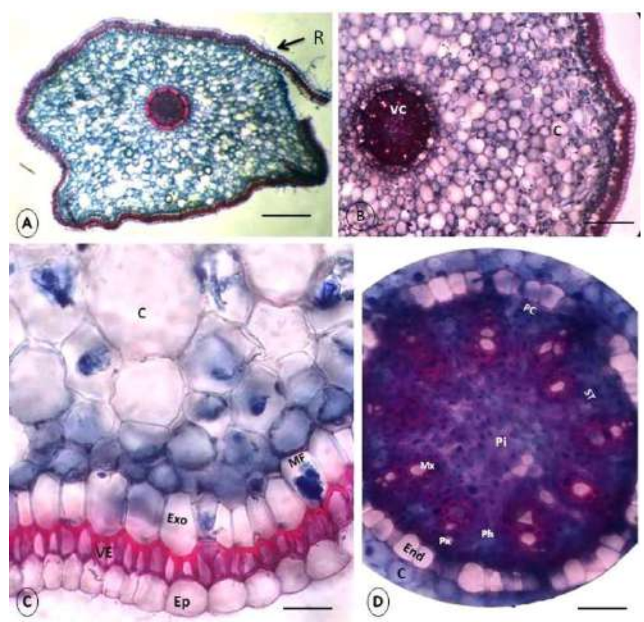

Fig. 3. Cross section in roots; A. Complete structure (R-rhizodermis); B. Section with three layers (V-Velamen, C-cortex, Vc- vascular cylinder); C. Velamen and cortex in details (Ep-epidermis, VE-velamen, Exo-Exodermis, MF-mycorrhizal fungi with arbuscule, C-cortex cells); D. Vascular cylinder in details (C-cortex, End-endodermis, PC-pericycle, Px-protoxylem, Ph-phloem, Mx- metaxylem, St-stele); Scale bars=A=500 µm; B=100 µm; C=D= 50 µm

from Tripura, which is a subspecies of *deliciosa* due to its yellow ground colour of the sepal and petals and named *Phalaenopsis deliciosa* subsp. *hookeriana* supplemented with photo flyer, morphological features, habitat ecology, global distribution and an account of anatomy. Internal root anatomy study revealed presence of velamen, cortex and vascular cylinder. The cell layers number next to the velamen to vascular cylinder and number of protoxylem pole are related to diameter of root. Total cross sectioned area of the root was estimated 264937.5 µm^2, of which 79.2 % area were cortex, velamen 5.12% and 4% of vascular cylinder. Exodermis showed 'U' shaped of wall thickening. The parenchymatous cells of exodermis and cortex were filled with peltons of mycorhizal fungi, since it might be infected with mycorrhiza at the time of germination from seed and absorbs minerals and nutrition passively from the host (Diez 2007, Piccoli et al 2014). In this study, mycorrhizal arbuscules were clearly visible at radicular root cortex. The cortex is 9 to 12, 'O' shaped, cell layers were thick and attached with uniserriate endodermis, which surrounds the pericycle of vascular cylinder. Paradermal section of leaf showed anomocytic type of stomatal apparatus. The leaf epidermal cells of upper surface consist of thick cuticle, lower stomatal index and stomatal density which may be due to restrict water loss (Bergel et al 2004, Wilmer and fricker 1996). Stoma and raphides are presents on lower surface where stomata only restricted only in upper surface. The internal features of the leaf indicated single layered thick cuticle on both the adaxial and abaxial side followed by epidermis and mesophyll cells respectively. A row of vascular bundles were embedded within the mesophyll cells. All this features are may be related to the changes of internal morphology of the species to adapt in such epiphytic habit and arid environment (Moreira et al 2013, Fan et al 2014). Root of this plant exhibited single layer velamen, which may be due to its adaptation in humid environments (Sanford and Adanlawo 1973) at very lower altitudinal range of Tripura. This velamen and outer cortex layer protects the interior surrounded parts of the root from heat and also prevent the inner cellular layers from dehydration (Gonzaga and Gonzaga 1996). Since, there were very little anatomical information is available for the genus *Phalaenopsis,*

Table 1. Leaf anatomical characters of *Phalaenopsis deliciosa* sub sp. *hookeriana*

Parameters	Thickness (µm)	No. of cell layers	Stomatal Study	
			Type	Anomocytic
Adaxial cuticle	7.3±0.1	1		
Abaxial cuticle	5.3±0.3	1	No. of stomata	2.1±0.55
Adaxial epidermis	45±2.0	1	No. of epidermal cell	54.45±3.65
Abaxial epidermis	30.66±2.0	1		
Adaxial hypodermis	61.3±1.5	4	Stomatal index	3.71%
Abaxial hypodermis	44.6±1.5	3	Area of microscopic view	92.9 mm^2
Leaf lamina	944.6±2.5	71	Stomatal density	2.1/92.9 mm^2
Mesophyll layer	763±2.0	51		

-Mean ± SD

Table 2. Anatomical features in the root of *P. deliciosa* sub sp. *hookeriana*

Parameters	No/form?	Thickness (µm)	Parameters	Area or % of area
Velamen (cell layers)	1/polygon	30±2.00	Total cross Sectioned Area of root	264937.5 µm^2
Cortex (cell layers)	9-12/O	748±2.64	Total area of velamen	13564.8 µm^2
Exodermis (Wall thickening)	1/U	45±2.00	Percentage of velamen	5.12 (%)
Endodermis (Wall thickening)	1/O	30.3±2.08	Total area of cortex	209830.5 µm^2
Protoxylem (poles)	10	-	Percentage of cortex	79.2 (%)
Epidermis (cell layers)	1/O	29.6±2.50	Stele and endodermis area	10597.5 µm^2
			Percentage of Stele and endodermis area	4 (%)

Mean ± SD

although anatomical feature of *Phalaenopsis amabilis* was studied by Bercu et al (2011). The habitat information, its geographical distribution may be useful to modelling the distribution with the goal to locate additional populations in the natural habitat.

CONCLUSIONS

Present study includes the taxa (*Phalaenopsis deliciosa* subsp. *hookeriana*) in the orchid flora of the state and the anatomical study contributes the information of internal morphology as well as adaptation knowledge of the genus *Phalaenopsis*. Internal structure of the leaf suggested that it reduce water transpiration with organized cuticle, epidermis, hypodermis, mesophyll and vascular bundles. Stomatal apparatus are made of anomocytic type of stomata which shows 2.1/92.9 mm^2 density and 3.71% of stomatal index Transverse sectioned of the aerial root consists of velamen with rhizodermis, parenchymatous cortex with mycorrhizal peltons and vascular cylinder which are typical structure of an epiphytic plant.

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Study on Biodiversity and Floristic at Wetland in Tirupattur Taluk

P. Ammu, R. Aswini and S. Murugesan

Department of Botany, Periyar University, Salem-636 011, India
E-mail: drsmbtpu@gmail.com

Abstract: The present review gives noteworthy data on biodiversity and floristic at wetland plants in Tirupattur Taluk. This is the principal biodiversity ponder, which records the morpho-ecological gatherings of wetland plants and their uses, point by point of assorted qualities in various lakes. This examination thinks about reports of the biodiversity and floristic investigations of the employments of plants by tenants in Tirupattur Taluk of the distinctive lake. The present review manages the preparing and expending biodiversity of wetland plants. The acquired information was utilized as a part of the learning of Tirupattur Taluk of wetland morphological, natural, pH and their employments. It supports to find out the rare and endangered plants in the particular area.

***Keywords*:** Biodiversity, Floristic, Wetland, Tirupattur Taluk, Plant uses

India with its changing geology and climatic administrations underpins various and extraordinary wetland environments. The accessible appraisals of the areal degree of wetlands in India shift generally from a least of 1% to a most elevated of 5% of the geological range however do bolster an almost fifth of the known biodiversity. Wetlands in India that involve 58.2 million hectares (counting regions under wet paddy development), confront huge anthropogenic weights, for example, quickly extending human populace, substantial scale changes in land utilize/arrive cover, blossoming advancement ventures and inappropriate utilization of watersheds, which thus enormously impact the oceanic biodiversity (Selvamony and Sukumaran 2011). The appropriated in the present investigation of the wetlands in Tamil Nadu include lakes, lakes, repositories and occasionally waterlogged ranges. It might be noticed that the land utilize measurements of the state does not demonstrate wetlands which are perhaps characterized under some different classes (ENVIS 2011). Wetlands are the ecotones or transitional zones between for all time sea-going and dry Terrestrial biological communities. A wide assortment of wetlands like bogs, bogs, vast water bodies, mangroves and salt marshes and salt swamps and so on exists in our nation (ENVIS 2011). Wetland and oceanic plants give bio-assets to coordinate financial use and in addition assume critical natural part in the biological community work including disinfecting of contaminated waters (Malaya et al 2012, Pal and Nimse 2006, Panda and Misra 2011). The present pattern of employments of wetland plant assorted qualities in the contemplated zones demonstrates that the employments of plants and conventional practices will keep on playing a noteworthy part in the socio-social existence of these town groups. In any case, the pattern of decrease in the plenitude of some extremely helpful local species, increment of unsustainable anthropogenic practices and infringement and spreading of obtrusive species demonstrate that activity for protection is desperately required. Hence, ought to be given to executing protection exercises with an incorporated approach for manageable improvement (Kensa 2011). Wetlands and Forests is the subject for World Wetlands Day 2011, particularly picked on the grounds that 2011 is the UN International Year of Forests. The Slogan is – "Timberlands for water and wetlands" highlighting the significance of Forested wetlands and why taking care of them matters (ENVIS 2011).The objective of present study is to manage and extend biodiversity of wetland plants. The acquired information will be utilized as a part of the learning of Tirupattur Taluk of wetland morphological, natural, pH and their employments.

MATERIAL AND METHODS

The botanical review was led in Tirupattur Taluk lake zone wetland plants. Lake encompassing regions which incorporate aggregate lakes (little and enormous) size are 25, choosing in just 15 lakes in Tirupattur taluk, Vellore area in Tamil Nadu, India. The GPS location gps coordinates of 12° 29' 54.0636'' N and 78° 33' 36.7056'' EIn is place 12.62 km^2 add up to zone, 5.12 km^2 around the local area 7.5 km2 towns, Total 93 zones incorporate into 66 towns it was Adhur-koratti to Kodiur (2011). Topographically, the height of region is around 102 m above mean ocean level. Temperature is hardly varies in the year, with the mean month to month least and most extreme temperatures of 31ºC and 55ºC individually, and yearly precipitation achieves 435-700 mm. A comprehensive and thorough investigation of plants present in study zones are Sevathur lake, Chinnakunichi lake, Adtyur lake, Jadayanur Tank, Rachamangalam Tank, Tirupattur enormous lake section 1 and 2, Yelagiri lake, Periyagaram lake, Thamalerimuthur Lake, Andiyappanur Lake, Achamangalam lake,Thiriyala lake, Kandhili lake, Sellarapatti lake in all out 15 pools of wetland plants was review.

The experiment was conducted from September 2015 to March 2016. The plant were identified by using of following reference books i.e., the obscure and doubtful plants were collected "Aquatic Angiosperms (Subramanyam 1962). A Systematic Account of normal Indian Aquatic Angiosperms. Council of Scientific and Industrial Research, the Flora of Tamil Nadu Grasses, the vegetation of Presidency of Madras, an Excursion Flora of Central Tamil Nadu, India. The plants recorded amid this review, prostate herb, erect herb and herb were incorporated into the class of 'Herb'. Little bush, sub-bush and bush were incorporated into the classification of 'Bush'. Creeper, twiner and climber were specified as 'Climber'. Natural propensity arranged in free drifting, submerged, submerged moored, gliding leaved tied down eminent secured and dampness put (Thangadurai et al 2012).

Herbarium method: The gathered examples were dry and treated with a blend of mercuric chloride (Hgcl2) and Alcohol (1:9). The plants were mounted on the standard size herbarium sheets, and have been saved in this herbarium was available in Department of Botany, Botany Research Laboratory, Periyar University, Salem.

RESULTS AND DISCUSSION

In this study an aggregate number of varieties 145 having a place with 44 family and 101 genera, under Angiosperm 138 types of 95 genera and 38 family, 84 types of 59 genera and 25 family under the class dicotyledons, 54 types of 36 genera and 13 family under the class monocotyledons, 5 types of 4 genera and 4 family under the class pteridophytes, 2 types of 2 genera and 2 family under the class green growth are recorded (Table 3).

Morpho-ecological groups of wetland plants: Facilitate the sea-going macrophytes characterized in morphological gathering viz., arranged free floating (7 species and 6 genera 5 family), submerged (6 species 6 genera 4 family), Submerged anchored (6 species 6 genera 6 family), Floating leaved anchored (8 species 7 genera 6 family) and Emergent anchored (50 species 35 genera 21 family), Moisture place (68 species 20 genera 51 family) (Table 1).

Wetland plants: The most species families were Cyperaceae with 18 species, Poaceae 13 Species, Convolvulaceae 12 species, Asteraceae 8 species, Acanthaceae 8 species, Amaranthaceae 7 species, Euphorbiaceae, Commelinaceae, Onagraceae and 6 species every, Fabaceae 5 species, Hydrocharitaceae 4 species, Scrophulariaceae 3 species, Lamiaceae, Boraginaceae, Malvaceae and Elatinaceae and Lemnaceae 3 species each, Nymphaceae, Verbenaceae, Aponogetonaceae, Araceae, Rubiaceae, Lythraceae and Pteridaceae were two species each. Typhaceae, Campanulaceae,Cannaceae,Plumbaginaceae,Campanulaceae,Cucurbitaceae, Sapindaceae, Najadaceae, Pontederiaceae, Alismataceae, Capparaceae, Brassicaceae, Eriocaulaceae, Polygonaceae, Apocynaceae, Onagraceae, Characeae, Zygnemataceae, Marsileacea and Salviniaceae (Table 2).

Ecological data: Among the 15 lake wetland put Morpho-ecologic gatherings rising moored with free coasting 7 species, submerged 6 species, submerged tied down 6 species, drifting leaved secured 8 species and emanate tied down 50 species, dampness put 68 species. A large portion of the present species is moister put plants overwhelming. Ipomoea cornea, Pistea stratiotes an unmistakable indication of intrusion (Prasad et al 2002) (Table 4). Lakes pH is 9 in this area and temperature is low cooling place nearby hills, it was not in pollution areas so this place species *Nelumbo nucifera, Scirpus cernuus, Aponogeton natans, Azolla caroliniana, Eichhornia crassipes, Coix lacryma, Egeria densa, Aponogeton ulvaceus, Certopteris cornuta, Ceratopteris richardii*, this two species rare species in this

Table 1. Morpho-ecological groups of wetland plants recorded in Tirupattur TK

Name of the species	Family	Morpho-ecological group
Azolla caroliniana willd	Salviniaceae	Free floating
Eichhornia crassies	Pontederiaceae	Free floating
Lemna gibba	Lamnaceae	Free floating
L. minor	Lamnaceae	Free floating
Pistia stratiotes	Araceae	Free floating
Spirogyra	zygnemataceae	Free floating
Wolffia globba	Lamnaceae	Free floating
Aponogeton ulvaceus	Aponogetonaceae	Submerged
Chara vulgaris	Characeae	Submerged
Egeria densa	Hydrocharitaceae	Submerged
Hydrilla verticillata	Hydrocharitaceae	Submerged
Najas minor	Najadaceae	Submerged
Vallisneria Americana	Hydrocharitaceae	Submerged
Alternanthera philoxeroides	Amaranthaceae	Submerge anchored
Hygrophilla auriculata	Acanthaceae	Submerge anchored
Lipocarpha micrantha.	Cyperaceae	Submerge anchored
Monochoria vaginalis	Pontederiaceae	Submerge anchored
Phyla lanceolata	Verbenaceae	Submerge anchored
Sagattaria latifol w.	Alismataceae	Submerge anchored
Aponogeton natans	Apnogetonaceae	Floating leaves anchored
Certopteris cornuta	Pteridaceae	Floating leaves anchored
C.richardii	Pteridaceae	Floating leaves anchored
Ludwigia adscendens	Onagraceae	Floating leaves anchored
Marsilia quadrifolia L.	Marsileaceae	Floating leaves anchored
Nelumbo nucifera	Nymphaceae	Floating leaves anchored
Nymphaea pubesecens Willd,.	Nymphaceae	Floating leaves anchored
Ottelia alismoides (L.)Pers	Hydrocharitaceae	Floating leaves anchored
Ammannia baccifera	Lythraceae	Emerged anchored
A. octandra L.F.,	Lythraceae	Emerged anchored
Alternanthera paronychioides	Amaranthaceae	emerged anchored
A. sessilis (L)	Amaranthaceae	Emerged anchored
Arundo donax L.	Poaceae	Emerged anchored
Asclepias curassavica L.	Apocynaceae	Emerged anchored
Bergia ammannioides Roxb. ex Roth	Elatinaceae	Emerged anchored
B.capensis L.	Elatinaceae	Emerged anchored

Cont...

Table 1. Cont...

Name of the species	Family	Morpho-ecological group
Commelina benghaensis	Commelinaceae	Emerged anchored
Colocasia esculenta	Araceae	Emerged anchored
Coix lacryma	Poaceae	Emerged anchored
Cyperus entrerianus	Cyperaceae	Emerged anchored
C. erangrosis	Cyperaceae	Emerged anchored
C. esculentus	Cyperaceae	Emerged anchored
Cyanotis somaliensis	Commelinaceae	Emerged anchored
Cyperus squarrosus	Cyperaceae	Emerged anchored
Dactyloctenium aegyptium L.	Poaceae	Emerged anchored
Echinochloa colona L.	Poaceae	Emerged anchored
Erircaulon cinereum R. Brown	Eriocaulaceae	Emerged anchored
Euphorbia hypericifolia L	Euphorbiaceae	Emerged anchored
Ipomoia aquatica Forssk	Convolvulaceae	Emerged anchored
I. coptica	Convolvulaceae	Emerged anchored
I. pandurata	Convolvulaceae	Emerged anchored
Kyllinga brevifolia Rottb	Cyperaceae	Emerged anchored
Kyllinga hyaline (Vahl)	Cyperaceae	Emerged anchored
K. monocephala	Cyperaceae	Emerged anchored
Lindernia anagallis	Scrophulariaceae	Emerged anchored
Lipocarpha microcephala	Cyperaceae	Emerged anchored
Ludwigia glandulosa	Onagraceae	Emerged anchored
Ludwigia grandiflora	Onagraceae	Emerged anchored
Ludwigia hyssopifolia	Onagraceae	Emerged anchored
Ludwigia linearis	Onagraceae	Emerged anchored
Ludwigia peruviana	Onagraceae	Emerged anchored
Oldenlendia affinis (Roemer & Schulter)	Rubiaceae	Emerged anchored
Oxystelma esculentum L. f.	Asclepidaceae	Emerged anchored
Oxyceros rugulosus (Thunb.)	Rubiaceae	Emerged anchored
Phalaris arundinacea L	Poaceae	Emerged anchored
Polygonum glabrum	Polygonaceae	Emerged anchored
Phyla nodiflora L	Verbenaceae	Emerged anchored
Ruellia tuberosa L.	Acanthaceae	Emerged anchored
Scirpus cernuus	Cyperaceae	Emerged anchored
Scoparia dulcis	Scrophulariaceae	Emerged anchored
Schoenoplectus tabernaemontani	Cyperaceae	Emerged anchored
Stachy tarpheta	Amaranthaceae	emerged anchored
Spermacoce ocymoides L.	Asteraceae	Emerged anchored
Typha angustifolia L	Typhaceae	Emerged anchored
Vernonia cinerea	Asteraceae	Emerged anchored
Vigna dalzelliana (Kuntze)	Fabaceae	Emerged anchored

Cont...

Table 1. Cont...

Name of the species	Family	Morpho-ecological group
Vigna marina (Burm) Merr	Fabaceae	Emerged anchored
Acanthospermum hispidum	Acanthaceae	Moisture place
Asystasia gangetica L	Acanthaceae	Moisture place
Achyranthes bidentata	Amaranthaceae	Moisture place
Apluda mutica	Poaceae	Moisture place
Brachiaria ramota	Poaceae	Moisture place
Canna indica	Cannaceae	Moisture place
Cardiospermum helicacabum L.	Sapindaceae	Moisture place
Calyptocarpus vialis	Asteraceae	Moisture place
Cenchrus pennisetiformis	Poaceae	Moisture place
Celosia argentea L.	Amaranthaceae	Moisture place
Cleome chelidonii L	Capparaceae	Moisture place
Chrozophora rottleri A. Juss	Euphorbiaceae	Moisture place
Chloris pycnothrix Trin.	Poaceae	Moisture place
Clitoria ternatea L	Fabaceae	Moisture place
Commelina clavata	Commelinaceae	Moisture place
Cyanotis cristata	Comelinaceae	Moisture place
Commelina diffusa Burman f.	Commelinaceae	Moisture place
Cyperus longus	Cyperaceae	Moisture place
Cyperus rotundus L.	Cyperaceae	Moisture place
Cyperus triceps	Cyperaceae	Moisture place
Coldenia procumbens L.	Boraginaceae	Moisture place
Dicliptera cuneata Nees	Acanthaceae	Moisture place
Ecbolium tanzaniense	Acanthaceae	Moisture place
Eclipta prostrata L.	Asteraceae	Moisture place
Elatine brachysperma	Elatinaceae	Moisture place
Emilia fosbergii	Asteraceae	Moisture place
Eragrostis gangetica (Roxb)	Poaceae	Moisture place
Euphorbia hetrophylla L.	Euphorbiaceae	Moisture place
Euphorbia hirta L	Euphorbiaceae	Moisture place
Euphorbia serpens Kunth	Euphorbiaceae	Moisture place
Eragrostis amabillis L.	Poaceae	Moisture place
Heliotropium europaeum	Boragenaceae	Moisture place
Heliotropium curassavicum	Boragenaceae	Moisture place
Hewittia malabarica	Convolvulaceae	Moisture place
Hibiescus vitefollies L	Malvaceae	Moisture place
Isachne bourneorum C.E.C.	Poaceae	Moisture place
Ipomoea alba L.	Convolvulaceae	Moisture place
Ipomoea cairica L.	Convolvulaceae	Moisture place
Ipomoea carnea	Convolvulaceae	Moisture place
Ipomoea muncikai	Convolvulaceae	Moisture place
Ipomoea sepiaria Koenig ex Roxb	Convolvulaceae	Moisture place

Cont...

Table 1. Cont...

Name of the species	Family	Morpho-ecological group
Justicia betonica (L)	Acanthaceae	Moisture place
Kyllinga brevifolia Rottb	Cyperaceae	Moisture place
Leucas diffusa Benth	Lamiaceae	Moisture place
Leucas martinicensis	Lamiaceae	Moisture place
Lobelia siphilitica L	Campanulaceae	Moisture place
Merremia aegyptia (L.)	Convolvulaceae	Moisture place
Merremia emarginata	Convolvulaceae	Moisture place
Merremia hederacea (Burm. f)	Convolvulaceae	Moisture place
Mimosa pudica	Fabaceae	Moisture place
Mukia scabrella	Cucarbitace	Moisture place
Phyllanthus niruri L.	Euphorbiaceae	Moisture place
Plectranthus neochilus	Lamiaceae	Moisture place
Plumbago zeylanica L	Plumbaginaceae	Moisture place
Pycreus polystachyos (Rottb.)	Cyperaceae	Moisture place
Pupalia lappaceae	Amaranthaceae	Moisture place
Rhynchosia velutina	Fabaceae	Moisture place
Rorippa indica (L) Hiern	Brassicaceae	Moisture place
Ruellia pathula	Acanthaceae	Moisture place
Schoenoplectus juncoides	Cyperaceae	Moisture place
Scirpus pallidus	Cyperaceae	Moisture place
Shagneticola trilobata (L)	Asteraceae	Moisture place
Sonchus asper (L.) Hill	Asteraceae	Moisture place
Sporobolus maderaspatanus	Poaceae	Moisture place
Tradescantia fluminensis	Commelinaceae	Moisture place
Triumfetta rhomboidea Jacq.	Malvaceae	Moisture place
Xanthium strumarium	Asteraceae	Moisture place
Waltheria indica	Malvaceae	Moisture place

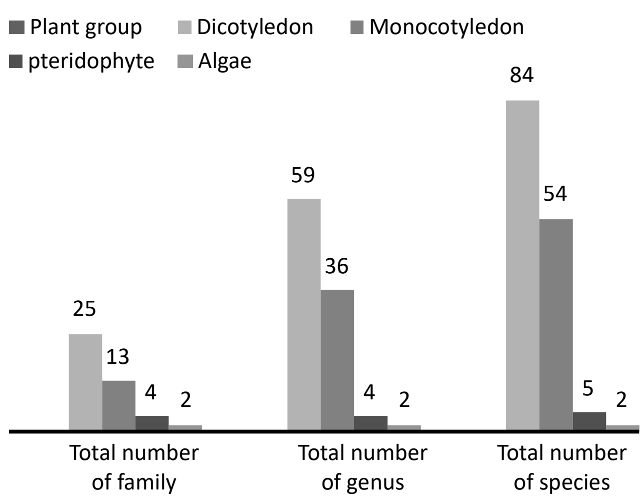

Fig. 1. Plant group data

Table 2. Wetland plants

Family name	Genus total	Species total
Dicotyledon		
Apocynaceae	1	1
Acanthaceae	8	8
Amaranthaceae	5	7
Asclepidaceae	1	1
Asteraceae	8	8
Brassicaceae	1	1
Boraginaceae	2	3
Capparaceae	1	1
Campanulaceae	1	1
Cucarbitaceae	1	1
Convolvulaceae	3	12
Elatinaceae	2	3
Euphorbiaceae	3	6
Fabaceae	4	5
Lamiaceae	2	3
Lythraceae	1	2
Malvaceae	3	3
Nymphaceae	2	2
Onagraceae	1	6
Plumbaginaceae	1	1
Polygonaceae	1	1
Rubiaceae	2	2
Sapindaceae	1	1
Scrophulariaceae	3	3
Verbenaceae	1	2
Monocotyledon		
Alismataceae	1	1
Aponogetonaceae	1	2
Araceae	2	2
Cannaceae	1	1
Commelinaceae	3	6
Characeae	1	1
Cyperaceae	6	18
Eriocaulaceae	1	1
Hydrocharitaceae	4	4
Lamnaceae	2	3
Najadaceae	1	1
Poaceae	12	13
Pontaderiaceae	1	1
Typhaceae	1	1
Zygnemataceae	1	1
Pteridophytaceae		
Marsileaceae	1	1
Pontederiaceae	1	1
Pteridaceae	1	2
Salviniaceae	1	1

Table 3. Plant group data (number)

Group of plant	Family	Genus	Species
Dicotyledon	25	59	84
Monocotyledon	13	36	54
Pteridophyte	4	4	5
Alga	2	2	2
Total number	44 Family	101 Genus	145 Species

Table 4. Ecological data

Morpho-ecological	Species	Genera	Family
Free floating	7	6	5
Submerged	6	6	4
Submerged anchored	6	6	6
Floating leaved anchored	8	7	6
Emergent anchored	50	35	21
Moisture place	68	20	51

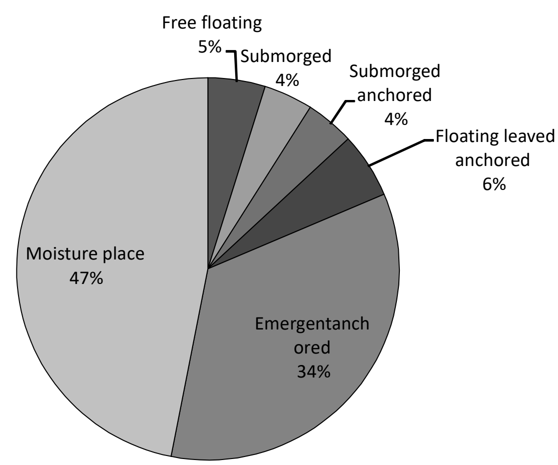

Fig. 2. Ecological data

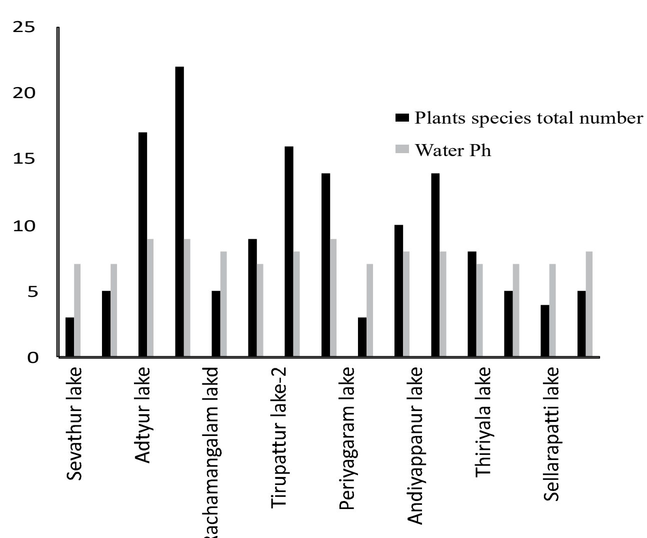

Fig. 3. Water pH

Table 5. Lake place and plant name and water pH

Locality	Plant species name	Water pH
Sevathur Tank	*Mukia scabrella, Dactyloctenium aegyptium, Chrozophora rottleri,*	7
Chinnakunichi Tank	*Xanthium Strumarium, Hygrophilla auriculata, Dicliptera cuneata, Justicia betonica, Canna indica*	7
Adiyur Tank	*Eichhornia crassies, Cyanotis cristata, Achyranthes bidentata, Celosia argentea, Leucas diffusa, Acanthospermum hispidum, Ipomoea muncikai, Heliotropium europaeum, Heliotropium curassavicum, Kyllinga hyaline, Cyperus esculentus, Cyanotis somaliensis, Hydrilla verticillata, Ottelia alismoides, Bergia capensis, Oldenlendia affinis, Ipomoia aquatic, Commelina diffusa*	9
Jadayanur Tank	*Lemna gibba, Ludwigia glandulosa, Ludwigia hyssopifolia, Ludwigia peruviana, Scoparia dulcis, Erircaulon cinereum, Schoenoplectus tabernaemontani, Phalaris arundinacea, Rorippa indica, Hewittia malabarica, Calyptocarpus vialis, Mimosa pudica, Kyllinga monocephala, Cyperus entrerianus, Lindernia anagallis, Egeria densa, Certopteris cornuta, Certopteris richardii, Asclepias curassavica, Eragrostis amabillis, Ipomoea alba* *Pycreus polystachyos, Apluda mutica, Eragrostis gangetica, Isachne bourneorum*	9
Rachamangalam Tank	*Clitoria ternatea, Alternanthera paronychioides, Vernonia cinerea, Euphorbia hirta, Brachiaria ramota,*	8
Tirupattur Tank-1	*Arundo donax, Cyperus erangrosis, Typha angustifolia, Pistia stratiotes, Lemna minor, Wolffia globba, Phyla lanceolata, Cyperus squarrosus, Typha angustifolia, Merremia aegyptia, Schoenoplectus juncoides*	7
Tirupattur Tank-2	*Coldenia procumbens, Spirogyra, Lobelia siphilitica, Sonchus asper, Emilia fosbergii, Elatine brachysperma, Vallisneria Americana, Aponogeton ulvaceus, Sagattaria latifol, Monochoria vaginalis, Marsilia quadrifolia, Nymphaea pubesecens, Aponogeton natans, Merremia emarginata, Merremia hederacea, Euphorbia serpens*	8
Yelagiri Tank	*Lipocarpha micrantha, Lipocarpha microcephala, Scirpus cernuus, Ludwigia grandiflora, Ludwigia linearis, Plectranthus neochilus, Euphorbia hetrophylla, Ipomoea alba, Kyllinga brevifolia, Cyperus squarrosus, Eichhornia crassies, Najas minor, Nelumbo nucifera, Ludwigia adscendens, Bergia ammannioides, Eragrostis amabillis*	9
Periyagaram Tank	*Eclipta prostrata, Euphorbia hypericifolia, Spermacoce ocymoides*	7
Nayanathiyur Tank	*Cardiospermum helicacabum, Cyperus longus, Cyperus rotundus, Dicliptera cuneata, Sporobolus maderaspatanus*	7
Thamalerimuthur Tank	*Cleome chelidonii, Alternanthera sessilis, Chara vulgaris, Vigna marina, Ammannia baccifera, Heliotropium europaeum, Asystasia gangetica, Tradescantia fluminensis, Cyperus triceps, Scirpus pallidus*	8
Andiyappanur Tank	*Azolla caroliniana ,Waltheria indica, Ipomoea pandurata, Bacopa monnier, Polygonum glabrum, Phyla nodiflora, Stachy tarpheta, Colocasia esculenta, Coix lacryma, Shagneticola trilobata, Phyllanthus niruri, Commelina clavata, Cenchrus pennisetiformis, Chloris pycnothrix, Asclepias curassavica*	8
Achamangalam Tank	*Oxystelma esculentum, Ipomoea carnea, Ipomoea cairica, Plumbago zeylanica, Rhynchosia velutina, Phalaris arundinacea, Ruellia tuberosa, Oxyceros rugulosus, Leucas martinicensis*	7
Thiriyalam Tank	*Hibiescus vitefollies, Echinochloa colona, Vigna dalzelliana, Ipomoea sepiaria, Ruellia pathula*	7
Kandhili Tank	*Triumfetta rhomboidea, Commelina benghaensis, Ipomoea coptica, Dactyloctenium aegyptium* L	7
Sellarapatti tank	*Pupalia lappaceae, Ecbolium tanzaniense, Alternanthera philoxeroides, Mukia scabrella, Celosia argentea*	8

Table 6. Lack name - species total number and water pH

Place name	Plant species total number	Water pH
Sevathur Tank	3	7
Chinnakunichi Tank	5	7
Adiyur Tank	17	9
Jadayanur Tank	22	9
Rachamangalam Tank	5	8
Tirupattur Tank-1	9	7
Tirupattur Tank-2	16	8
Yelagiri Tank	14	9
Periyagaram Tank	3	7
Nayanathiyur Tank	5	7
Thamalerimuthur Tank	10	8
Andiyappanur Tank	14	8
Achamangalam Tank	8	7
Thiriyalam Tank	5	7
Kandhili Tank	4	7
Sellarapatti Tank	5	8

Table 7. Plant uses table

Species name	Family	Uses	Parts
Spirogyra	Zygnemataceae	Marine animals food	Whole plant
Azolla caroliniana Willd	Salviniaceae	Fertiliser	Small herb
Eichhornia crassies	Pontederiaceae	Medicinal use	Flower
Pistia stratiotes	Araceae	Medicinal use,edible	Leaves
Lemna gibba	Lamnaceae	Marine animals food	Small herb
Lemna minor	Lamnaceae	Medicinal green manure	Small herb
Wolffia globba	Lamnaceae	Edible	Small herb
Chara vulgaris	Characeae	Nitrogen fixer	Whole plant
Egeria densa	Hydrocharitaceae	Water animal eaten	Leaves
Hydrilla verticillata	Hydrocharitaceae	Edible use	Tenter ,leaf
Vallisneria Americana	Hydrocharitaceae	Green manure	Whole plant
Najas minor	Najadaceae	Aquarium	Whole plant
Aponogeton ulvaceus	Aponogetonaceae	Ornamental	Whole plant
Sagattaria latifol w.	Alismataceae	Edible Uses	Root
Hygrophilla auriculata	Acanthaceae	Medicinal use	Leaves, root
Phyla lanceolata	Verbenaceae	Medicinal use	Leaves,
Alternanthera philoxeroides	Amaranthaceae	Medicinal use	Leaves, stem
Monochoria vaginalis	Pontederiaceae	Medicinal use	Leaves
Lipocarpha micrantha.	Cyperaceae	Fodder	Whole plant
Marsilia quadrifolia L.	Marsileaceae	food,,medicinal	Leaves
Certopteris cornuta	Pteridaceae	aquarium plant	whole plant
Certopteris richardii	Pteridaceae	aquarium plant	whole plant
Nelumbo nucifera	Nymphaceae	*Medicinal*	Flower,tuber
Nymphaea pubesecens Willd	Nymphaceae	*Ornamental*	Flower
Ludwigia adscendens	Onagraceae	*Medicinal*	Flower,leaves
Ottelia alismoides (L.) Pers	Hydrocharitaceae	Flavor-cousmetics	Root
Aponogeton natans	Apnogetonaceae	ornamental	Herb
Bergia ammannioides	Elatinaceae	Medicinal	Herb
Bergia capensis L.,	Elatinaceae	Medicinal	Herb
Vigna dalzelliana (Kuntze)	Fabaceae	Edible vegetable	Seeds
Vigna marina (Burm) Merr	Fabaceae	Medicinal	Leaf-stalk
Ammannia baccifera	Lythraceae	Medicinal	Leaf
Ammannia octandra L.F.,	Lythraceae	Medicinal	Herb
Ludwigia glandulosa	Onagraceae	Ornamental	Whole plant
Ludwigia grandiflora	Onagraceae	Ornamental	Whole plant
Ludwigia hyssopifolia	Onagraceae	Ornamental	Whole plant
Ludwigia linearis	Onagraceae	Medicinal	Herb
Ludwigia peruviana	Onagraceae	Medicinal	Herb
Oldenlendia affinis	Rubiaceae	Medicinal	
Oxyceros rugulosus	Rubiaceae	Edible	
Spermacoce ocymoides L.	Asteraceae	Edible	
Vernonia cinerea	Asteraceae	Medicinal	Herbal
Asclepias curassavica L.	Apocynaceae	Ornamental	
Oxystelma esculentum L. f.	Asclepidaceae	Medicinal.	
Ipomoea coptica	Convolvulaceae	Artificial	Leaf,
Ipomoea pandurata	Convolvulaceae	Edible	Root
Ipomoia aquatica Forssk.,	Convolvulaceae	Animal food	Leaves, shoot, roots
Bacopa monnier (L)	Scrophulariaceae	Medicinal	Leaves

Cont...

Table 7. Cont...

Species name	Family	Uses	Parts
Lindernia anagallis	Scrophulariaceae	Medicinal	Herb
Scoparia dulcis	Scrophulariaceae	Agroforestry	Herb
Ruellia tuberosa L.	Acanthaceae	Medicinal	Leaves
Phyla nodiflora L,	Verbenaceae	Medicinal	Leaves
Alternanthera paronychioides	Amaranthaceae	Green manure	Tenter
Alternanthera sessilis (L)	Amaranthaceae	Vegetable	Tenter, root
Stachy tarpheta	Amaranthaceae	Agroforestry	Herb
Polygonum glabrum	Polygonaceae	*vegetabel*	*Leaf*
Euphorbia hypericifolia L	Euphorbiaceae	herbal Medicinal.	Herb
Commelina benghaensis	Commelinaceae	Vegitabel	Herb
Cyanotis somaliensis	Commelinaceae	Ornamental	Herb
Typha angustifolia L	Typhaceae	Mat making	Whole plant
Colocasia esculenta	Araceae	Edibel, Vegetable	Tuber
Erircaulon cinereum R. Brown	Eriocaulaceae	Medicinal	Whole plant
Cyperus squarrosus	Cyperaceae	Fodder	Whole plant
Cyperus entrerianus	Cyperaceae	Fodder	Full plant
Cyperus erangrosis	Cyperaceae	mat making	Full plant
Cyperus esculentus	Cyperaceae	Fodder	Herb
Kyllinga brevifolia Rottb	Cyperaceae	Medicinal	Herb
Kyllinga hyaline	Cyperaceae	Medicinal	Herb
kyllinga monocephala	Cyperaceae	Medicinal	Rhizomes
Lipocarpha microcephala	Cyperaceae	Medicinal	Herb
Schoenoplectus tabernaemontani	Cyperaceae	ornamental	Herb
Scirpus cernuus	Cyperaceae	ornamental	Herb
Arundo donax L.	Poaceae	Medicinal	Herb
Coix lacryma	Poaceae	Artificial use	Seeds
Dactyloctenium aegyptium L.,	Poaceae	Medicinal	Leaves, stem
Echinochloa colona L.,	Poaceae	Fodder	Herb
Phalaris arundinacea L	Poaceae	Artificial	Whole plant
Rorippa indica (L) Hiern	Brassicaceae	Animals food	Seed
Cleome chelidonii L	Capparaceae	Medicinal	Leaves
Elatine brachysperma	Elatinaceae	Ornamental plant.	Herb
Hibiescus vitefollies L	Malvaceae	Ornamental plants	Full plant
Triumfetta rhomboidea Jacq.	Malvaceae	Medicinal	Whole plant
Waltheria indica	Malvaceae	Animal food	Herb
Cardiospermum helicacabum L.,	Sapindaceae	Medicinal	Root
Clitoria ternatea L	Fabaceae	Fodder	Leaf, corolla, seed.
Mimosa pudica	Fabaceae	Medicinal	Root, leaves
Rhynchosia velutina	Fabaceae	Ornamental	Whole plant
Mukia scabrella	Cucarbitace	Medicinal	Shoot, leaves, seeds
Calyptocarpus vialis	Asteraceae	Ornamental	Herb
Eclipta prostrata L.	Asteraceae	Medicine.	Herb
Emilia fosbergii	Asteraceae	Medicine	Leaves
Shagneticola trilobata (L)	Asteraceae	*Ornamental*	Full plant
Sonchus asper (L.)Hill	Asteraceae	Medicine	Leaves
Xanthium Strumarium	Asteraceae	Edible, fodder	Shoot, leaves
Lobelia siphilitica L	Campanulaceae	Medicinal	Herb
Plumbago zeylanica L	Plumbaginaceae	Medicine	Seeds

Cont...

Table 7. Cont...

Species name	Family	Uses	Parts
Coldenia procumbens L.	Boraginaceae	Medicinal	Fresh leaves
Heliotropium curassavicum	Boragenaceae	Medicinal	Roots
Heliotropium europaeum	Boragenaceae	Mdeicinal.	Leaves
Hewittia malabarica	Convolvulaceae	Mdeicinal.	Leaves
Ipomoea alba L.,	Convolvulaceae	Medicinal	Leaves
Ipomoea cairica L.	Convolvulaceae	Medicinal	Full plant
Ipomoea carnea	Convolvulaceae	Medicinal	Leaf
Ipomoea muncikai	Convolvulaceae	Medicinal	Leaf, stem
Ipomoea sepiaria Koenig ex Roxb	Convolvulaceae	Medicinal	Full plant
Merremia aegyptia (L.)	Convolvulaceae	Medicinal	Leaf
Merremia emarginata	Convolvulaceae	Edible	Full plant
Merremia hederacea (Burm.f)	Convolvulaceae	Medicinal	Leaves
Acanthospermum hispidum	Acanthaceae	Medicine	Herb
Asystasia gangetica L	Acanthaceae	Medicine	Full plant
Dicliptera cuneata Nees	Acanthaceae	Fodder	Leaves
Ecbolium tanzaniense	Acanthaceae	Medicine	Herb
Justicia betonica (L)	Acanthaceae	Medicinal	Whole plant
Ruellia pathula	Acanthaceae	Medicinal	Herb
Leucas diffusa Benth.,	Lamiaceae	Medicinal	Herb
Leucas martinicensis	Lamiaceae	Medicinal	Leaves
Plectranthus neochilus	Lamiaceae	Medicinal	Leaf
Achyranthes bidentata	Amaranthaceae	Medicinal	Leaf
Celosia argentea L.	Amaranthaceae	Medicinal	Seeds
Pupalia lappaceae	Amaranthaceae	Agroforestry	Herb
Chrozophora rottleri A.Juss	Euphorbiaceae	Medicinal	Seed
Euphorbia hetrophylla L.,	Euphorbiaceae	Medicinal	Seed
Euphorbia hirta L	Euphorbiaceae	Medicinal	Plant
Euphorbia serpens Kunth	Euphorbiaceae	Medicinal	Herb
Phyllanthus niruri L.,	Euphorbiaceae	Medicinal	Leaf
Canna indica	Cannaceae	Edible	Root
Commelina diffusa	Commelinaceae	Fodder	Herb
Commelina clavata	Commelinaceae	Animal food	Herb
Cyanotis cristata	Comelinaceae	*Ornamental*	Full plant
Tradescantia fluminensis	Commelinaceae	Fodder	Climber
Cyperus longus	Cyperaceae	Fodder	Herb
Cyperus rotundus L.	Cyperaceae	Medicinal	Root
Cyperus triceps	Cyperaceae	Fodder	Herb
Kyllinga brevifolia Rottb.	Cyperaceae	Fodder	Herb
Pycreus polystachyos	Cyperaceae	Ornemental	Herb
Schoenoplectus juncoides	Cyperaceae	Fodder	Herb
Scirpus pallidus	Cyperaceae	Fodder	Herb
Apluda mutica	Poaceae	Fodder	Herb
Brachiaria ramota	Poaceae	Fodder	Herb
Cenchrus pennisetiformis Hochst	Poaceae	Fodder	Herb
Chloris pycnothrix Trin.	Poaceae	Fodder	Herb
Eragrostis amabillis L.,	Poaceae	Fodder	Herb
Eragrostis gangetica (Roxb.)	Poaceae	Fodder	Herb
Isachne bourneorum C.E.C.	Poaceae	Fodder	Herb
Sporobolus maderaspatanus	Poaceae	Fodder	Herb

survey(Kumar and Gupta 2009), Commonplace in pH 8 is other plants species ex. *Schoenoplectus tabernaemontani, Rorippa indica, Cyperus esculentus, Erircaulon cinereum, Alternanthera sessilis, Phyla nodiflora, Ludwigia grandiflora, Nymphaea pubesecens, Marsilia quadrifolia* ex. Some species in town border it is pollution area pH is 7 in this place presented the species were *Commelina benghaensis, Typha angustifolia, Cyperus erangrosis, Arundo donax, Dactyloctenium aegyptium* species present (Kiruba and Das 2010, Eyarin Jehamalar et al 2010) (Table 5 and 6).

Theories plants were utilized for different illnesses. (Malaya et al 2012). Most of the general population are utilized the plants for different uses are the restorative plants was most extreme uses 69 species, other than Vegetable 21 species, Fodder 28 species, Ornamental 17 species, Aquarium-creature sustenance 11 species, Green compost 5 species, Artificial 11 species, Mat making 4 species utilizing. This plant biosources are exhausting quickly imperiling the business of the poor wetland (Singh et al 2006, Prasad 2010, Rasingam 2010) (Table 7 and 8).

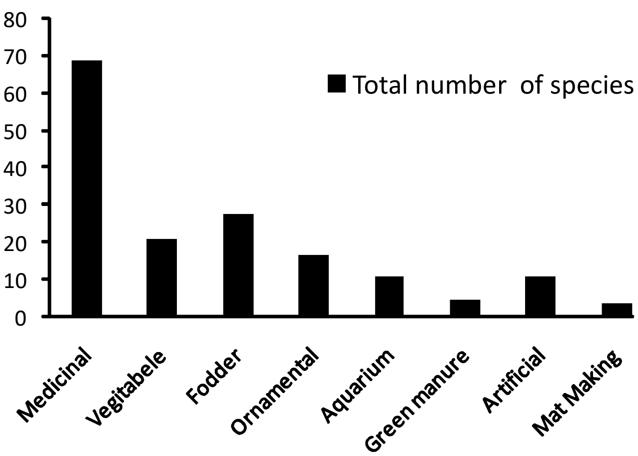

Fig. 4. Plant uses data

Table 8. Plant uses data

Uses	Total number of species
Medicinal	69
Vegetable/edible	21
Fodder	28
Ornamental	17
Aquarium-animal food	11
Green manure	5
Artificial	11
Mat making	4

CONCLUSION

The present review reports that there are such a variety of eatable plants accessible in the wetlands, Lake territory of Tirupattur taluk in Vellore area. This place having diverse scope of Ecological temprater, rain, water pH, soil, territory. This is the explanation behind developing distinctive plants in this place. The Convention on Wetlands of International Importance particularly as Waterfowl Habitat mirrors the first accentuation upon the protection and savvy utilization of wetlands principally as living space for water birds.

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Removal of Methyl Violet Dye from Industrial Waste Water Using Neem Leaf Powder

P. Balamurugan and G. Vinnilavu

Department of Civil Engineering, M.Kumarasamy College of Engineering, Karur- 639 113, India
E-mail: balamurugan.phd10@gmail.com

Abstract: The purpose of this study is to remove the dye from the paper mill industry waste water and to use neem leaf powder as an adsorbent. Bath adsorption parameters such as the effect of adsorbent dosage, contact time, agitation speed, pH, are studied. The maximum removal percentage by varying the pH of MV is 80.39%, The maximum amount of adsorption using neem leaf powder was found to be 0.12 g for MV. Maximum removal percentage of MV is 74.2%. Freundlich and Langmuir Isotherms were plotted and that concludes neem leaf powder is a good adsorbent for the removal of dye from the waste water.

***Keywords*:** Freundlich Isotherm, Langmuir Isotherm, Neem leaf powder, Removal of colour

Adsorption is the process through which a substance, originally present in one phase, is removed from that phase by accumulation at the interface between that phase and a separate (solid) phase. In principle adsorption can occur at any solid fluid interface (Balamurugan et al 2019, Vinnilavu et al 2019, Rubini et al 2019). Adsorption is one of the established unit operations used for the treatment of contaminated water i.e. raw water and/or wastewater. Activated carbon is the most used adsorbent and due to its high cost and considering the enormous quantity of effluent produced by textile industries, researches are turning toward the use of alternative adsorbents, also called non-conventional low-cost adsorbents (Ghanshyam et al 2013). The demand for water requirements for basic needs increases with increase in population and industrialization. The biggest consumers of water are textile, tannery, pulp and paper and electroplating industries and perhaps these are the most serious polluters of environment (Kumar et al 2016, Balamurugan et al 2018). These industries generate equally large volumes of coloured waste water, in which colour is contributed by colloidal or suspended material. Such coloured waste water is unfit for recycling without proper treatment (Chakradhar et al 2004). Thus, colour is removed to make the water suitable for general or industrial applications. The main objective of the study is to remove the methyl violet dye from industrial waste water by using natural coagulants, protect and enhance the good healthy environment

MATERIAL AND METHODS

Preparation of neem leaf powder: Mature Neem leaves, collected from a number of tall Neem trees (Tamil Nadu, India) were washed repeatedly with water to remove dust and soluble impurities and were allowed to dry first at room temperature in a shade till the leaves were dried. These were crushed into a fine powder in a mechanical grinder to obtain the neem leaf powder (NLP). The powder was dried in hot air oven. The NLP was sieved and the 53-74 micron (mesh no 270-200) fraction was separated. This fraction was washed further with double distilled water till the washings were free of colour and turbidity. After drying for several hours at room temperature, the NLP was preserved in glass bottles for use as an adsorbent (Krishna et al 2003). 100 ml of wastewater is taken in 250 ml conical flask of varying weights such as 0.02 to 0.14g of NLP is added and then it is kept in shaker for optimum time period. The graph is drawn between Per cent removal of dye VS Dosage of adsorbent.

Wastewater: The waste water used for these studies was collected from pulp and paper mill industry in India. Effluent from the paper mill was collected. The batch adsorption was conducted after the wastewater was decanted for 1 hour to remove the dirt. The colour of effluent in the paper machine is only due the presence of dye. The dye used by the industry was methyl Violet (MV). The pH of the effluent was varied only in pH study. The absorbance of solutions was measured at the wave length (590nm. The pH of waste water is ~6.8. The initial dye concentration of the dye in the effluent is 25 ppm. The physicochemical characteristics of the effluent were tabulated in Table 1.

Batch experiments: The batch adsorption was carried out in 250 ml borosil conical flasks by mixing a pre-weighed amount of the NLP with 100 ml of the waste water which was collected from the paper industry. The conical flasks were kept in an orbital shaker at room temperature and were agitated for a

Table 1. Characteristics of the paper mill wastewater

Parameter	Initial value
pH	6.8
Total hardness (mg l^{-1})	186
Calcium hardness (mg l^{-1})	112
Magnesium hardness (mg l^{-1})	74
Chlorides (mg l^{-1})	187
Sulphates (mg l^{-1})	153
Total dissolved solids (mg l^{-1})	1420
Total dissolved solids-inorganic (mg l^{-1})	1146
Total suspended solids (mg l^{-1})	1524
COD (mg l^{-1})	1872
BOD_5 (mg l^{-1})	1298
Conductivity (mg l^{-1})	1.72
Sodium (mg l^{-1})	456
Potassium (mg l^{-1})	48

Except pH and conductivity all parameters are represented in mg l^{-1} and conductivity represented in µS/m

predetermined time interval at a constant speed. Batch experiments are conducted for various parameters such as optimum dosage, contact time, agitation speed and pH. After adsorption was over, the mixtures were allowed to settle for 10 min, the supernatant liquid portions were centrifuged for 20 min and the dye remaining unadsorbed was determined spectrophotometrically. The percentage removal efficiency is determined. The amount of colour adsorbed by the adsorbent and the percentage removal of colour are calculated using the following equations:

$Q = (C_O - C_e)$ (1)

Removal Percentage of colour

$$= \frac{C_o - C_e}{C_o} \times 100 \quad (2)$$

The Langmuir and freundlich isotherm models are used to determine the adsorption of components from a liquid phase onto a solid phase .Through this isotherm model we find out the amount of adsorbate on the adsorbent is analyzed.

Langmuir isotherm: The simplest proposed model for characterizing adsorption is the Langmuir isotherm. The Langmuir isotherm assumes that each unit of surface area consists of n sites, which can adsorb one molecule, and all of the sites are energetically equivalent. Surface contains uniform energies of adsorption. Maximum adsorption corresponds to a saturated monolayer of solute molecules on the adsorbent surface. This model is an adequate approximation for uniform surfaces. In addition, the model does not account for the interaction of adsorbed species and multi-layer adsorbate growth. The Langmuir isotherm is developed by assuming that a fixed number of adsorption sites are available, and that the adsorption is reversible. The Langmuir isotherm may be used when the adsorbent surface is homogeneous. The Langmuir isotherm (Taha et al 2011) is expressed as Eq.

$$q_e = \frac{X}{M} = \frac{(q_{max} bC_e)}{1 + (bC_e)} \quad (3)$$

The above equation can be recast in a linear form as 4-5

$$\frac{1}{q_e} = \frac{1}{q_{max}} + \frac{1}{q_{max} bC_e} \quad (4)$$

$$q_e = \frac{V (C_o - C_e)}{M} \quad (5)$$

And the equilibrium parameter (R_L) can be calculated from the following equation,

$$R_L = \frac{1}{1 + (bC_0)} \quad (6)$$

Which represent the monolayer adsorption of the adsorbent

If, $R_L = 0$, adsorption is irreversible

$R_L = 1$, adsorption is linear

$0 < R_L < 1$, adsorption is favorable

$R_L > 1$, adsorption is unfavorable

Langmuir isotherms for MV on NLP are represented in Figure 6.

Freundlich Isotherm (Van Bemmelen Equation): The Freundlich isotherm is more accurate by considering an exponential distribution of enthalpies for low coverage of adsorbed species. The Freundlich isotherm is an improvement over the Langmuir isotherm by including physical adsorption of species. This equation is a special case for heterogeneous surface energies. The Freundlich equation is an empirical equation that is very useful as it accurately describes much adsorption data. The Freundlich isotherm (Taha et al 2011) is expressed as

$$q_e = \frac{X}{M} = K_F C_e^{1/n} \quad (7)$$

The above equation can be represented in a linear form as

$$\log q_e = \log K_F + \left(\frac{1}{n}\right) * \log C_e$$

Freundlich isotherms for MV on NLP are represented in Figure 7.

Various isotherm constants and correlation coefficients calculated are represented in Table 2.

RESULTS AND DISCUSSION

Effect of contact time: The 0.06 g of Neem leaf powder was

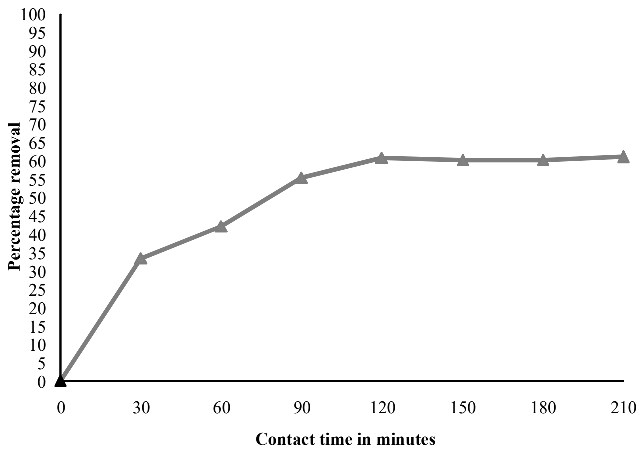

Fig. 1. Percentage removal vs contact time
NLP dose = 0.06 gm/100ml, agitation rate = 200 rpm

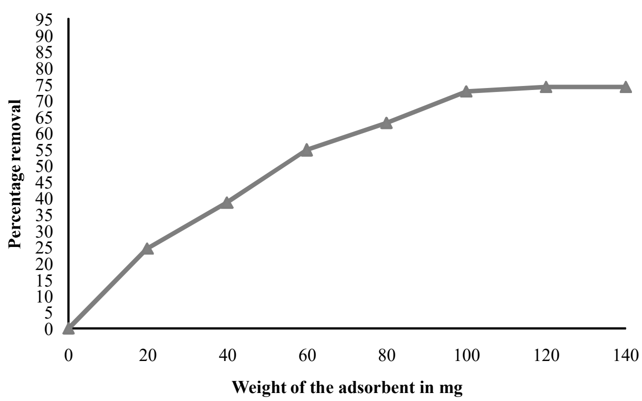

Fig. 2. Percentage removal vs weight of the adsorbent
Contact time for MV is 120 min, agitation rate = 200 rpm

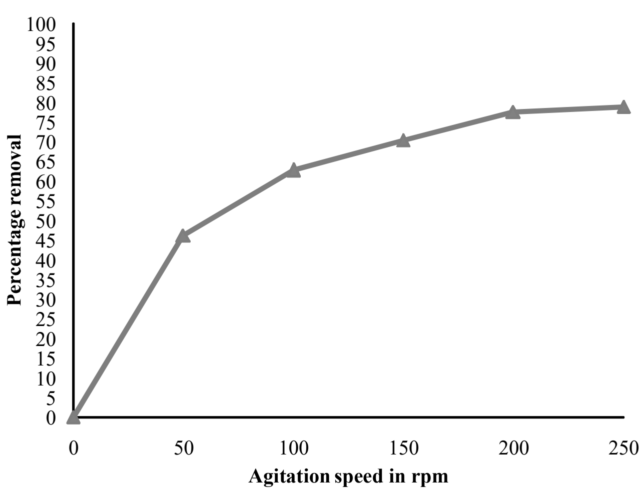

Fig. 3. Percentage removal vs agitation speed
Contact time is 120 min, NLP dose = 0.12 gm 100 ml^{-1}

used for this experiment at different contact time such as 30, 60, 90, 120, 150, 180 and 210 minutes. The equilibrium time required for the adsorption of MV is 120 min (Fig. 1). Maximum removal percentage of MV was 60.77%. At the initial stage, the rate of removal of dye was higher and later it becomes became slower.

Effect of adsorbent dosage*:* The maximum amount of adsorption using NLP was 0.12 g for MV (Fig. 2). Maximum removal percentage of MV is 74.2%

Effect of agitation speed: The equilibrium agitation rate required for the adsorption of MV is 250 rpm (Fig. 3). The maximum removal percentage of MV is 78.84%.

Effect of pH: The pH range of 2 to 12 was observed. The maximum amount of adsorption occurs at pH 2 for MV as shown (Fig. 4). The maximum removal percentage by varying the pH of MV is 80.39%

Isotherms: The maximum amount of adsorption using NLP was 0.12 g for MV (Fig. 5). Maximum removal percentage of MV is 78.84%.

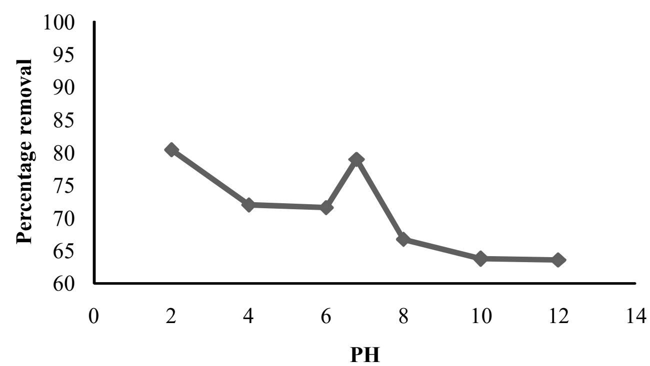

Fig. 4. Percentage removal vs pH
NLP dose = 0.12 gm 100 ml^{-1}, contact time = 120 min, agitation speed =250 rpm

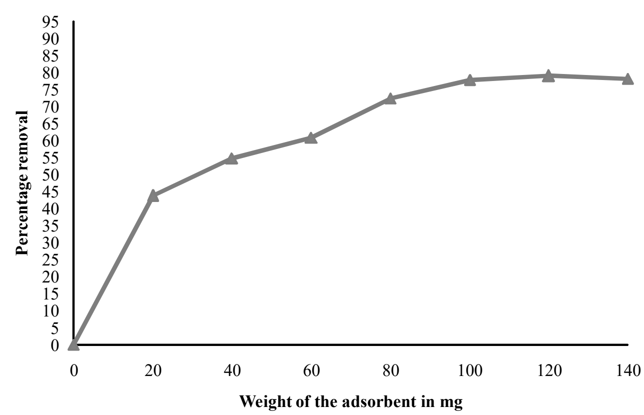

Fig. 5. Percentage removal vs weight of the adsorbent
NLP dose = 0.12 gm 100 ml^{-1}, contact time = 120 min, agitation speed =250 rpm

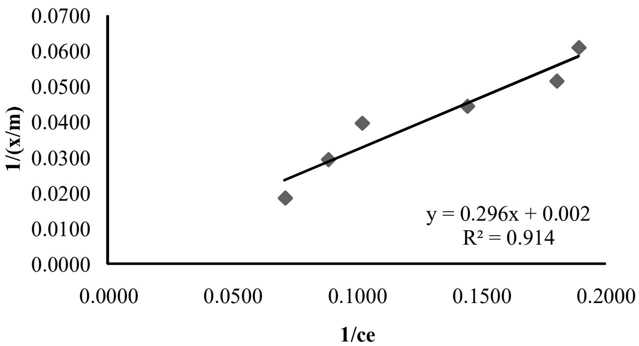

Fig. 6. Langmuir isotherm model for the MV waste water

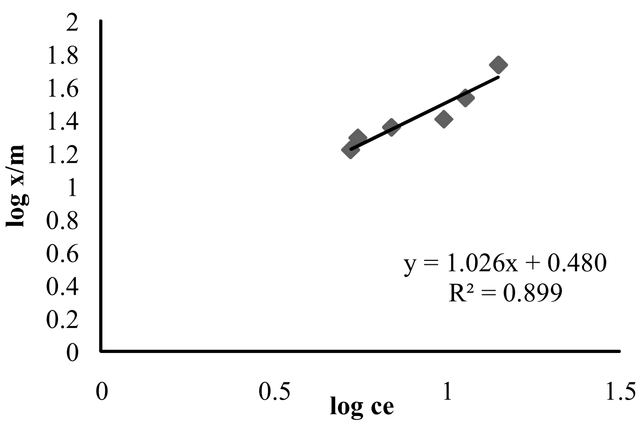

Fig. 7. Freundlich isotherm model for the MV waste water

Table 2. Various isotherm constants and correlation coefficients calculated for the adsorption of methyl violet on neem leaf powder

Isotherm	Parameter	Wastewater containing methyl violet dye
Langmuir	R^2	0.914
	q_{max} (mg g^{-1})	50.00
	b (l mg^{-1})	0.06
	R_L	0.85
Freundlich	R^2	0.89
	K_F (l mg^{-1})	2.08
	n	0.97

Freundlich isotherm*:* Freundlich Isotherm reveals that the increase in concentration of coagulant dosage increase the removal efficiency of methyl violet dye from the wastewater and it was represented with the equation (Fig. 7). The observation of results is verified by the R^2value (R^2= 0.899).

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CONCLUSION

Maximum Methyl Violet dye removal in the waste water is obtained at 250rpm. About 78.84% removal is obtained when 0.12 gram of neem leaf powder is used as adsorbent and with a contact time of 120 minutes. At pH 2 maximum dye removal of 80.39% is obtained. The Langmuir and Freundlich adsorption models are well suited for the experimental data and as conclusion the adsorbent selected for this study proved to be good adsorbent for the removal of dyes which present in the paper mill waste water.

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Dynamics of Nutrients in Temperate Coniferous Forests of North Western Himalaya with Special Reference to Available and Total Phosphorus

Muzamil Ahmad Sheikh, Avinash Tiwari and Jasra Anjum

School of Studies in Botany, Jiwaji University, Gwalior-474 011 India
E-mail: muzamiljabbar11@gmail.com

Abstract: Forest ecosystems are important pool of nutrients with good retention potential, mostly depend on vegetation type, soil depth, elevation as well as seasonal fluctuation and have direct relation with changing environmental conditions. Standard protocols were adopted for estimation of phosphorus and results revealed that available phosphorus and total phosphorus highest at Site 1 and lowest at Site 3. Autumn season showed highest value followed by summer and spring respectively. Annual variation for total phosphorus was found highest during summer season while for available phosphorus it was found highest during autumn season. Depth-wise value revealed that both total and available phosphorus were found maximum at upper surface of soil compared to sub-surface layers. Forest vegetation have strong influence on Physico-chemical properties of soil especially phosphorus due to varying climatic conditions and are considered rich source of nutrients required for proper growth and development of vegetation growing in the forest ecosystem.

***Keywords*:** Annual variation, Phosphorus, Seasons, Western Himalaya

Stoichiometry of nutrients in natural forests mostly depends on vegetation type, soil depth as well as seasonal fluctuation (Aponte et al 2010) with their variation in alpine ecosystems and storage having direct relation with global warming (Li et al 2012). Alpine ecosystems are considered important pool for nutrients due to varying climate and elevation with more susceptibility (Hagedorn et al 2010) and affects ecosystem functioning. Forest soils have strong influence on forest vegetation (trees, shrubs and herbs) and its growth rate. Annual contribution of forest floor to soil, in the form of needles, cones, branches and twigs, gradually decomposes and becomes a part of the soil nutrients (Sheikh et al 2017). Physico-chemical characteristics of forest soils vary with space and time because of variation in topography, climate, weathering processes, vegetation covers and microbial activities (Paudel and Sah 2003). Soil phosphorus (P) is the most common macronutrients which had influence on plant growth under natural conditions (Liu et al 2014). Available phosphorus mainly came from the cleavage of soil organic phosphorus and soil organic matter via biochemical mineralization and plays an important role in growth of plants, found in both organic and inorganic form and depends on various factors like pH, organic matter, texture for its fixation. Soil factors have great influence on concentration of phosphorus and showed variation on annual as well as seasonal basis with most of it inorganic form bonded to oxides of different metals in acidic environment of soil (Pierzynski et al 2005), which affects its availability for plant uptake (Arai and Sparks 2001, Mustafa et al 2008). Phosphorus limits plant growth under natural conditions with lowest in tropical and sub-tropical regions according to global inventories. According to geological point of view, Himalayas have multifaceted history having great impact on earth's dynamics with reference to weathering, seismicity, erosion which affects the soil environment. It consists of Northern, Western, Himalaya and North Eastern Himalaya (Nantiyal et al 2005). The region varies in climate, vegetation and between outer and inner Himalaya. The vegetation of the area is controlled by altitude, soil type topographic conditions etc. The western Himalaya consists of lesser Himalaya and greater Himalaya with snow covered regions above 4880 msl mostly remains below freezing point. Winter experiences heavy snowfall, while summer is mild and have warming atmosphere. Since Himalayas of Kashmir valley are subalpine in nature and showed change with respect to time for the soil properties. The current work was to assess the soil phosphorus level at different altitudes during different seasons and its annual change at different locations of western Himalaya with the hypothesis that phosphorus level showed increasing trend on annual basis.

MATERIAL AND METHODS

Study area and experimental technique: The study area is north western part of Indian Himalayas and southern part of Kashmir valley with varying climate. All the sites showed variation with season, altitude, anthropogenic disturbance etc. GPS mapping was done by taking coordinates from all the permanent quadrats with the help of GPS instrument model Garmin (GPSMAP 78s). Permanent quadrat of (20 m x 20 m) were laid down at different sites of the study area viz., Daksum, Pahalgam, Kokernag and Kuthar designated as Site 1, Site 2, Site 3 and Site 4 respectively. Soil samples were taken inside the quadrats from different depths viz. 0-10 cm, 10-20 cm and 20-30 cm during different seasons from 2014 to 2016 with the help of metallic soil corer and collected in polythene bags with proper marking for laboratory analysis. The nature of the soil was found acidic therefore Bray's method was adopted. The air dried soil samples were subjected to Bray's extract followed by shaking and filtration. The reading was taken at 660 nm by using (Systronic's spectrophotometer 169). The total phosphorus of the soil was estimated using the procedure of Behera (2014) in which tri acid mixture was used for digestion of the soil. The digestion was done on hot plate after addition of nitric acid followed by the tri acid mixture. Volume make up was done after filtration and reading was taken at 690 nm on (Systronic's spectrophotometer 169). Stannous chloride was used for colour development.

Statistical analysis: The statistical analysis was done using sigma stat 3.5 software. Descriptive analysis with normality test and equal variance test were also applied following Student-Newman-Keuls (SNK) range test. Prism Pad 5 was used for various graphical representations along with excel sheet.

RESULTS AND DISCUSSION

Available phosphorus (AP) and its variation: Available phosphorus during autumn season at the depth of 10 cm during 2014 was highest at Site 1and lowest at Site 4. Annual variation of available phosphorus at 10 cm of soil depth was highest at Site 2 and lowest at Site 4. At 20 cm of depth for 2014, Site 2 had highest AP and Site 4 lowest. Highest annual variation of available phosphorus at 20 cm of soil depth was at Site 1 followed by Site 2, Site 4 and Site 3. Highest value of AP at 30 cm was at Site 1 and lowest at Site 2 for 2014, while for 2015 highest at Site 1 and lowest at Site 4 respectively. At 30 cm depth maximum annual variation of AP was at Site 1 with 4.63 kg ha^{-1} and lowest at Site 4 with 0.21 kg ha^{-1}(Table 1, Fig. 1). During spring season decrease in AP was recorded at all sites and depths. At 10 cm of soil depth, Site 1 showed highest value and Site 4 lowest with annual variation highest Site 1, and lowest at Site 2. At 20 cm depth highest value of AP for 2015 was at Site 1 and lowest at Site 3. Site 4 had highest annual increment and Site 2 lowest. At soil depth of 30 cm for 2015, highest value of AP was found at Site 1 and lowest at Site 3 while for 2016 Site 2 showed highest and Site 3 lowest. Site 2 showed highest annual variation followed by Site 1. Site 3 and Site 4 had similar enhancement of 0.42 kg ha^{-1} each (Table 2, Fig. 2). Site 1 and 2 had an increment in annual variation with increasing soil depth.

During summer season at 10 cm of soil depth, highest value of AP was at Site 1 and lowest at Site 4 with annual variation highest at Site 3 (0.48 kg ha^{-1}) and lowest at Site 2 (0.21 kg ha^{-1}). At 20 cm of depth Site 1 again recorded highest and Site 3 lowest with annual variation highest at Site 41.26 kg ha^{-1} and lowest at Site 2 (0.41 kg ha^{-1}). At 30 cm of depth Site 1 in both the years had highest AP and Site 3 lowest with annual variation maximum at Site 1 (5.72 kg ha^{-1}) and minimum at Site 2(2.50 kg ha^{-1}) (Table 3, Fig. 3). Seasonally autumn season dominated both in depth wise as well as season wise among all the sites followed by summer and spring, respectively.

Total phosphorus (TP) variation and seasons: Total phosphorus was estimated for autumn season at all sites and depths and results revealed that phosphorus showed decreasing trend with increase in depth at all the sites. At 10 cm depth, both for 2014 and 2015, Site 1 showed highest value of total phosphorus followed by Site 2, Site 3 and Site 4, respectively with highest variation at Site 1 (108.3 kg ha^{-1}) and lowest at Site 4. At 20 cm depth similar trend of decrement from Site 1 to Site 4 was observed in both the years. Site 4 showed highest variation 57.45 kg $ha^{-1}$and Site 3 lowest 16.32 kg ha^{-1}. At 30 cm depth the highest total phosphorus was again at Site 1 and lowest at Site 4. Site 3 showed highest variation and Site 2 lowest (Table 4, Fig. 4). During spring season annual variation both site wise and depth wise was estimated and the results showed at 10 cm of depth total phosphorus was found highest at Site 1 and lowest at Site 4. Annual variation was found highest at Site 1(104 kg ha^{-1}) and lowest at Site 3 (38.3 kg ha^{-1}). At 20 cm of depth again Site 1 had highest value and Site 4 lowest. Maximum variation was found at Site 1 (90 kg ha^{-1}) and lowest at Site 3 (28.72 kg ha^{-1}). Similar results were observed at 30 cm of soil depth with annual variation highest at Site 1 (72 kg ha^{-1}) followed by Site 3, 4 and 2 (Table 5, Fig. 5).

During summer season all the sites showed decreasing trend of total phosphorus with depth i.e., from 10 cm to 30 cm. At 10 cm depth Site 1 was found with highest value in both the years and Site 4 lowest with similar observation on annual variation. At 20 cm of depth highest value of total phosphorus was found at Site 1 and lowest was recorded at Site 4. Annual variation was observed highest at Site 1and lowest at Site 3. At 30 cm depth highest similar results with Site 1 highest and Site 4 lowest. Annual variation at 30 cm of depth revealed highest at Site 3 and lowest at Site 4. The autumn season showed high content of total phosphorus and spring season lowest (Table 6, Fig. 6).The highest variation was at Site 1 and 2 which may be due to various environmental as well as anthropogenic factors. Site 1 had highest value for available and total phosphorus due to various reasons like altitudinal variation, chemical characteristics of soil and climatic condition. The results for available and total phosphorus were higher at elevated regions which were supported by Jehangir et al (2012) for higher value at higher altitude. Edaphic factors affect the phosphorus variation and the SOC is positively correlated with phosphorus variation may be due to various microbes responsible for production of various enzymes which helps in mineralization of soil phosphorus. Same conclusion was drawn by Huo et al (2014), while studying the relation between SOC and phosphorus in sub-tropical forests they concluded that SOC might provide the availability of phosphorus in the forest soil. Since Site 1 and Site 2 has good inputs of litter which increases the nutrient content of the soil by decomposition process than Site 3 and 4 which had more anthropogenic disturbance and affected the litter concentration also. Results of litter decomposition and nutrient release are in harmony with earlier workers (Sheikh et al 2017, Sheikh and Kumar 2010, Zhou et al 2007) and observed suggested that litter fall is related to nutrient cycling and forest growth due to interaction of various environmental factors. The protected sites have highest standing litter (Rawat et al 2009) similar observations were in Site 1 and Site 2 as both the sites are protected in nature as compared to Site 3 and 4. Seasonal variation of available phosphorus and total phosphorus during different seasons was observed by earlier workers (Sheikh et al 2013, Bhat et al 2014) and observed that seasons had great impact on availability of phosphorus. Highest phosphorus content was found during autumn season the reason may be due to decomposition of various litter components and other related factors viz. moisture, temperature etc. Since decomposition process is slow in coniferous forests as it starts from spring and partially completed to autumn. Lowest value during spring season may be due to peak growth period and wet condition (Bhuyan et al 2013). Autumn season has maximum availability of almost all the nutrients with phosphorus among them and different workers supported the current findings of having phosphorus highest during autumn season (Semwal

Table 1. Available phosphorus (kg ha^{-1}) during autumn season

Depth	Site 1		Site 2		Site 3		Site 4	
	2014	2015	2014	2015	2014	2015	2014	2015
10 cm	24.87± 0.55	25.50± 1.63	24.25± 1.46	25.50± 10.55	22.99± 0.90	23.62± 1.10	20.70± 1.08	20.48± 1.27
20 cm	18.81± 1.2	20.96± 0.91	19.65± 0.62	20.27± 1.16	17.17± 1.30	17.56± 1.08	16.93± 1.20	17.35± 1.10
30 cm	15.02± 0.9	19.65± 0.91	14.01± 0.90	18.60± 1.10	15.02± 1.10	15.26± 0.75	14.42± 1.30	14.63± 1.25
CD (p=0.05)	2.50	2.31	1.72	1.64	2.75	2.48	2.75	3.44

The results showed significant difference at P<0.05 after passing normality and equal variance test using SNK test for ANOVA

Table 2. Available phosphorus (kg ha^{-1}) during spring season

Depth	Site 1		Site 2		Site 3		Site 4	
	2015	2016	2015	2016	2015	2016	2015	2016
10 cm	21.95± 1.65	22.37± 1.7	21.74± 0.91	21.95± 1.7	18.39± 0.91	18.81± 1.3	17.14± 0.75	17.56± 0.95
20 cm	16.72± 0.55	17.14± 0.75	16.3± 2.06	16.51± 2.21	12.96± 1.37	13.17± 1.57	15.47± 1.63	16.09± 1.99
30 cm	12.96± 0.95	15.26± 0.91	12.54± 0.55	15.68± 0.95	11.7± 0.55	12.12± 0.91	12.54± 0.36	12.96± 0.55
CD (p=0.05)	2.36	1.84	1.18	1.56	2.34	3.23	2.99	2.95

The results showed significant difference at P<0.05 after passing normality and equal variance test using SNK test for ANOVA

Table 3. Available phosphorus (kg ha^{-1}) during summer season

Depth	Site 1		Site 2		Site 3		Site 4	
	2015	2016	2015	2016	2015	2016	2015	2016
10 cm	23.83± 1.3	24.25± 1.7	23.83± 0.95	24.04± 1.7	20.48± 0.75	20.96± 0.91	18.82± 0.95	19.23± 1.16
20 cm	18.18± 1.82	18.60± 1.65	17.77± 0.55	18.18± 0.62	14.21± 1.37	14.63± 1.78	16.30± 1.3	17.56± 1.08
30 cm	14.21± 0.62	19.93± 0.75	14.01± 0.91	16.51± 0.91	12.96± 0.55	13.58± 0.91	14.21± 0.55	14.84± 0.75
CD (p=0.05)	3.23	3.36	1.61	1.86	4.52	3.24	3.01	3.51

The results showed significant difference at P<0.05 after passing normality and equal variance test using SNK test for ANOVA et al 2009). They were of the suggestion that heavy grazing and removal of litter may be possible reasons of having low phosphorus content in forest observed at Site 3 and 4 where local people remove all the litter present for their household purposes and all the herbaceous material were grazed out by the animals rearing in the forests by the adjacent villagers. Rawat et al (2009) reported that highest litter fall and highest nutrients like phosphorus in October while analysing nutrient release in Himalayas, October is considered as autumn season and similar observation was recorded at all the sites with highest value during the same season. Liu et al (2014) observed positive relation between available phosphorus and total phosphorus. Similar positive relation between AP and TP were found in current study. Decreasing value of

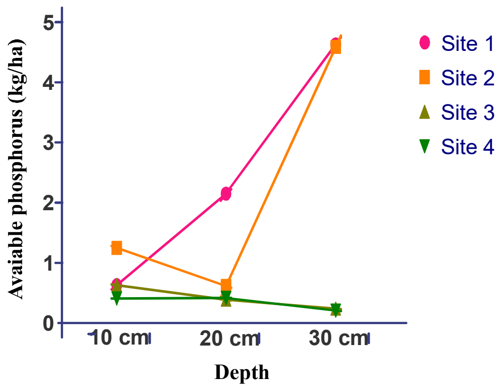

Fig. 1. Annual variation of available phosphorus during autumn season

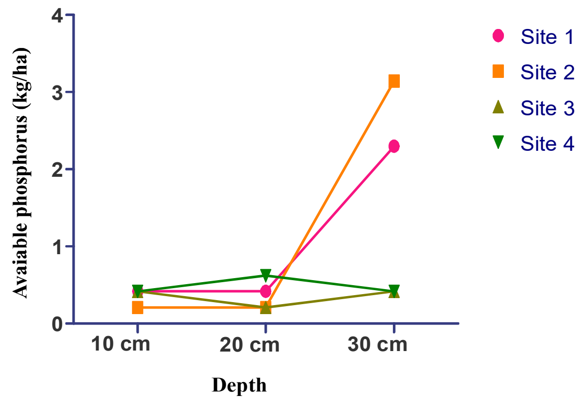

Fig. 2. Annual variation of available phosphorus during spring season

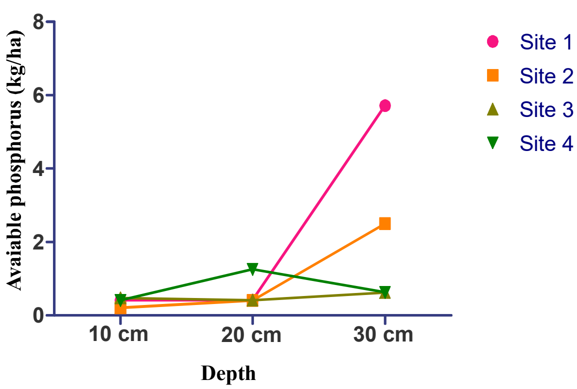

Fig. 3. Annual variation of available phosphorus during summer season

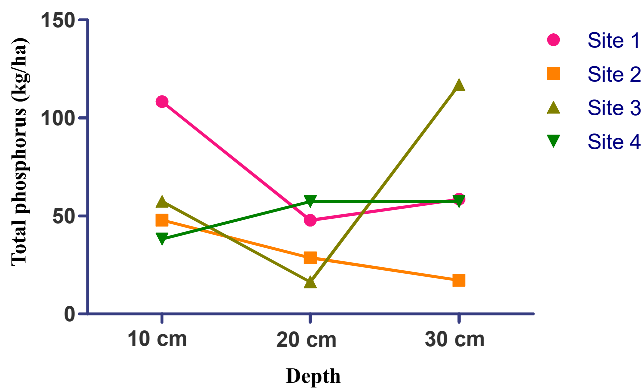

Fig. 4. Annual variation of total phosphorus during autumn season

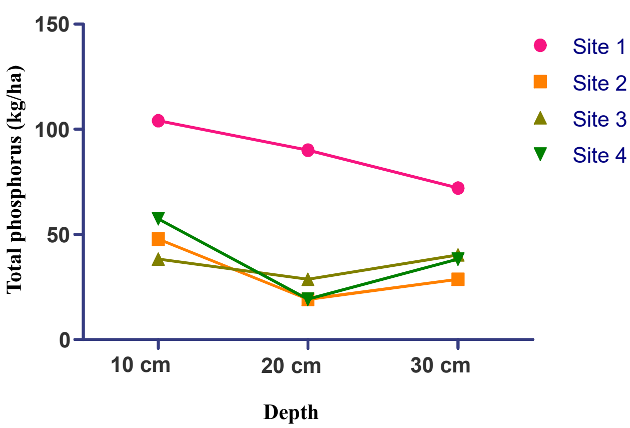

Fig. 5. Annual variation of total phosphorus during spring season

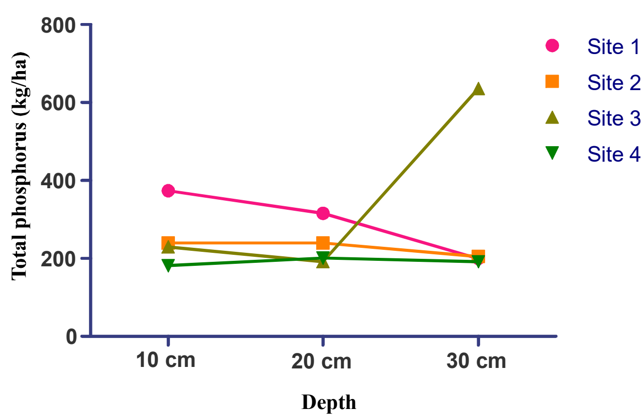

Fig. 6. Annual variation of total phosphorus during summer season

Table 4. Total phosphorus (kg ha^{-1}) during autumn season

Depth	Site 1		Site 2		Site 3		Site 4	
	2014	2015	2014	2015	2014	2015	2014	2015
10 cm	2292.0± 54.6	2400.3± 20.8	1943.77± 50.6	1991.65± 81.8	1733.12± 25.3	1790.57± 81.8	1608.64± 72.3	1646.94± 99.7
20 cm	1991.6± 67.0	2039.5± 92.3	1579.91± 89.9	1608.64± 92.3	1484.16± 62.7	1500.48± 78.9	1216.05± 19.1	1273.50± 25.3
30 cm	1612.1± 59.0	1670.7± 83.0	1313.72± 50.3	1330.96± 47.8	1386.37± 21.1	1503.31± 95.7	1005.40± 66.3	1062.85± 87.7
CD (p=0.05)	79.93	131.60	267.34	152.95	53.01	264.78	337.66	211.78

The results showed significant difference at P<0.05 after passing normality and equal variance test using SNK test for ANOVA

Table 5. Total phosphorus (kg ha^{-1}) during spring season

Depth	Site 1		Site 2		Site 3		Site 4	
	2015	2016	2015	2016	2015	2016	2015	2016
10 cm	1950.00±91.3	2054.00±76.1	1790.57± 50.6	1838.44 ± 59.8	1522.46± 33.2	1560.76 ± 19.1	1436.28± 73.8	1493.73± 76.0
20 cm	1760.00±33.1	1850.00±87.7	1426.71± 83.4	1445.86 ± 85.1	1283.08± 78.3	1311.8± 83.4	1091.57± 72.2	1110.72± 62.7
30 cm	1490.00±87.7	1562.00±66.3	1193.07± 49.9	1221.8± 78.5	1261.89± 41.8	1302.23± 97.1	871.34± 25.3	909.64± 38.3
CD (p=0.05)	161.49	202.02	70.49	53.76	188.73	187.10	137.28	158.55

The results showed significant difference at P<0.05 after passing normality and equal variance test using SNK test for ANOVA

Table 6. Total phosphorus (kg ha^{-1}) during summer season

Depth	Site 1		Site 2		Site 3		Site 4	
	2015	2016	2015	2016	2015	2016	2015	2016
10 cm	2020.40±91.3	2393.80 ± 62.7	1790.57± 50.6	2029.93± 62.7	1656.51± 85.1	1886.32± 50.6	1522.46± 33.1	1704.39± 58.2
20 cm	1809.70±33.1	2125.70 ± 43.8	1426.71± 83.4	1666.09 ± 76	1417.14± 58.2	1608.64± 49.7	1283.08± 78.3	1484.16± 85.1
30 cm	1522.50±87.7	1721.90 ± 59.4	1193.07± 49.9	1397.99 ± 41.7	1072.42± 78.3	1708.30± 82.2	1110.72± 41.3	1302.23± 97.2
CD (p=0.05)	193.07	133.75	73.73	62.37	187.40	159.81	59.79	244.42

The results showed significant difference at P<0.05 after passing normality and equal variance test using SNK test for ANOVA

available phosphorus with depth in natural forests was also reported by Karam et al (2013).

CONCLUSION

The Kashmir Himalayas are rich in nutrients especially phosphorus with autumn season dominating both in depth wise as well as season wise among all the sites followed by summer and spring respectively. Site 1 dominated with highest value of total and available phosphorus during 2014-2016 followed by site 2, site 3 and site 4 respectively. Annual variation for total phosphorus was found highest during summer season while for available phosphorus it was found during autumn season. Depth wise value revealed that both TP and AP were found maximum at upper surface of soil i.e., 0-10 cm of depth. The macronutrient was also observed varying with altitudes and within different sites of the study area with great retention power of nutrients which can combat with global warming by having available to the standing vegetation.

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Seed Bank and Regeneration Studies of *Canarium strictum* Roxb. - A threatened species of Western Ghats

C.N. Prasannakumar, R.K. Somashekar, B.C. Nagaraja and D. Shivaprasad

Department of Environmental Science, Jnanabharathi Campus,
Bangalore University Bangalore-560 056, India
E-mail: nagenvi@gmail.com

Abstract: Studies on the seed production, modes of their dispersal and regeneration patterns of threatened tree species are crucial for the management of their genetic diversity. Seed bank estimation of a threatened species *Canarium strictum* was conducted from three different locations of Western Ghats of Karnataka using two factorial completely randomized design. The seeds are mainly dispersed by means of ornithochory and mammalochory. The Indian grey hornbill (*Ocyceros birostris*) and pied hornbills (*Anthracoceros albirostris*) are the major seed dispersers. The seed densities among the forest ranges are significant but, it is insignificant among the distances. The mean *in-situ* regeneration studies revealed an insignificant relationship among the forest ranges and distances. The *ex-situ* regeneration are also insignificant among the forest ranges and distances. The high mean percentage of *ex-situ* regeneration suggests as a best suitable method to conserve this threatened species.

Keywords: *Canarium strictum*, Seed bank, *In-situ* regeneration, *Ex-situ* regeneration, Conservation

Seed dispersal with clumped seed deposition pattern is common in case of vertebrate-dispersed seeds, and has the potential to significantly affect interactions with density responsive enemies (Beckman et al 2012). Seed dispersal at large scales strongly influences plant population dynamics (Carlo et al 2013). The long-distance dispersal of seeds by wind is affected by functional traits of the species, specifically seed terminal velocity and height of seed release above the vegetation cover (Heydelet al 2014) and is influenced by a variety of seed properties and functional responses of dispersers. However, seed dispersal distance patterns are poorly understood (Liuet al2013). In general long distance seed dispersal is considered as a crucial determinant of tree distributions, but its effects depend on demographic processes that enable seeds to establish into adults and it remain poorly understood at large spatial scales (Caughlin et al 2014). *Canarium strictum* Roxb., is a large canopy tree distributed across parts of India, Myanmar and Yunnan province of China and is mainly utilized as source of resins. It can grow up to about 40 m height and is found in the moist deciduous to evergreen forests at altitudes ranging from about 750 m to 1400 m MSL (Ravikumar and Ved 2000). Earlier studies by several workers showed tapping practices as the major threat to *C. strictum* population and have conveying concerns about decreasing of their population (Augustine and Krishnan 2006) andnaturally occurs at low densities and is sparsely distributed (Mathachen et al 2005, Tambat et al 2005), with individuals growing together forming small clumps like patches (Varghese and Ticktin 2008). The current study was carried at the selected sites of Western Ghats region to assess the pattern of seed dispersal, seed bank densities and regeneration patterns of this threatened species.

MATERIAL AND METHODS

The seed bank density at different distance of seed dispersal was studied by selecting five trees with diameter at breast height (DBH) above 10 cm trees each from three different locations using two factorial completely randomized design to assess the distance of seed dispersal and the *in-situ* and *ex-situ* regeneration patterns. The locations selected for the study include Agumbe (13° 30' 33.48'' N and 75° 5' 47.3892'' E), Sringeri (13° 25' 36.84'' N and 75° 15' 18.3456'' E), and Koppa (13° 32' 15.72'' N and 75° 21' 15.1272'' E) forest ranges.

The plots were established around each mother tree along the four directions. Seed dispersal and regeneration plots with a dimension (1 m x 1 m) were established at a distance of approximately 5, 10, 15, 20 and 25 meters from the approximate edge of tree canopy followed by enumerating the number of seeds and regenerated seedlings. The average seed density from each fixed distance was calculated. The mean percent of natural regeneration from the random plots were calculated for each distance from the base of the mother tree as their weighed average using the below formula,

$$\text{Mean percentage (\%) of germination} = \frac{\text{Average number of seeds germinated}}{\text{Average seed count of all the plots}} \times 100$$

Regeneration studies was conducted by selecting the five individual mother trees from each location, then random quadrates of 1 m x 1 m, were laid in such a way that each plot is at least 5 m apart from each other at a distance of approximately 5, 10, 15, 20 and 25 meters from the approximate edge of tree canopy. The number of fruits per each quadrat was counted each day during the fruit ripening and dispersal period. The observations were continued until regeneration. The regeneration success and seedling survivability were monitored by counting the number of seedlings (Kuuluvainen and Kalmari 2003).

RESULTS AND DISCUSSION

The highest mean seed density per square meter was 17.78, 10.20, 15.95 at a distance of 10, 5 and 25 m and the lowest is 4.66, 4.75, and 7.79 at a distance of 25 m each in Agumbe and Sringeri, and 20m at Koppa, respectively (Fig. 1). The seed densities among forest ranges was significant different. However, there was no significant relation between the seed densities among the distances. The interaction effect of forest ranges and distances on seed density was significant.

The two factor analysis of seed dispersal revealed significant effect of locations at different distances implying that the dispersal distance and seed density are not independent and not uniform across the locations. The interaction effect is also significant suggesting the involvement of biotic and environmental factors that influence variations in the distance of seed dispersal and the seed density such as canopy width, dispersers, slopesetc. *In-situ* regeneration experiments showed a less mean percentage of seed regeneration across all the sites as influenced by microclimate. The removal of litter under the tree by the neighborhood people culminate in failure of humus bed formation underneath the tree. As a result, the seeds are exposed to air and light and fail to properly absorb water during monsoon, with a resultant failure in germination. However, wherever humus is available, the seeds produced a good number of saplings. Although trees produce abundant seeds, the overall regeneration and establishment into matured trees are less than one percent of the total seed output. The locations and the distances showed an insignificant relationship, suggesting that the mean effect of each factor was identical. But the interaction effect of each factor is significant confirming that the *in-situ* regeneration depends on local microclimate conditions.

The *in-situ* regeneration studies yielded high mean percent regeneration of 17.78, 10.20 and 15.95% at a distance of 10, 5 and 25m and the lowest mean regeneration was 3.20, 2.07 and15.95% at a distance of 10, 5 and 25 m in Agumbe, Sringeri and Koppa respectively (Fig. 2). The results revealed an insignificant association between with the mean *in-situ* regeneration among the forest ranges was not significant. Similarly, non-significant relationship was observed with the *in-situ* regeneration among the different distances. The interaction effect of forest ranges and the distances on *in-situ* regeneration was not significant.

Some of the previous studies revealed the importance of the study of pattern of seed germination and regenerations in rain forests of Western Ghats region (Prasannakumaret al 2017). The seeds of *Canarim strictum* are nuts with a fleshy epicarp and stony endocarp, the seed coat is eaten by mammals such as spotted deer (*Axis axis*), Porcupine (*Hystricomorph* sp.), Barking deer (*Muntiacini sp.*), rodents and sambar (*Rusa unicolour*). The Indian grey hornbill (*Ocyceros birostris*) and pied hornbills (*Anthracoceros albirostris*) are the major seed dispersers of *Canarium*, they swallow the entire fruit, the fleshy portion is digested while the hard seed (nut) is discharged. The bird passed seeds readily regenerate and the rate of germination is high. Seed viability and delay monsoon also affects the seed regeneration in natural forests (Hegde et al 2018). The seeds are orthodox in nature, viable for a long period and germinate even up to three years of sowing in *ex-situ* experiments. The seeds are

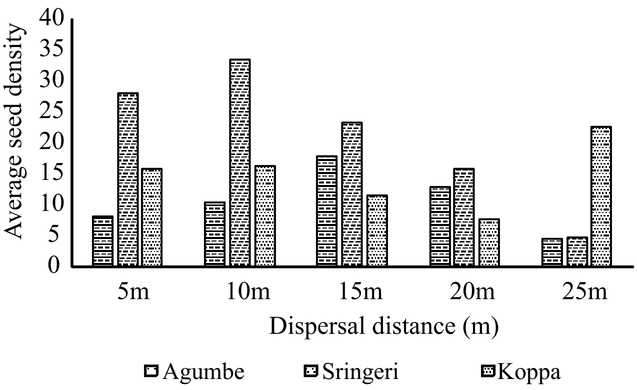

Fig.1. Seed bank estimation studies of *C. strictum*

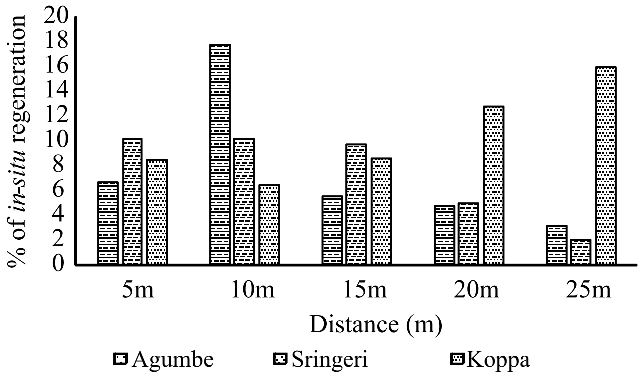

Fig. 2. *In-situ* regeneration studies on *C. strictum*

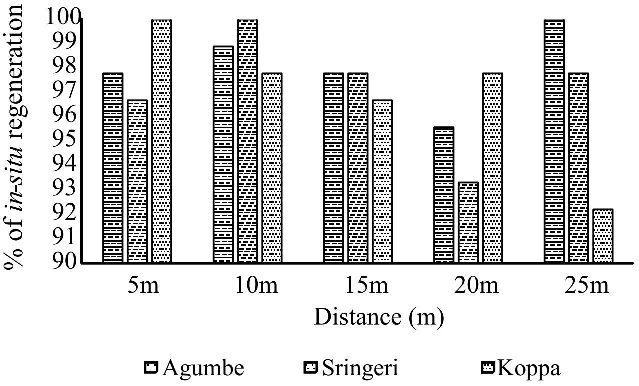

Fig. 3. *Ex-situ* regeneration studies on *C. strictum*

dispersed up to 30 m by anemochory from the base of the tree and it also dependent on the canopy width. The natural regeneration assessment from the various location revealed a poor seed germination when compared to the number of seeds produced and dispersed from each tree.

The *ex-situ* studies resulted in a high mean percent of regeneration of about 99.9%. The lowest mean percent of regeneration is observed to be 95.56, 93.33 and 92.22% from Agumbe, Sringeri and Koppa, respectively (Fig. 3). The results revealed an insignificant relation with the mean *ex-situ* regeneration among the forest ranges ($F_{0.26}$, p=0.78). Contradictory, an insignificant relationship was observed among the seeds, collected from different distances (F=0.47, p=1.8). The interaction effect of forest ranges and distances on the *ex-situ* regeneration was also insignificant ($F_{1.58}$, p=0.28).

The *ex-situ* regeneration showed higher regeneration at all the three locations, which implies the importance of appropriate method for effective conservation, as the natural regeneration and survival is less than 30% and 5%, respectively, against the *ex-situ* regeneration of more than 95% in each case. This strongly suggests the problems associated with the microclimate conditions and the direct impact of human interference. An insignificant relationship of the seed densities among the locations and the distances suggested the similarity in the mean seed densities, with respect to the two factors. A significant interaction effect suggests the seeds are highly viable and their viability and regeneration is independent of the locations or the distances. The seeds collected from all the three locations exhibited a high mean per cent germination confirming good seed quality. Thus, *ex-situ* conservation appears to be the most suitable methods for restoring the population of this threatened species.

CONCLUSION

The seed densities among the forest ranges is significant implies the differences with respect to canopy width, dispersers and geographical variations such as slopes. The *in-situ* regeneration is lowest among all the study sites but, contradictorily shows highest *ex-situ* regeneration of the seeds collected from all the sites indicate the constrains with the natural regeneration of seeds. Hence, this study concludes *ex-situ* method is best suitable to conserve this important, threatened tree species.

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Effect of Environmental Factors on Phenology of Wild Species of Anacardiaceae in Garhwal Himalaya

Dinesh Singh, A.K. Negi and J.C. Purohit[1]

Department of Forestry and Natural Resources; [1]Department of Statistics
Hemvati Nandan Bahuguna Garhwal University, Srinagar Garhwal, Pauri-246 174, India
E-mail: bittubisht008@yahoo.com

Abstract: The aim of present study was to describe the phenology of five trees (*Buchnania lanzan* Spreng., *Pistacia khinjuk* Stocks, *Semecarpus anacardium* L.f., *Lannea coromandelica* (Houtt.) Merr, *Spondias pinnata* (L.f. Kurz) and two shrub (*Rhus parvifora* Roxb., *Continus coggygria* Scop) species of Anacardiaceae family in sub-montane forest of Lansdowne Forest Division in Uttarakhand. The phenological events of these species were recorded in order to determine the relationship between environmental factors (temperature and precipitation) and phonological events. The main branches and sub-branches of individuals of each species were randomly selected and marked with metal tags to represent the whole canopy from January, 2017 to December, 2018. The data was analyzed with the help of circular statistics and Spearman's rank correlation. The result showed that leaf bud initiation start from February and peaks in May. Young leaves start expanded in April and peaks in July, whereas leaf senescence starts in August. Leaf fall starts from September and peaks in November. Flower/flowering bud starts from February to March and turns into flower in April. Ripening of fruits starts from April and peaks in May while fruit fall occurs in May and peaks in June. It is concluded that environmental factors play important role in timing and recurring of phenophase events in all the species. However, seasonality in vegetative and reproductive phase shows that each phenophase event indicates the circular pattern at different time scale.

Keywords: Shivalik range, Sub-montane forest, Western Himalaya, Phenophase, Circular statistics

Flowering in dry tropical forest trees may be depending partly or wholly on leaf or deciduous states (Singh and Kushwaha 2006). The timing of tree vegetative phenology determines the flowering periods, and thus flowering depends indirectly on environmental factor (Rivera et al 2002). Temperature and precipitation are the most important drivers for spring flowering but in rainy season it becomes more pronounced with increasing altitude in Himalaya (Rawat 2012). Air temperature has been recognized on the basis of environmental feature which govern the spring phenology (Menzel et al 2006). Nevertheless, tree species with similar leaf phenology often differ in the timing of their flowering and fruiting. A variety of environmental factors such as winter/summer, decreasing or increasing photoperiod or drought affects the phenophase events i.e., leafing, flowering and fruiting in tropical trees (Nanda et al 2014). Climate change has led to vary in phenological behaviour of many species distributed over taxonomic groups (Singh and Kushwaha 2006). Many studies have proven ample indications which confirm that over the past decades, the phenophase status of many species have been changed and that these confirmations are related to climate change (Kimkim and Yadava 2001).The tree and shrubs species of Anacardiaceae are deciduous to semi-deciduous in nature, associated with *Shorea robusta* and *Pinus roxburghii* distributed in Shivalik range of Garhwal Himalaya in Uttarakhand. Secondary literature and published articles did not give sufficient information about phenology of these species. Therefore, a comprehensive study is needed to analyze the effects of temperature and precipitation on phenophase event of these species in Garhwal Himalaya.

MATERIAL AND METHODS

Present study was conducted in sub-montane (sal dominated forest) forest of Dugadda in Lansdowne Forest Division located between 29.80° N and 78.62° E at 932 meter above sea level. The geological formations of rocks in sub-montane zone contain Tal, Krol, Siwalik, Dugadda and Subathu formation. The various types of soils are formed due to weathering of these rocks in the area. However, the climatic conditions experience exhausting summers and harsh winters in sub-montane zone. Heavy precipitation occurs during July to September. Cold dry spell occurs between mid-November to January whereas hot weather remains from April to June afterwards.

The phenological events of selected individuals for all seven species were observed at monthly interval from January, 2017 to December, 2018 in their natural conditions where they were distributed abundantly in relation to environmental factors (precipitation and temperature). Phenophase observations were categorized into vegetative and reproductive phase (Denny et al 2014). For phenological investigation, documentation of phenophase events of 4 individuals of each species were randomly marked (Table 1). The main and sub-branches of each individual were marked with metal tag for observation to represent the whole plant canopy for phenophase events (Kushwaha et al 2011).

Data analysis: Each phenophase stages of different species were scored qualitatively according to intensity on a 0 to 100% scale to assess the performance at different stages within each phenophase. Spearman's rank correlation was used to analyze the effect of environmental factors on phenophase status for current and previous year (Zar 2007). The seasonality of the species was tested with the help of circular statistics by using the software Oriana 4.02 (Kovach 2013). For this analysis, circular diagram were constructed with frequency distribution of species into two phases viz; vegetative (leaf bud initiation, young/mature leaves, coloured leaves or leaf senescence and falling leaves or leaf abscission) and reproductive phase (flower or flower bud initiation, open flower, ripen fruit/seed, recent fruit or seed fall) at monthly interval, when January was considered 0° and each observation period of 30 days corresponded to 30° (Nanda et al 2014). The mean angle 'a' is the time of year around in which the phenophase events occurred for most species. For mean angle, the Rayleigh's Z test was used to determine the level of significance at different phenophase. The hypothesis of the study was: H_o = dates are distributed uniformly (or randomly) around the year for phenophase events of species; there is circular uniformity or no mean direction, and consequently, no seasonality; and H_A = dates are not distributed uniformly or randomly throughout the year having significant mean angle or mean direction and consequently, there is some seasonality. If H_A is accepted, the intensity of concentration around mean angle viz; mean vector denoted by 'r' can measure the length of mean date or month or year for particular event. The mean vector 'r' has no units and varies from 0 (when phenophase event is distributed uniformly throughout the year) to 1 (when phenophase event is occurred around one single date or time of year). If the H_0 is accepted, then 'r' will be considered as 0 (Morellato et al 2000, Zar 2007, Nanda et al 2014).

Table 1. Tree and shrub species for phenophase observation at Sub-montane forest of Dugadda, Lansdowne Forest Division

Species	Form	Altitudinal range (msl)
Buchanania lanzan Spreng.	Tree	800-1200
Pistacia khinjuk Stocks	Tree	350-2500
Semecarpus anacardium Linn	Tree	1000-1600
Lannea coromandelica (Houtt.) Merr	Tree	400-1500
Spondias pinnata (L.f.) Kurz	Tree	900- 1500
Rhus parvifora Roxb.	Shrub	900-2000
Continus coggygria Scop	Shrub	800-2400

RESULTS AND DISCUSSION

Phenology: Among seven species, leaf bud initiation starts from February (three species with 42.86%) and peaks in May (six species with 92.86%) in the dry season for species *Buchnania lanzan*, *Pistacia khinjuk*, *Semecarpus anacardium*, *Lannea coromandelica*, *Spondias pinnata* and *Rhus parviflora,* while *Cotinus cogygria* initiates leaf bud in April and peaks in June (Fig. 2). Young leaves start in April (six species with 85.71%) and peaks in July (seven species with 100%) for all species (Fig. 3). Coloured leaves start senescence also show the same trend (Fig. 4).

Falling of leaves starts from September and peaks in November (seven species with 100%) for all the species. Whereas, *Rhus parviflora* do not fall leaves completely due to its semi-deciduous nature.

The trees (*Buchnania lanzan*, *Pistacia khinjuk*, *Semecarpus anacardium*, *Lannea coromandelica* and *Spondias pinnata*) and shrub (*Cotinus cogygria*) species remain leafless afterward November to February due to their deciduousness. Flower/flowering bud starts from February to April (5 species with 71.42%) for species *Buchnania lanzan*, *Pistacia khinjuk*, *Semecarpus anacardium*, *Lannea coromandelica* and *Cotinus cogygria.* Initiation of flower bud

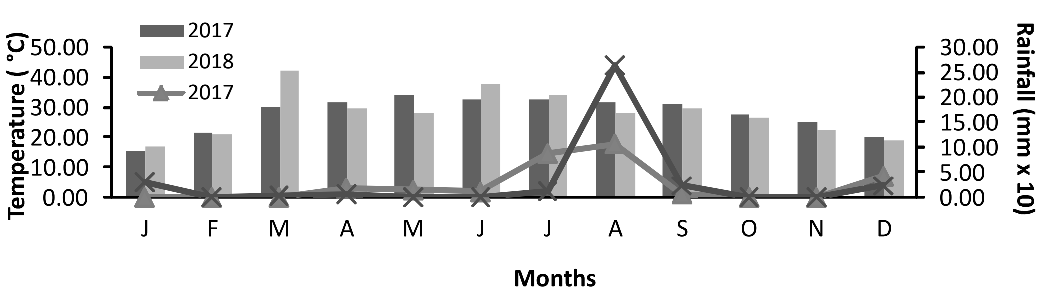

Fig. 1. Average monthly precipitation and temperature at Sub-montane forest of Dugadda, Lansdowne Forest Division

starts from November to January for *Spondias pinnata,* whereas, *Rhus parviflora* initiate flower bud from July onwards. Opening of flowers commence from March and peaks in April (5 species with 71.42%) excluding *Spondias pinnata* and *Semecarpus anacardium*. Ripening of fruits start from April and peak in May (7 species with 100%) for all species.

Recently fruit or seed fall occurs in May to June (6 species with 85.71%) for species *Buchnania lanzan*, *Pistacia khinjuk*, *Lannea coromandelica*, *Rhus parviflora*, *Spondias pinnata* and *Cotinus cogygria*. In *Semecarpus anacardium,* fruit or seed fall occurs in April.

Influence of temperature and precipitation on phenology: Leaf bud initiation was not significant to precipitation for both the years (current and previous year), whereas, temperature had a positive influence for all the species during current (r_s = 0.789, p<0.01) and previous year (r_s = 0.612, P<0.05). Precipitation and temperature had strong positive influence for young leaves during current year (r_s = 0.615, p<0.05 and r_s = 0.819, p<0.01) only. Leaf senescence had negative relationship with precipitation during current year ($r_{s=}$-0.603, p<0.05) only. Precipitation and temperature had strong negative influence with falling leaves for current year (r_s = 0.615, p<0.05 and r_s = 0.819, p<0.01) and having negative influence with temperature during previous year for all the species. Reproductive phenophase did not show any significant influence with precipitation and temperature neither for current year nor previous year. Temperature had strong positive influence with ripen fruit for both current and previous year (r_s = 0.764, p<0.01 and r_s = 0.673, p<0.05). Recent fruit or seed fall showed positive influence with temperature for current and previous year (r_s = 0.668, p<0.05 and r_s = 0.581, p<0.05), whereas, precipitation do not show any significant influence.

Influence of seasonality on phenology: Seasonality of vegetative phenophase is strongly prominent and shows highly significant Rayleish's Z values for all the species. The mean vector month for leaf initiation is May (136.90), young leaves at the beginning of July (210.00), coloured leaves/leaf senescence at mid-January (15.45) and abscission at the end of December (351.18) (Fig. 10, 11, 12 and 13). The length of mean vector r indicates that the falling leaves or leaf abscission (0.37) event has strong influence on seasonality,

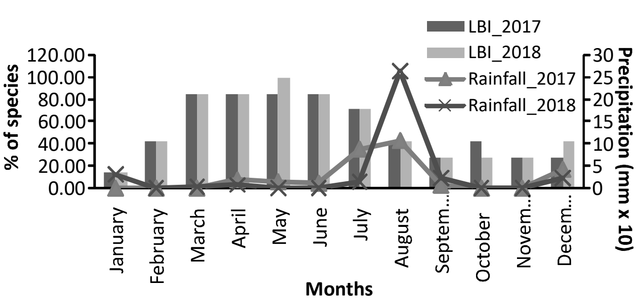

Fig. 2. Leaf bud initiation (LBI) and precipitation in trees/shrubs species of Dugadda, Lansdowne Forest Division

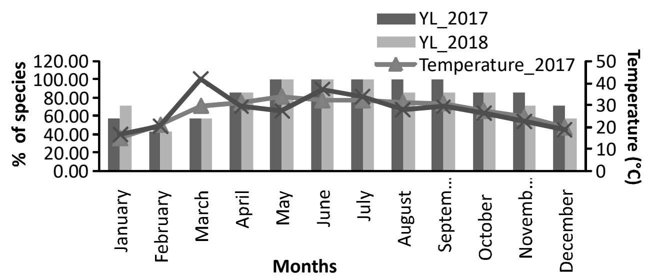

Fig. 3. Young leaves (YL) and temperature in trees/shrubs species of Dugadda, Lansdowne Forest Division

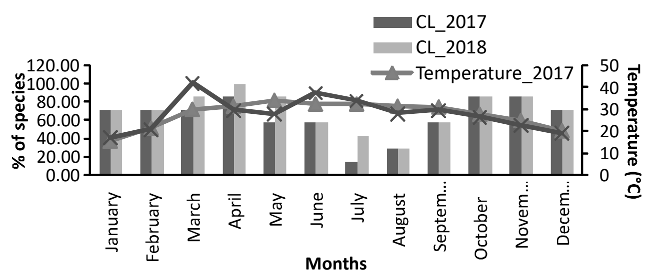

Fig. 4. Leaf senescence or coloured leaves (CL) and temperature in trees/shrubs species of Dugadda, Lansdowne Forest Division

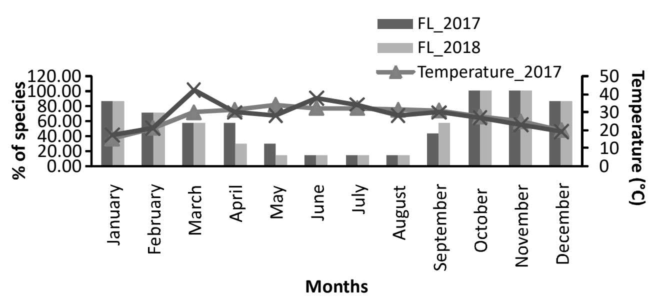

Fig. 5. Leaf abscission or falling leaves (FL) and temperature in trees/shrubs species of Dugadda, Lansdowne Forest Division

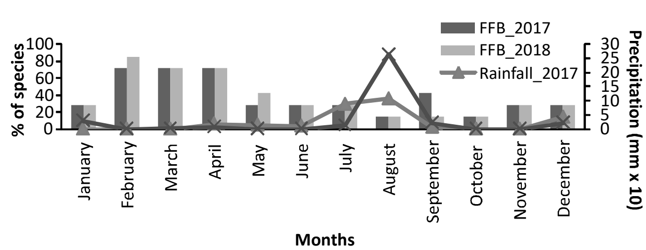

Fig. 6. Flower bud initiation (FFB) and precipitation in trees/shrubs species of Dugadda, Lansdowne Forest Division

followed by leaf bud initiation (0.33), coloured leaves or leaf senescence (0.17) and young leaves (0.15), respectively (Table 2).

Seasonality in reproductive phenophase is also highly significant (Rayleish's Z values) as indicated by the mean vector (month) for all the species. All the species initiates their flower bud during March (75) and open in April (99.05) (Fig. 14 and 15). The length of vector r indicates that flower buds (r = 0.28) have strong influence on seasonality followed by open flower (r = 0.23). Seasonality in fruit/seed phenophase shows that all the species starts ripening in April (146.22), and falls in June (165.25) (Fig. 16 and 17). The length of seasonality measured by mean vector 'r' shows that ripe fruit (r = 0.38) has strong influence on seasonality as compared to recent fruit or seed drop (r =0.36).

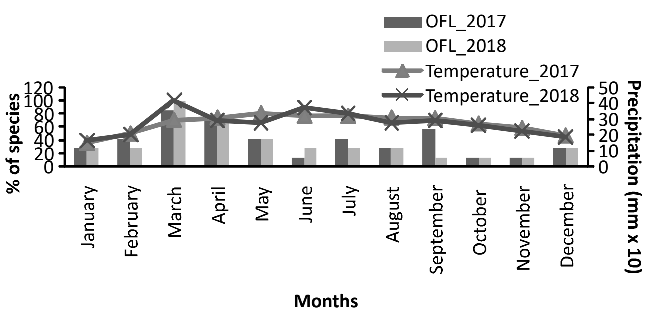

Fig. 7. Open flower (OFL) and temperature in trees/shrubs species of Dugadda, Lansdowne Forest Division

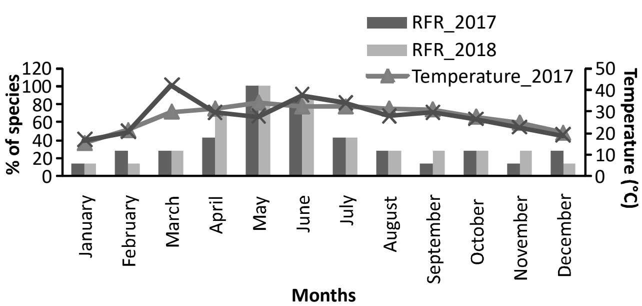

Fig. 8. Ripen Fruits/seed (RFR) and temperature in trees/shrubs species of Dugadda, Lansdowne Forest Division

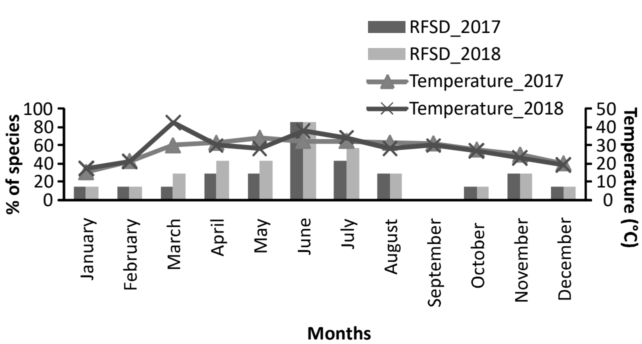

Fig. 9. Recent fruits/seed drop (RFSD) and temperature in trees/shrubs species of Dugadda, Lansdowne Forest Division

Most of the wild trees and shrubs species of family Anacardiaceae shows less differences of timing and duration in phenology of their vegetative phase except *Cotinus cogygria*. In the present study, it was observed that vegetative phases for all species are affected by environmental factors viz; precipitation and temperature for both the years. Similarly, Rivera et al (2020) reported that temperature and precipitation had great influence on vegetative phase during deciduousness period that cause variations in phenology of species belongs to the same family (Singh and Khushwaha 2005). Leaf expansion starts during July for all the species of Anacardiaceae whereas flushing and leaf production towards the end of dry season and just before the onset of monsoon has also been reported by several workers (Frankie et al 1974, Shukla and Ramakrishnan 1982, Sundriyal 1990) and twice in a year with leaf fall during December to March (7.7 ± 4.8) and again in July to September (5.1 ± 2.0) for *Ficus racemosa* (Zhang et al 2006). A study on phenology of trees carried out in the Tropical Farm of Kom-Ombo near Aswan city of Egypt indicates that complete leaf develops during mid-February to late-March for deciduous tree species (Ebeid and Ali 2015).

Leaf senescence in April during the mean minimum temperature period for 15 (23%) species were reported by Nanda et al in 2014 while 92.86% for 6 species were found in senescence stage during May except *Rhus parviflora* (semi-deciduous) in present study. Peak period for leaf fall was examined in month of December as stated by Frankie et al (1974) in which they reported that leaf fall during dry season is different in woody species (Ebeid and Ali 2015). In Garhwal Himalaya, winter dry spell starts from mid-November to January. In reproductive phase, flower bud initiation starts from late January to late May for the trees in Tropical Farm of Kom-Ombo near Aswan city of Egypt (Ebeid and Ali 2015) due to warm dry period during pre-monsoonal period. Warm dry period during pre-monsoonal period enforce flowering upto May for all species. Similar study has been done by Ebeid and Ali (2015) to report flowering stages for various species in May during hot dry spell. Optimum temperature favours opening of flower buds between March to April just before onset of monsoon for all species except *Semecarpus anacardium* and *Rhus parviflora* in study area. Plants having more than 80% of flowering events occur in April after precipitation (Adriano et al 2016) but exhibit peak during the rainy months in Atlantic rain forests of southeastern Brazil (Morellato et al 2000). The environmental forces generate the flowering and fruiting related to moisture and temperature was supported by Murali (1994) and Boojh (1981) just before rainy season due to hot dry spell (Kikim and Yadava 2001). Frankie et al (1974) reported that variation in flowering of *Spondias mombin* commonly observed internally synchronized, portion of a population suddenly burst into full or partial flower rarely resulted in fruit set. Thus, flowering in pre-monsoon season activate development of fruits during rainy season when photosynthesis takes place (Singh and Singh 1992).

Fruit initiates ripening just before a warm dry period begins. In present study, majority of individuals of different tree species shows peak activity of fruit maturation and ripening up to May. Our study has also been in closed agreement with that of Nanda et al (2014) who worked on phenology of trees of Bhadra wildlife sanctuary of Karnataka. Fruit ripening starts during May to June due to excessive temperature which is more than 35°C and this has been supported by similar study done in Western Ghat at Kodayar village in Kanyakumari district of Tamil Nadu by Sundarapandian et al (2005). A very interesting finding in this study was that flowering and fruiting phase in *Semecarpus anacardium* were observed twice in a year at Sub-montane forest of Lansdowne Forest Division at Dugadda in Garhwal

Table 2. Seasonality in different phenophase of trees and shrub species of Dugadda, Lansdown Forest Division

Phenophase		Mean vector (Month)	Length of mean vector (r)	Circular SD[2]	Rayleish's Z	P value
Vegetative phase	a) Leaf bud Initiation	136.90° (May)	0.33	85.15°	5.05	<0.006[1]
	b) Young leaves	210.00° (July)	0.15	110.62°	23.70	<0.000[1]
	c) Coloured leaves/leaf senescence	15.45° (January)	0.17	107.87°	21.82	<0.000[1]
	d) Falling leaves/Leaf abscission	351.18° (December)	0.37	80.49°	93.23	<0.000[1]
Reproductive phase	a) Flower/flower bud	75.00° (March)	0.28	91.43°	35.87	<0.000[1]
	b) Open flower	99.05° (April)	0.23	98.23°	24.96	<0.000[1]
	c) Ripe Fruits/seeds	146.22° (May)	0.38	79.61°	66.55	<0.000[1]
	d) Recent fruit/seed drops	165.25° (June)	0.36	81.89°	40.82	<0.000[1]

[1]Significant at <0.05. [2]Standard Deviation

Circular diagram of each phenophase stages for all species

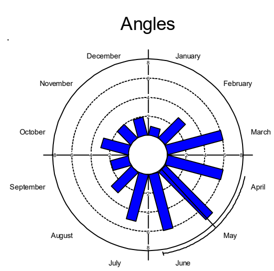

Fig. 10. Leaf Bud Initiation

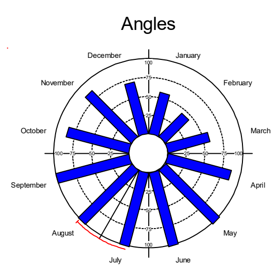

Fig. 11. Young Leaves

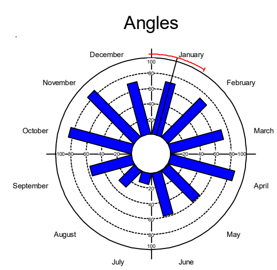

Fig 12. Coloured Leaves

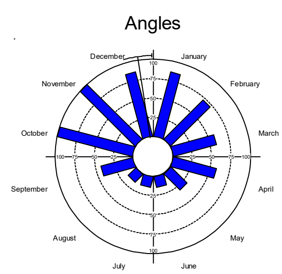

Fig. 13. Falling Leaves

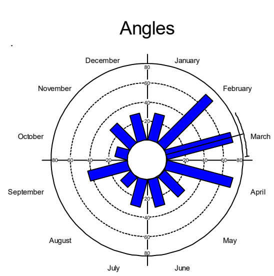

Fig. 14. Flower or flowering bud

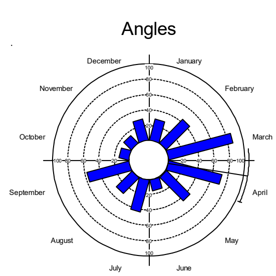

Fig. 15. Open Flower

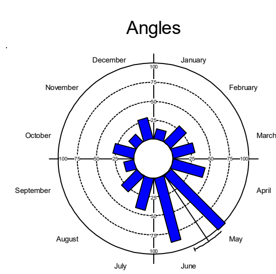

Fig. 16. Ripen Fruits/seeds

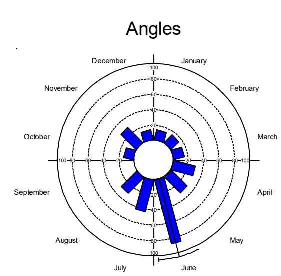

Fig. 17. Recent Fruit or seed fall

Himalaya. Variation in seasonality of different phenophase were proved significantly for all the species showed differences in timing of vegetative and reproductive phase. Nanda et al (2014) reported that leaf bud initiation starts in May, leaf expansion at end of May, leaf senescence in January and leaf fall in February for 22 species of Bhadra wildlife sanctuary in Southern India which supports the findings of present study. However, old leaves in evergreen species fall throughout the years along with flushing of new leaves (Singh and Kumar 2019) in *Rhus parviflora*. The length of fruit maturation period varies from species to species (Singh and Kumar 2019). Length of mean vector shows the duration of a particular phenophase at a time such as flowering was initiated from March and started opening in April. Nanda et al (2014) reported the flowering of 22 species starts in May and become pollinated in middle of March. Temperature and precipitation also trigger the fruit ripening which determine setting of fruits in month of June for all species.

CONCLUSIONS

The present study provides facts about the phenological pattern of wild species of family Anacardiaceae in sub-montane forest of Lansdowne Forest Division in Uttarakhand. It will help in knowing about biological events of species which can be of concern to local people of the region. From this study, it is concluded that temperature and precipitation plays a vital role in leading the biological changes from species to species. However, temperature and precipitation significantly affect the phenological pattern of the species in the area. Seasonality in vegetative and reproductive phase shows that each phenophase events are highly significant and indicates the circular pattern at different time scale in natural habitat for all the species. Thus, the study reveals that environmental factors affect the seasonality and timing of phenophase events of wild species of Anacardiaceae in Garhwal Himalaya.

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Ecological Status of Aquatic Vascular Macrophytes of Nalbari Assam, North-East India

Rupalim Sarmah and Ajit Kumar Das*

Department of Ecology and Environmental Science, Assam University, Silchar-788 011, India
**E-mail: dasajitkumar15@gmail.com*

Abstract: The present investigation was carried out to study the status of aquatic vascular macrophytes in wetlands of Nalbari district, Assam. A total of 76 aquatic vascular macrophytes were recorded in different wetlands of Nalbari district, belonging to 57 genera and 36 families. The highest number of species was recorded in Poaceae, followed by Cyperaceae, Asteraceae and Onagraceae. The species of the family Poaceae (Grass) and Cyperaceae (Sedge) has the major contribution to the aquatic vegetation of different wetlands in the entire district. During the study species richness was high for monocotyledonous species followed by dicotyledonous and Pteridophytes. *Eichhornia crassipes* was the most dominant aquatic vascular macrophytes of entire study area followed by *Isachne himalaica*, *Colocasia esculenta* and *Monochoria hastata*. Moreover, the marginal and anchored floating species were the dominant species of entire study area.

Keywords: Ecology, Nalbari district, Vascular macrophytes, Wetlands

Aquatic plants played crucial role in triggering and maintaining food chain both for aquatic and terrestrial life forms. Simultaneously, they also maintained the aquatic environment congenial for livelihood security. The macroscopic forms of aquatic vegetation were denoted as aquatic macrophytes (and term 'aquatic macrophytes refer to a diverse group of aquatic photosynthetic organisms, which are large enough to be seen with the naked eye (Chambers et al 2008). Aquatic macrophytes included minute macro-algae to seed-bearing higher plants Spermatophyta and the vegetative parts of which actively grow either permanently or periodically submerged below, floating on, or rising up through the water surface. Aquatic vascular macrophytes consisted of only the Pteridophyta and the Spermatophyta (Gecheva et al 2013) and have been the indicator species of the wetland habitat and normally stand in water and must grow for at least a part of their life cycle in water, either completely submerged or emerged. As aquatic vascular macrophytes are very problematic for different crop ecosystems as well as aquatic ecosystems due to their weedy nature and a least work have been reported form the study area regarding the ecology of aquatic flora; therefore, the present study was carried out to investigate the status, distribution as well as proper identification of the aquatic vascular macrophytes to better understanding their microhabitat and sustainable management in their natural habitat.

MATERIAL AND METHODS

The present study was carried out in all the seven developmental blocks (DB) of Nalbari district, Assam. Repeated visits were made to different areas of Nalbari district and major wetlands were identified through interview and opinion of local farmers, block officials, revenue officials and agricultural officials of Nalbari district. Moreover, the rice fields were also surveyed during the transplanted rice fields inundated by water, are a good habitat of different aquatic vascular macrophytes. On the basis of preliminary survey and with the help of the block map, one main road was selected in each developmental block that passing through the entire block, a stop was made after every 5-6 km distance and the crop fields were alternately selected from the main road (Duary et al 2015, Sarmah et al 2016).

The random quadrat (1m x 1m) sampling was conducted within the different wetlands and crop fields. All the recorded aquatic vascular macrophytes were categorized on the basis of their life forms and total six categories were considered, viz. anchored emerged (AE), anchored floating (AF), free floating (FF), marginal or semi-aquatic (M), suspended (SP) and submerged (SB).

$$\text{Density} = \frac{\text{Total number of individual of a species in all the quadrats studied}}{\text{Total number of quadrats studied}}$$

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrates studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individual of a species in all quadrats}}{\text{Number of quadrats of occurrence}}$$

RESULTS AND DISCUSSION

A total 76 aquatic vascular macrophytes were recorded from the wetlands of Nalbari district, which belonged to 57 genera and 36 families. Amongst these the highest number of species were from family Poaceae having 12 species, followed by Cyperaceae (9 species), Asteraceae (4 species), and Onagraceae, Lamnaceae and Pontederiaceae with 3 species each. The life form distribution amongst the 76 aquatic vascular macrophytes indicated that with 29 and 28 numbers of species, marginal and anchored floating species had dominated the wetlands of Nalbari district during the study period. Free floating and anchored floating life forms possessed 10 and 6 species respectively (Table 1). The highest percentage contribution among the categories were marginal (38.16 %), followed by anchored emerged (36.84 %), free floating (13.16 %) and anchored floating (7.89 %). Out of the total 76 species recorded from the different wetlands of Nalbari district, the monocotyledonous flora represented by 39 species, 31 species were found to be dicotyledons and only six species were aquatic ferns (Pteridophytes). The percentage contribution of monocot species was 51.32 %, followed by dicot (40.79 %) and pteridophytes (7.89 %) (Table 2).

Among the monocots the highest number of species belonged to the life form marginal (16 species), followed by anchored emerge (15 species), free floating (5 species), anchored floating (2 species) and submerged (1 species). Among the dicots species richness was as many as 12 species for both anchored emerge and marginal life forms. And free floating was represented by solitary species. Similarly, number of Pteridophytic species recorded under free floating, marginal and anchored emerge were 4, 1 and 1, respectively. In the present investigation, the highest density of species were for *Isachne himalaica* (50.47 m^{-2}), followed by *Lemna minor* (43.94 m^{-2}) and *Azolla pinnata* (31.32 m^{-2}). However, the least density was for *Aeschynomene indica* (0.15 m^{-2}), *Ceratopteris pteridoides* (0.12 m^{-2}) and *Nelumbo nucifera* (0.18 m^{-2}). The highest frequency was recorded for *Eichhornia crassipes* (33.82%), followed by *Sacciolepis interrupta* (26.47%) and *Colocasia esculenta* (25%), respectively. However, lowest frequency value 0.74% was recorded for *Ceratopteris pteridoides*, *Eleocharis acicularis* and *Fimbristylis bisumbellata* (Table 3).

The IVI value of *E. crassipes* (60.66) was the most dominant aquatic vascular macrophytes of entire study area followed by *I. himalaica* (19.07), *C. esculenta* (12.97) and *Monochoria hastata* (12.49). *E. crassipes* is the truly dominant aquatic macrophytes as relative frequency and relative dominance both are highest in case of *E. crassipes*; However, *I. himalaica*, *C. esculenta* and *M. hastata* are falsely dominant species as only one factor is responsible for highest IVI value. The five most dominant monocot species were *E. crassipes*, followed by *I. himalaica*, *L. minor*, *C. esculenta* and *M. hastata* (Fig. 1). Moreover, *Ludwigia adscendens*, *Rotala rotundifolia*, *Mikania micrantha*, *Ludwigia hyssopifolia* and *Alternanthera sessilis* were the five most dominant species among the dicotyledonous aquatic vascular macrophytes (Fig. 2). Out of the total six species of

Table 1. Species richness and percentage (%) contribution of different life-form of aquatic vascular macrophytes of Nalbari district

Life form	No. of species	Contribution (%)
Anchored emerged (AE)	28	36.84
Anchored floating (AF)	6	7.89
Marginal (M)	29	38.16
Free floating (FF)	10	13.16
Suspended (SP)	2	2.63
Submerged (SB)	1	1.32
Total	76	100.00

Table 2. Plant group wise species richness, percentage contribution and life forms of aquatic vascular macrophytes of Nalbari district

Plant groups	Species	Percentage (%) contribution	Life form (%)					
			AE	AF	M	FF	SP	SB
Monocotyledons	39	51.32	15	2	16	5	0	1
Dicotyledons	31	40.79	12	4	12	1	2	0
Pteridophytes	6	7.89	1	0	1	4	0	0

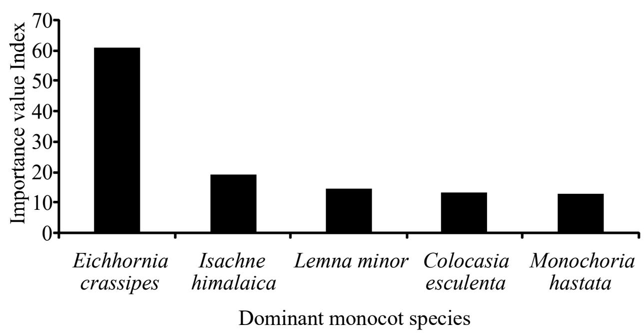

Fig. 1. Dominant monocot species in wetlands of Nalbari district, Assam

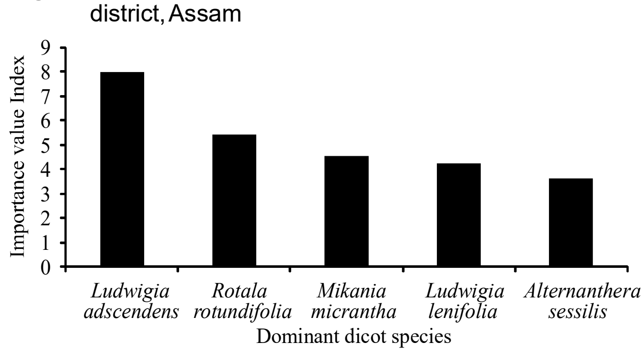

Fig. 2. Dominant dicot species in wetlands of Nalbari district, Assam

Table 3. Different ecological parameters of aquatic vascular macrophytes recorded in wetlands of Nalbari district

Scientific name	Frequency	Density	IVI	Category	Family
Acmella ciliata (Kunth.) Cass.	8.82	1.29	2.18	M	Asteraceae
Acorus calamus L.	6.62	0.94	3.31	AE	Acoraceae
Aeschynomene indica L.	1.47	0.15	0.37	AE	Fabaceae
Alpinia nigra (Gaertn.) Burtt	3.68	0.47	1.34	AE	Zingiberaceae
Alternanthera philoxeroides (Mart.) Griseb.	3.68	1.09	1.36	AE	Amaranthaceae
A. sessilis (L.) DC.	11.03	4.41	3.62	M	
Arundo donax L.	2.21	0.21	0.63	M	Poaceae
Axonopus compressus (Sw.) P. Beauv.	5.88	3.53	2.44	M	
Azolla pinnata R. Br.	2.94	31.32	9.80	FF	Azollaceae
Centella asiatica (L.) Urban	2.94	1.68	1.07	M	Apiaceae
Ceratophyllum demersum L.	6.62	11.97	4.86	SP	Ceratophyllaceae
Ceratopteris pteridoides (Hook.) Hieron.	0.74	0.12	0.26	FF	Pteridaceae
Colocasia antiquorum Schott	17.65	2.53	5.86	AE	Araceae
C. esculenta (L.) Schott	25.00	3.76	12.97	M	
Commelina benghalensis L.	9.56	3.26	2.95	M	Commelinaceae
C. diffusa Burm.f.	2.94	1.71	1.14	M	
Cynodon dactylon (L.)Pers.	7.35	9.24	4.18	M	Poaceae
Cyperus difformis L.	4.41	0.97	1.16	AE	Cyperaceae
*C. digitatus*Roxb.	1.47	0.38	0.40	M	
C. haspan L.	2.94	1.03	1.18	M	
C. iria L.	1.47	0.38	0.40	AE	
Digitaria setigera Roth.	7.35	13.85	5.56	M	Poaceae
Diplazium esculentum (Retz.)Sw.	5.88	1.15	1.52	AE	Athyriaceae
Echinochloa crus-galli (L.) P. Beauv.	2.94	1.35	1.13	AE	Poaceae
Eclipta prostrata (L.) L.	7.35	2.29	2.27	M	Asteraceae
Eichhornia crassipes (Mart.) Solms	33.82	6.97	60.66	FF	Pontederiaceae
Eleocharis acutangula (Roxb.) Schult.	1.47	1.12	0.74	AE	Cyperaceae
E. dulcis (Burm.f.) Trin. ex Hensch.	3.68	6.85	2.80	AE	
Enhydra fluctuans Lour.	7.35	7.09	4.34	AE	Asteraceae
E. acicularis (L.) Roem. & Schult.	0.74	0.88	0.40	M	Cyperaceae
Fimbristylis bisumbellata (Forssk.) Bubani	0.74	0.24	0.21	AE	
F. littoralis Gaudich.	7.35	3.24	2.39	AE	
Floscopascandens Lour.	5.88	1.15	1.82	M	Commelinaceae
Hydroceratriflora(L.) Wight & Arn.	3.68	0.82	1.51	AE	Balsaminaceae
Hygroryza aristata (Retz.) Nees ex wight & Arn.	2.21	3.18	7.29	FF	Poaceae
Ipomoea aquatica Forssk.	4.41	1.50	1.47	AF	Convolvulaceae
I. carnea Jacq.	5.88	1.00	1.90	AE	
Isachne himalaica Hook. f.	20.59	50.47	19.07	FF	Poaceae
Lasia spinosa (L.) Thwaites	2.94	0.35	1.04	M	Araceae
Lemna minor L.	6.62	43.94	14.21	FF	Lamnaceae
Limnophila aromatica (Lam.) Merr.	2.94	0.68	0.85	AE	Scrophulariaceae
L. heterophylla (Roxb.) Benth.	2.21	3.00	1.66	AE	
Lindernia anagallis (Burm. f.) Pennell	11.03	3.35	3.26	AE	Linderniaceae

Cont...

Table 3. Cont...

Scientific name	Frequency	Density	IVI	Category	Family
Ludwigia adscendens (L.) H. Hara	16.18	8.18	7.98	AF	Onagraceae
L. hyssopifolia (G. Don) Exell	15.44	3.06	4.24	M	
L. octovalvis (Jacq.) Raven	5.15	0.59	1.39	M	
Marsilea minuta L.	16.91	9.41	6.09	FF	Marsileaceae
Mikania micrantha Kunth	19.85	2.41	4.56	M	Asteraceae
Monochoria hastata var. *elata* (Ridl.)	10.29	1.35	12.49	AE	Pontederiaceae
Monochoria vaginalis (Burm. f) C. Presl.	8.82	2.50	3.61	AE	
Murdannia spirata (L.) G. Bruckn.	5.15	2.65	1.80	M	Commelinaceae
Nelumbo nucifera Gaertn.	1.47	0.18	0.67	AE	Nelumbonaceae
Nymphaea nouchali Burm. f.	2.21	0.29	0.56	AF	Nymphaeceae
N. pubescens Willd.	1.47	0.38	0.46	AF	
Nymphoides indica (L.) kuntze	8.09	0.85	1.82	FF	Menyanthaceae
Oldenlandia diffusa (Willd.) Roxb.	5.15	1.29	1.38	M	Rubiaceae
Oryza rufipogon Griff.	6.62	1.82	1.83	AF	Poaceae
Ottelia alismoides (L.) Pers.	1.47	0.15	0.37	SB	Hydrocharitaceae
Oxalis corniculata L.	6.62	5.50	2.92	M	Oxalidaceae
O. debilis Kunth	2.94	2.12	1.44	M	
Panicum repens L.	5.15	2.00	1.67	M	Poaceae
Paspalum conjugatum P. J.Bergius	1.47	1.38	0.72	M	
Persicaria hydropiper (L.) Spach	9.56	3.03	2.80	AE	Polygonaceae
P. barbata (L.) H.Hara	3.68	1.32	1.16	AE	
Pistia stratiotes L.	1.47	2.21	5.05	FF	Araceae
Rotala indica (Willd.) Koehne	7.35	6.21	3.28	M	Lythraceae
R. rotundifolia (Buch.-Ham. ex Roxb.) Koehne	8.82	12.50	5.44	M	
Saccharum spontaneum L.	2.94	1.24	1.76	M	Poaceae
Sacciolepis interrupta (Willd.) Stapf	26.47	10.44	9.41	AE	
Sagittaria guayanensis Kunth	8.09	5.41	3.18	AF	Alismataceae
Salvinia cucullata Roxb.	2.94	7.32	4.40	FF	Salviniaceae
Sphaerostephanosunitus (L.) Holttum	18.38	5.29	5.21	M	Thelypteridaceae
Sphenoclea zeylanica Greatn.	2.94	0.38	0.73	AE	Sphenocleaceae
*Typha angustifolia*L.	3.68	0.56	1.92	AE	Typhaceae
T. latifolia L.	1.47	0.47	0.92	AE	
Utricularia aurea Lour.	2.21	2.38	1.14	SP	Lentibulariaceae

*AE-Anchored emerged, AF-Anchored floating, FF-Free floating, M-Marginal, SP-Suspended, SB-Submerged

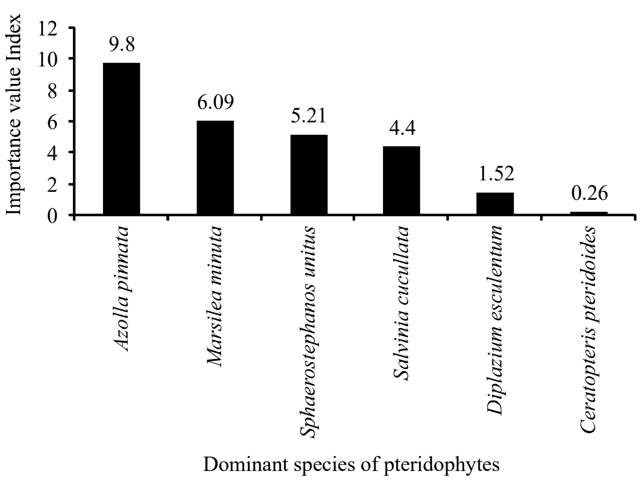

Fig. 3. Dominant species of Pteridophytesin wetlands of Nalbari district, Assam

Pteridophytes, *A. pinnata* showed the highest IVI 9.80, followed by *Marsilea minuta* and *Salvinia cucullata* (Fig. 3).

CONCLUSION

The present study reveals that the monocot flora leads by grasses and sadges were most prevalent during the study period, as grasses and sedges prefers semi-aquatic ecosystems for their growth and regeneration. Over growth of several species including few broad leaves found causing trouble in certain aquatic situations as they are more or less problematic weeds. *Eichhornia crassipes*, *Ludwigia adscendens* and *Azolla pinnata* had showed the highest IVI value amongst monochot, dichot and pteridophytis during the study period. Among the aquatic vascular macrophyte of the study area *E. crassipes* was recorded more frequently and had high value of relative dominance.

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Vegetation Structure, Composition and Species Diversity in an Age Series of Coal Mine Overburden Dumps

Santu Malakar and Hema Gupta Joshi

Department of Botany, Visva-Bharati, Santiniketan-731 235, India
E-mail: santumalakar.lik@gmail.com

Abstract: This paper reports on the vegetation composition and diversity of herb, shrub and tree layers developing on an age series of overburden dumps (1, 3, 9, 12, 18 and 21yr) in Bansra and Sonepur Bazari colliery of Raniganj Coalfields. An adjacent native forest Garhjungle was also studied to compare the vegetation development. Total 69, 20, and 30 species of herbs, shrubs including climbers, and trees, respectively, were recorded from the overburden dumps, whereas 10 species of trees, 7 of shrubs and 20 herbaceous species were recorded from the natural forest Garhjungle. Four indices of species diversity estimated the richness, heterogeneity, evenness and dominance of species. Herbs appeared from 1yr dump while shrubs and trees appeared from 3yr onwards. Herb layer was most diverse in the early successional stage while shrub layer was most diverse in the intermediate stage. Density of herbs and shrubs decreased, whereas density, basal area and diversity of tree increased with increase in dump age. Herb layer was dominated by invasive species in the initial phase of succession and gradually replaced by higher successional herbs. Shrub layer was dominated by invasive species throughout the succession. Importance of *Leucaena leucocephala*, only invasive tree species recorded, increased in the late successional stage. Generic Coefficient indicated the possibility of ecological restoration.

***Keywords*:** Diversity indices, Garhjungle, Overburden dumps, Raniganj coalfields, Successional changes, Similarity indices, Species composition

Opencast mining of coal produces huge amount of mine spoil by removing the overlying soil and rock fragments along with existing vegetation, and depositing into another fresh area forming the overburden dumps with disturbed soil microbial population (Chandra 2014). Overburden of coal mine represents a dis-equilibriated geomorphic system (Maharana and Patel 2013, Ramesh et al 2014). On these dumps natural succession of plant species takes place at a very slow pace (Kar and Palit 2016) and it ends when the composition of species no longer changes. Deficit of major nutrients in the top soil of overburden dumps is an important factor for limiting the plant growth (Yaseen et al 2012). However, such degraded lands need human hand for reclamation, the process of recovery of a deformed land surface to some form of usefulness (Kuter 2013).

Various native and exotic species showing better growth performance have been introduced to reclaim the coal mine dumps (Sheoran et al 2010, Gudadhe and Ramteke 2012). However many workers are skeptical about artificial reclamation. Erksine and Flitcher (2013) argued that fast growing exotic species provide protection against erosion at the expense of native species. Hughes et al (2012) expected large scale rehabilitation efforts with high management costs to develop non-polluting novel ecosystem only. Abandoned quarries may be converted into important biodiversity centre if spontaneous (natural) succession is allowed to occur (Trnkova et al 2010) but spontaneous succession is rarely prescribed in restoration project (Prach et al 2011). Nationwide there are reports on the natural succession of plant species on the overburden dumps (Borpujari 2008, Ekka and Behera 2011, Das et al 2013).

The present study was carried out in the open cast coal mining areas of Raniganj Coalfields under Eastern Coalfields Limited (ECL) to identify the plant species that colonize; and study the changes in species composition and diversity.

MATERIAL AND METHODS

Study area: The study area includes Bansra OCP and Sonepur Bazari OCP of Raniganj coalfield under ECL (Eastern Coalfield Limited) located near Raniganj in Burdwan district of West Bengal (Fig. 1). Geographically Bansra OCP lies between latitudes 23˚37′ 38.75″N and 23˚ 38′ 52.66″N, and longitudes 87˚07′36.50″E and 87˚08′52.01″ E whereas Sonepur Bazari OCP lies between latitudes 23˚ 40′58.74″N and 23˚41′47.64″N, and longitudes 87˚12′55.93″ E and 87˚13′57.62″E. The climate in general is dry tropical with three prominent seasons, summer (middle of March to middle of June), rain (middle of June to middle of October) and winter (November to February).

Vegetation sampling: For the present study, six dumps of different ages, i.e., 1, 3, 9, 12, 18 and 21year were selected. The 3yr old dump was selected from Sonepur Bazari OCP and the rest from Bansra OCP. During vegetation sampling 10 quadrats of 10m x 10m were randomly laid in each overburden dump and also in the natural forest for sampling of tree species (dbh≥1 cm). The shrubs (height >30 cm) including climbers were sampled in twenty 5m x 5m quadrats and herbs (height <30 cm) including grasses in forty 1m x 1m quadrats nested within the bigger 10m x 10m quadrat. All the plant species were recorded in each quadrat and their number counted. Specimens that could not be satisfactorily identified were marked and brought to the laboratory for identification by consulting with taxonomist and regional floras (Prain 1903, Sanyal 1994). Herbarium specimens were prepared for the collected species. Families were categorized as mentioned in the *Flora of Bilaspur* (Panigrahi and Murti 1989, 1999). Scientific names and author citations have been updated following the website The Plant List (www.theplantlist.org).

Data analysis: Different structural parameters such as density, frequency and basal area were calculated using standard methodology (Mishra 1968). The importance value index (IVI) for each tree species is calculated as sum of the relative density, relative dominance and relative frequency (Curtis and McIntosh 1950) for a maximum value of 300. For shrubs, climbers, herbs and grasses, IVI was calculated by summing relative density and relative frequency only, so that maximum possible value is 200 (Williams-Linera et al 2005, Lopez et al 2008). Basal area was not calculated for shrub and herb layers because of difficulty in measuring the precise diameter of small sized individuals. Species dispersion pattern was calculated by Whitford's index (Curtis and Cottom 1956). Family importance value (FIV) of tree species was calculated as the sum of relative density, relative diversity and relative dominance of a family (Ganesh et al 1996). Generic Coefficient was calculated according to (Jaccard 1901) as:

$$\text{Generic Coefficient} = \frac{\text{No. of genera}}{\text{No. of species}} \times 100$$

Various species diversity and similarity measures were calculated. Species diversity or heterogeneity (H') was determined from Shannon-Weiner's information function (Shannon and Weaver 1949); Simpson's index or concentration of dominance (Cd) as per Simpson (1949); Species richness using Margalef's index (M) (Margalef 1968); eveness (E) as per Pielou (1966); within habitat beta diversity (β) according to Whittaker (1972); beta diversity as species turnover (β_d) as per Wilson and Shmida (1984); and similarity index (IS) according to Jaccard (1928).

$$H' = -\Sigma_{i=1}^{s} pi \ \text{In}\ pi$$

$$Cd = \Sigma_{i=1}^{s} (pi)^2$$

M = (s-1)/ln N

E= H'/H^{max};

H^{max} = Maximum value of H = ln(s) (Krebs 1978)

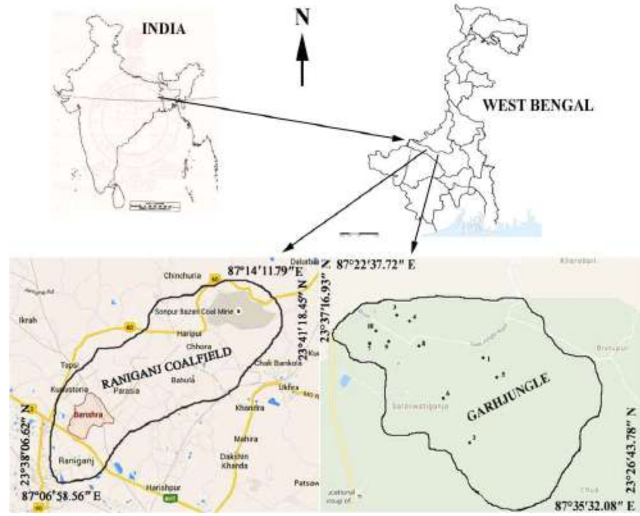


Fig. 1. Location of the study sites (Source: Malakar and Gupta (Joshi) 2018)

β = Sc/ S

β_d=(b+c)/(2a+b+c)

IS = (a/a+b+c) x 100

Where, s = number of species

p_i = proportion of total sample belonging to *i*th species = ni/N

n_i = number of individuals in the *i*th species

N = total number of individuals in the community

Sc = total number of species

S = average number of species per sample

a = total number of species common in both sites

b and c = number of species occurring in one or other site only

RESULTS AND DISCUSSION

The present study recorded 69 species of herbs, 20 of shrubs and climbers and 30 of trees from different overburden dumps. From natural forest Garhjungle 10 species of trees, 7 of shrubs and 20 of herbs were recorded. Kumar et al (2011) reported 36 herbs and grasses from some other mined dumps of Raniganj Coalfield. Das et al (2013) reported 58 species from the 1 to 37 years old overburdens of Ramnagore Colliery, where 26 species of herbs dominated the overburden flora and had highest share in the form-composition of the sites. Biswas et al (2014) reported an increase in species number with the increasing dump age from Sonepur Bazari area of Raniganj coalfields. Previously we listed 126 angiospermic species including tree saplings and seedlings from the same sites (Malakar et al 2015). All the species had clumped dispersion with Whitford index value >0.05. Similar result reported by Kumar et al (2020) from an adjacent tropical dry deciduous forest.

The species recorded from 1 and 3yr overburden dumps were designated as early colonizing species or early successional species. Species appearing from 9 and 12yr dumps were intermediate successional species, while those appearing from 18 and 21yr dumps were late successional species.

Community structure and composition of trees: On 1yr dump no trees or shrubs were recorded; only herbs and seedlings of *Butea monosperma* and *Trema orientalis* were present. Early successional trees were observed on 3yr dump with five species having 19 individuals under five families (Fig. 2, Table 1). Dominance of tree species in the overburden dumps from 3yr onwards showed that the herbs and grasses occupied the area first and made it suitable for

Table 1. Importance Value Index (IVI) of tree species in different overburden dumps and Garhjungle

Species name	Family	Overburden dumps (year)					Garhjungle
		3	9	12	18	21	
Dalbergia sissoo DC.	Fabaceae	104.53	-	3.42	19.27	14.63	-
Bombax ceiba L.	Bombacaceae	69.41	36.24	-	4.42	8.38	11.72
#*Leucaena leucocephala* (Lam.) de Wit	Mimosaceae	62.03	-	177.25	79.48	111.71	-
Haldina cordifolia (Roxb.) Ridsdale	Rubiaceae	44.19	-	-	-	-	16.36
Holoptelea integrifolia Planch.	Ulmaceae	19.83	-	-	-	6.82	
Alangium salviifolium (L.f.) Wangerin	Alangiaceae	-	95.29	11.93	7.57	24.06	3.49
Ziziphus jujuba Mill.	Rhamnaceae	-	51.25	31.25	7.29	17.69	-
Ficus hispida L.f.	Moraceae	-	34.14	-	14.08	37.73	-
Butea monosperma (Lam.) Taub.	Fabaceae	-	25.76	6.08	28.08	-	-
Streblus asper Lour.	Moraceae	-	21.71	11.98	7.76	5.91	-
Albizia lebbeck (L.) Benth.	Mimosaceae	-	15.12	8.56	-	-	-
Gmelina arborea Roxb.	Verbenaceae	-	14	4.42	-	4.55	-
Holarrhena pubescens Wall. ex G.Don	Apocynaceae	-	6.48	-	-	-	-
Azadirachta indica A.Juss.	Meliaceae	-	-	10.64	4.79	7.18	-
Acacia auriculiformis Benth.	Mimosaceae	-	-	8.93	5.62	-	-
Senna siamea (Lam.) H.S.Irwin and Barneby	Caesalpiniaceae	-	-	6.7	47.44	-	-
Peltophorum pterocarpum (DC.) K.Heyne	Caesalpiniaceae	-	-	6.38	-	-	-
Acacia nilotica (L.) Delile	Mimosaceae	-	-	4.61	42.24	-	3.77
Glochidion sp.	Euphorbiaceae	-	-	4.15	12.05	5.07	-
Litsea glutinosa (Lour.) C.B.Rob	Lauraceae	-	-	3.68		-	-
Spondias pinnata (L. f.) Kurz	Anacardiaceae	-	-	-	16.1	2.9	-
Morus alba L.	Moraceae	-	-	-	3.82	-	-
Phoenix sylvestris (L.) Roxb.	Arecaceae	-	-	-	-	33.95	-
Trema orientalis (L.) Blume	Ulmaceae	-	-	-	-	4.46	-
Terminalia chebula Retz.	Combretaceae	-	-	-	-	3.3	-
Strychnos potatorum L.f.	Loganiaceae	-	-	-	-	3.22	-
Anogeissus latifolia (Roxb. ex DC.) Wall. ex Guillem and perr.	Combretaceae	-	-	-	-	2.36	-
Tectona grandis L.f.	Verbenaceae	-	-	-	-	2.05	9.58
Miliusa velutina (Dunal) Hook.f. and Thomson	Annonaceae	-	-	-	-	2.03	-
Helicteres isora L.	Sterculiaceae	-	-	-	-	2.02	-
Shorea robusta Gaertn.	Dipterocarpaceae	-	-	-	-	-	151.43
Madhuca longifolia var. *latifolia* (Roxb.) A.Chev.	Sapotaceae	-	-	-	-	-	49.28
Buchanania cochinchinensis (Lour.) M.R.Almeida	Anacardiaceae	-	-	-	-	-	42.02
Schleichera oleosa (Lour.) Merr.	Sapindaceae	-	-	-	-	-	8.87
Pterocarpus marsupium Roxb.	Fabaceae	-	-	-	-	-	3.49

(Invasive species indicated by #)

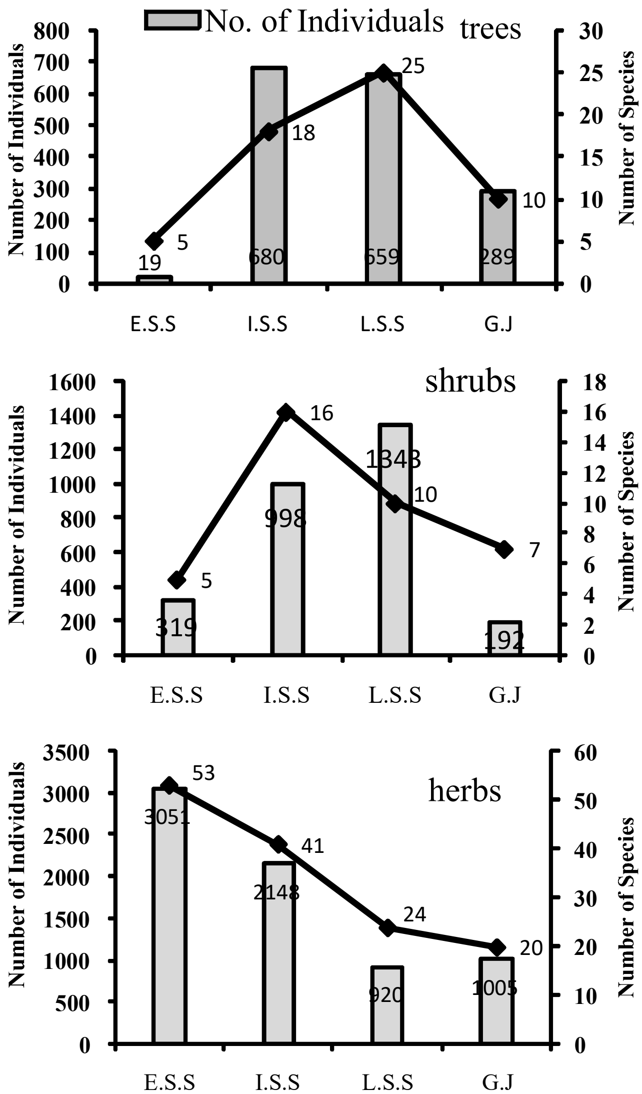


Fig. 2. Number of species and individuals of different strata in overburden dumps (early, intermediate and late Successional stages) and Garhjungle

survival of trees in adverse conditions. Dominant species were *Dalbergia sissoo*, *Bombax ceiba* and the invasive species *Leucaena leucocephala* with highest IVI value (104.53) obtained by *Dalbergia sissoo*. Resistance showed by *Dalbergia sissoo* to mine overburden stress is previously reported by Juwarkar and Singh (2007) and Dowarah et al. (2009). As the dumps got older the number of tree species increased upto 30, however, *Leucaena leucocephala* with high invasive potential became the most important tree species in intermediate and late successional stages and importance of *D. sissoo* and *B. ceiba* decreased. Importance of many leguminous N-fixing tree species like *Leucaena leucocephala*, *Acacia* sp., *Albizia lebbeck* in bioreclamation has been widely reported. Presence of 18 species under 12 families with 680 individuals was recorded on intermediate successional stage. In this stage 15 new species (not present in earlier stage) were found of which four were restricted to this stage only. In 9yr dump *Alangium salviifolium* showed highest IVI (95.29) followed by *Ziziphus jujuba* (51.25) and later its importance decreased along with *Streblus asper*. *Alangium salviifolium* was also present in Garhjungle. From 12 to 21yr dumps *Leucaena leucocephala* displayed highest IVI value. Late successional stage included 659 individuals of 25 species belonging to 17 families. Ten new species (not present in earlier stages) appeared in this stage. *Leucaena leucocephala* dominated followed by *Senna siamea*, *Acaia nilotica*, *Ficus hispida* and *Phoenix sylvestris*. In Garhjungle 289 individuals belonging to 10 tree species under 10 families were recorded. *Shorea robusta* dominated with highest IVI (151.43) followed by *Madhuca longifolia* var. *latifolia* and *Buchanania cochinchinensis*. Five out of the 10 species were present in Garhjungle exclusively. Dominance of *Shorea robusta* in Garhjungle established that trees species composition of this natural forest is different from that of the overburden dumps. Moreover no invasive shrub or tree species was recorded from this natural forest.

Total 20 families of tree species were found in the overburden dumps. Fabaceae, Mimosaceae, Alangiaceae, Bombacaceae and Moraceae were some important families with greater contribution in establishment of tree vegetation (Table 2). Highest FIV was obtained by Mimosaceae from 12yr dump onwards, followed by Alangiaceae in 9yr dump with only species *Alangium salviifolium* and by Fabaceae in 3yr dump. In Garhjungle Dipterocarpaceae obtained highest FIV. Total ten families were recorded from Garhjungle, out of which three, including Dipterocarpaceae, did not occur in the overburden dumps. Fabaceae and Mimosaceae were recorded from all the overburden dumps as well as Garhjungle.

Both tree density and basal area increased with increase in the age of dumps (Fig. 3a). Tree density of Garhjungle was lower than that of 12 and 21yr dumps; basal area was also less than that of 21yr dump but more than other overburden dumps.

Community structure and composition of shrubs and climbers: In 1yr dump mature shrubs were absent. Early successional shrubs were represented by 319 individuals of only five species (including four invasive species) under four families (Fig. 2, Table 3). The most important species were *Chromolaena odorata* (having highest IVI among all the shrubs) and *Lantana camara,* which continued their abundance upto 21yr dump. *Clerodendrum infortunatum* appeared as intermediate successional species in the 9yr dump and became the most important species in 21 yr dump.

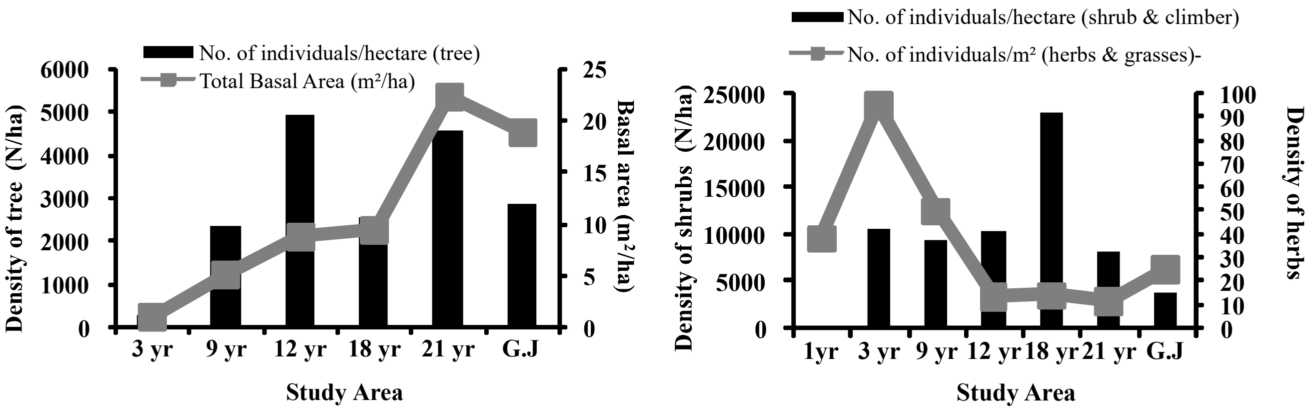
Sixteen species with 998 individuals under 14 families constituted the intermediate stage. *Chromolaena odorata* had highest IVI in 3 and 9yr dumps whereas *Lantana camara* became the most important species in 18yr dump, after which its importance declined. *Clerodendrum infortunatum* was the most important species in 12 and 21yr dumps. *Chromolaena odorata* and *Clerodendrum infortunatum* recorded IVI more than 100, at 3 and 21yr dumps, respectively, showing dominance by few shrub species in early and late successional stages. Late successional stage had ten species under 8 families with 1343 individuals. Intermediate stage recorded maximum appearance of species but number of individuals was highest in late successional stage (Fig. 2). Four species including three climbers in 9yr dump, three shrub species in 12yr dump, one climber species in 18yr dump and one shrub species in 21yr dump were present exclusively on the overburden dumps. Three shrub species *Chromolaena odorata*, *Clerodendrum infortunatum* and *Lantana camara* exchanged the position of dominant and co-dominant species among themselves, accounting for more than 70 per cent of IVI in all the dumps possibly preventing other species to colonize and dominate. High IVI of *Lantana camara* and *Chromolaena odorata* from overburden dumps of Raniganj coalfields has been previously reported by Biswas et al (2014). Invasiveness of *Lantana camara* has also been reported by many workers (Ekka and Behera 2011, Soni and Gairola 2011, Vijayan and Joy 2016).

In Garhjungle seven species were recorded with 192 individuals under seven families. Except *Catunaregum spinosa* and *Flacourtia indica* all other species were exclusively present in Garhjungle. Dominant species in Garhjungle were *Catunaregum spinosa*, *Erycibe paniculata* and *Carrisa spinarum* with highest IVI obtained by *Erycibe paniculata*. Shrub density declined with the increase in dump age from 3 to 21yr dumps, however, maximum density was observed in the 18yr dump that was more than two times the density at any other dump (Fig. 3b). Garhjungle had lower shrub density than those of overburden dumps.

Community structure and composition of herbs and grasses: 69 herb species were recorded in different aged

Table 2. Family Importance Value (FIV) of tree species

Family	Overburden dumps (Year)					Garhjungle
	3	9	12	18	21	
Fabaceae	81.68	29.18	17.43	49.95	12.49	10.46
Bombacaceae	75.12	39.66		8.39	9.81	18.69
Mimosaceae	67.74	22.38	185.46	112.16	98.83	10.74
Rubiaceae	49.9	-	-	-	-	23.33
Ulmaceae	25.54	-	-	-	14.13	-
Alangiaceae	-	79.48	10.49	8.83	20.13	10.46
Moraceae	-	47.3	10.54	29.34	37.57	-
Rhamnaceae	-	46.98	21.71	8.55	11.98	-
Verbanaceae	-	21.26	8.4	-	13.07	16.55
Apocynaceae	-	13.74	-	-	-	-
Caesalpiniaceae	-	-	21.01	46.04	-	-
Meliaceae	-	-	9.21	8.76	6.81	-
Euphorbiaceae	-	-	8.12	13.31	6.5	-
Lauraceae	-	-	7.65	-	-	-
Anacardiaceae	-	-	-	14.67	6.11	30.81
Arecaceae	-	-	-	-	33.58	-
Combretaceae	-	-	-	-	12.08	-
Loganiaceae	-	-	-	-	6.43	-
Annonaceae	-	-	-	-	5.24	-
Sterculiaceae	-	-	-	-	5.23	-
Dipterocarpaceae	-	-	-	-	-	134.16
Sapotaceae	-	-	-	-	-	32.01
Sapindaceae	-	-	-	-	-	12.81



a) Successional changes in tree density and basal area

b) Successional changes in shrub density and herb density

Fig. 3. Successional changes in tree basal area and densities of different vegetation strata

Table 3. Importance Value Index of shrubs and climbers in different overburden dumps and Garhjungle

Species name	Family	Overburden dumps (Year)					Garhjungle
		3	9	12	18	21	
#*Chromolaena odorata* (L.) R.M.King and H.Rob.	Asteraceae	130.5	67.2	23.9	40.3	42.3	-
#*Lantana camara* L.	Verbenaceae	43.3	35.9	59.6	84.7	34.2	-
#*Calotropis procera* (Aiton) Dryand.	Asclepiadaceae	10.9	5	4.7	-	-	-
#*Calotropis gigantea* (L.) Dryand.	Asclepiadaceae	10.6	-	-	2.4	-	-
Phyllanthus reticulatus Poir.	Euphorbiaceae	4.6	-	-	5.6	6.6	-
Clerodendrum infortunatum L.	Verbenaceae	-	61.9	64.4	54.2	103.7	-
**Cocculus hirsutus* (L.) W.Theob.	Menispermaceae	-	11.7	-	-	-	-
**Ventilago denticulata* Willd.	Rhamnaceae	-	6.4	-	-	-	-
**Cardiospermum halicacabum* L.	Sapindaceae	-	5.2	-	-	-	-
Deeringia amaranthoides (Lam.) Merr.	Amaranthaceae	-	3.8	-	-	-	-
Abutilon indicum (L.) Sweet	Malvaceae	-	2.9	-	4.6	2.6	-
**Olax scandens* Roxb.	Olacaceae	-	-	14.4	2.5	-	-
Breynia vitis-idaea (Brum.f.) C. E. C. Fisch.	Euphorbiaceae	-	-	10.8	-	-	-
Ziziphus oenopolia (L.) Mill.	Rhamnaceae	-	-	6.3	-	2.3	-
Woodfordia fruticosa (L.) Kurz	Lythraceae	-	-	4.3	-	-	-
Flacourtia indica (Burm.f.) Merr.	Flacourtiaceae	-	-	4.1	-	-	9.21
Catunaregam spinosa (Thunb.) Tirveng.	Rubiaceae	-	-	3.9	-	-	44.1
Cestrum diurnum L.	Solanaceae	-	-	3.6	-	-	-
**Ichnocarpus frutescens* (L.) W.T.Aiton	Apocynaceae	-	-	-	5.7	-	-
Mallotus repandus (Willd.) Müll.Arg.	Euphorbiaceae	-	-	-	-	8.4	-
**Erycibe paniculata* Roxb.	Convolvulaceae	-	-	-	-	-	59.9
Carissa spinarum L.	Apocynaceae	-	-	-	-	-	42.36
Jasminum multiflorum (Burm. f.) Andr.	Oleaceae	-	-	-	-	-	19.62
**Butea superba* Roxb.	Fabaceae	-	-	-	-	-	17.18
Combretum decandrum Jacq.	Combretaceae	-	-	-	-	-	7.64

Climbers indicated by *, Invasive species indicated by **#**

dumps. 3051 individuals of 53 herbaceous species under 21 families were recorded from early successional stage (Table 4, Fig. 2). Dominant early colonizing species as indicated by their importance values were *Brachiaria reptans*, *Echniochloa colona*, *Dactyloctenium aegyptium* from 1yr dump, and *Desmodium triflorum, Evolvulus nummularius* and *Aristida adscensionis* from 3yr dump. *Desmodium trifolium* and *Evolvulus nummularius* occurred in 1yr dump but their importance increased in 3yr dump. Fourteen species were restricted to 1yr dump while nine species were exclusively present in 3yr dump, including the dominant species *Echinochloa colona* and *Aristida adscensionis*. Species under Cyperaceae family were restricted to 1yr old dump where Poaceae and Fabaceae were dominant families. Monocots like Poaceae and Cyperaceae, and dicots like Fabaceae, Asteraceae and Rubiaceae contributed significantly in the early stages of succession. For ecological restoration of mined land, the colonizing ability of grasses along with nitrogen fixing leguminous species in degraded soil condition leading to vegetation development by tolerating low soil nutrient and adverse environmental conditions has been previously reported (Ekka and Behera 2011, Biswas et al 2014). Fourteen species recruited from 1or 3yr dump continued their existence upto late successional stage including species like *Cynodon dactylon* and *Sida cordata*.

Intermediate successional stage was represents by 2148 individuals of 41 species under 18 families, most of them belonging to Poaceae, Malvaceae and Fabaceae. Dominant herbs in this stage were *Desmodium triflorum*, *Sida cordata*, *Andrographis paniculata*, *Perotis indica*, *Cynodon dactylon*. Five species – *Sida cordata*, *Rungia pectinata*, *Cynodon dactylon*, *Anisomeles indica* and *Triumfetta rhomboidea* - were present in all dumps except 1yr dump while *Evolvulus nummularius* was present in all the overburden dumps. Species present throughout 9 to 21yr were *Andrographis paniculata*, *Cyanthillium cinereum* and *Perotis indica*. Five species were exclusively present in 9yr dump but there was no exclusive species in 12yr dump. Late successional stage was represented by 920 individuals of 24 species under 12 families. Dominance of *Andrographis paniculata*, *Sida cordata*, *Cynodon dactylon* and *Perotis indica* persisted in this stage in addition to another species of *Sida-Sida cordifolia*. The highest IVI recorded for a herbaeous species was 61.6 for *Andrographis paniculata* in 21yr dump. *Sida acuta* in 18yr dump and *Dichanthium* sp. in 21yr dump were exclusive species. In Garhjungle, 20 species of herbs with 1005 individuals belonging to nine families were recorded. Six out of these twenty species were not recorded from any overburden dump. Most important species were *Desmodium triflorum*, *Evolvulus nummuarius* and *Cynodon dactylon*. Two species each from 1yr dump (*Echinochloa colona* and *Hybanthus enneaspermus)* and 3yr dump (*Zornia gibbosa* and *Sporobolus diandrus*) and 1 species from 9yr dump (*Evolvulus alsinoides*), which were exclusive to that particular overburden dump, were also recorded from Garhjungle.

Density of herbs and grasses increased initially but decreased as the succession progressed (Fig. 3b). Garhjungle had higher herb density as compared to the late successional stage of the overburden dumps. Of 69 herbaceous species from overburden dumps, 15 were invasive alien species (Reddy et al 2008, www.bsienvis.nic.in 2016). Eight of these appeared from the first year of succession, five appeared from 3yr dump, and one each from 9 and 18yr dumps. However only two invasive species, *Triumfetta rhomboidea* and *Evolvulus nummularius,* continued upto 21yr dump. In Garhjungle three invasive herbs were recorded of which one was not present on overburden dumps. Vijayan and Joy (2016) in a study on distribution of invasive alien flora also reported majority of the invasive plants as herbs.

Generic co-efficient of the natural forest Garhjungle was 95.65 and of overburden dumps was 88.89 indicating more generic diversification in Garhjungle. Generic coefficient gives an indication of the trend of microclimatic status of a floristic organization (Roy and Mukherjee 2014). Tree density and basal area increased with dump age in the present study, however, density declined sharply in the 18yr dump that coincided with extremely high shrub density dominated by invasive *Lantana camara*. Again tree density and basal area increased appreciably in the 21yr dump. This gradual increase in tree density and basal area accompanied by decrease in herb density indicates progress of vegetation succession in right direction. Dominance of tree species effects functioning of ecosystem (El-Sheikh 2005) by reducing the ground water supplies. However total ecosystem recoveries has not been achieved after 21 years as the dumps still have high density of shrubs and climbers compared to adjacent natural forest.

Diversity and similarity measures of trees: Species richness (M) and heterogeneity (H') increased while within habitat beta diversity and evenness (E) decreased as the dump age increased (Table 5). Shannon-Wiener index increased from 1.92 in 3yr dump to 2.25 in 21yr dump though 12 and 18yr dumps had lowest and highest values, respectively. Species richness increased continuously from 1.36 in 3yr dump to 3.11 in 21yr dump during succession. Biswas et al (2014) also showed increase in species richness with increase in dump age. Dominance index (Cd) was highest in 12yr dump, but did not show any trend with dump

Table 4. Importance Value Index of herbs and grasses in different overburden dumps and Garhjungle

Species name	Family	Overburden dumps (year)						Garhjungle
		1	3	9	12	18	21	
Brachiaria reptans (L.) C.A.Gardner and C.E.Hubb.	Poaceae	39.42	-	4.4	-	-	-	-
#*Echinochloa colona* (L.) Link	Poaceae	27.62	-	-	-	-	-	12.15
Dactyloctenium aegyptium (L.) Willd.	Poaceae	19.77	-	2.5	-	-	-	-
#*Cleome viscosa* L.	Capparaceae	12.55	-	0.8	-	-	-	-
Centella asiatica (L.) Urb.	Apiaceae	11.49	-	-	-	-	-	-
Cyperus rotundus L.	Cyperaceae	11.07	-	-	-	-	-	-
#*Corchorus aestuans* L.	Tiliaceae	9.97	-	-	-	-	-	-
# *Evolvulus nummularius* (L.) L.	Convolvulaceae	9.65	15.2	6	5.7	22.9	5.1	22.24
Desmodium triflorum (L.) DC.	Fabaceae	8.04	40.3	42.4	-	-	-	37.99
Cyperus distans L.f.	Cyperaceae	5.12	-	-	-	-	-	-
# *Melochia corchorifolia* L.	Sterculiaceae	5.12	-	-	-	-	-	-
Merremia tridentata (L.) Hallier f.	Convolvulaceae	4.99	-	-	1	-	-	-
Spermacoce articularis L.f.	Rubiaceae	4.93	4.6	0.8	-	-	-	2.84
Cyperus castaneus Willd.	Cyperaceae	3.82	-	-	-	-	-	-
Tridax procumbens (L.) L.	Asteraceae	3.82	13.8	-	-	-	-	-
Lindernia crustacea (L.) F.Muell.	Scrophulariaceae	2.98	-	1.8	-	-	-	-
Digitaria bicornis (Lam.) Roem. and Schult.	Poaceae	2.27	1.7	-	-	-	-	-
Fimbristylis aestivalis Vahl	Cyperaceae	2.01	-	-	-	-	-	-
Crotalaria sp.	Fabaceae	1.49	-	-	-	-	-	-
Hybanthus enneaspermus (L.) F Muell.	Violaceae	1.36	-	-	-	-	-	13.85
Tephrosia purpurea (L.) Pers.	Fabaceae	1.36	2.3	1.6	-	-	-	-
Senna tora (L.) Roxb.	Caesalpiniaceae	1.36	-	2.9	-	-	-	-
# *Croton bonplandianus* Baill.	Euphorbiaceae	1.23	-	-	-	-	-	-
Murdannia nudiflora (L.) Brenan	Commelinaceae	1.23	-	-	-	-	-	-
# *Scoparia dulcis* L.	Scrophulariaceae	1.23	-	-	-	-	-	-
Senna sophera (L.) Roxb.	Caesalpiniaceae	1.23	-	-	-	-	-	-
Euphorbia hirta L.	Euphorbiaceae	1.23	5.8	0.8	-	1.2	-	-
Sida rhombifolia L.	Malvaceae	1.23	-	6.6	2.9	2.4	-	-
Solanum virginianum L.	Solanaceae	1.23	-	0.9	1	3.9	-	-
Teramnus labialis (L.f.) Spreng.	Fabaceae	1.23	-	-	-	2.3	-	-
Aristida adscensionis L.	Poaceae	-	13.9	-	-	-	-	-
Zornia gibbosa Span.	Fabaceae	-	11.9	-	-	-	-	2.84
Ammannia dentelloides Kurz.	Lythraceae	-	10.7	-	-	-	-	-
Sida cordata (Burm.f.) Borss.Waalk.	Malvaceae	-	9.9	9.3	41.4	37.8	24.8	-
Cajanus scarabaeoides (L.) Thouars	Fabaceae	-	8.9	-	1	3.7	-	1.69
Alysicarpus vaginalis (L.) DC.	Fabaceae	-	7.9	4.6	-	-	-	-
# *Hyptis suaveolens* (L.) Poit.	Lamiaceae	-	6.9	4.9	1.8	-	-	-
Pennisetum pedicellatum Trin.	Poaceae	-	6.2	-	-	-	-	-
Desmodium gangeticum (L.) DC.	Fabaceae	-	5.6	-	7.9	12.7	12.2	-
# *Urena lobata* L.	Malvaceae	-	5.5	1.8	-	-	-	-
Rungia pectinata (L.) Nees	Acanthaceae	-	4.2	2.3	14.1	11.3	4.2	-
# *Saccharum spontaneum* L.	Poaceae	-	3.6	5.8	-	-	-	-

Cont...

Table 4. Cont...

Species name	Family	Overburden dumps (year)						Garhjungle
		1	3	9	12	18	21	
Eragrostis unioloides (Retz.) Nees ex Steud.	Poaceae	-	3.3	-	-	-	-	-
Cynodon dactylon (L.) Pers.	Poaceae	-	3.3	24	12	31.9	5.5	45.98
Anisomeles indica (L.) Kuntze	Lamiaceae	-	2.9	2.5	1	4.5	7.8	-
# *Parthenium hysterophorus* L	Asteraceae	-	2	5.7	-	-	-	-
Achyranthes aspera L.	Amaranthaceae	-	1.7	1.5	1.8	2.6		-
Bothriochloa pertusa (L.) A. Camus	Poaceae	-	1.6	-	-	-	-	-
# *Triumfetta rhomboidea* Jacq.	Tiliaceae	-	1.5	0.8	9.7	4.7	7.6	-
Sporobolus diandrus (Retz.) P. Beauv.	Poaceae	-	1.4	-	-	-	-	1.89
Oldenlandia corymbosa L.	Rubiaceae	-	1.3	-	-	-	-	-
Blumea membranacea DC.	Asteraceae	-	1.3		2	1.6	-	-
Mitracarpus hirtus (L.) DC.	Rubiaceae	-	0.9	-	-	-	-	-
Perotis indica (L.) Kuntze	Poaceae	-	-	10.1	38.2	30.6	9.6	6.11
Chrysopogon aciculatus (Retz.) Trin.	Poaceae	-	-	9.7	-	-	-	-
# *Mimosa pudica* L.	Mimosaceae	-	-	7.8	-	-	-	-
Sida cordifolia L.	Malvaceae	-	-	7.2	-	-	26.1	0.95
Oplismenus compositus (L.) P.Beauv.	Poaceae	-	-	6.8	-	-	12.2	-
Andrographis paniculata (Burm.f.) Nees	Acanthaceae	-	-	6.6	40.8	7.8	61.6	0.87
Peristrophe bicalyculata (Retz.) Nees	Acanthaceae	-	-	5.2	2.6	-	-	-
Cyanthillium cinereum (L.) H.Rob.	Asteraceae	-	-	4.3	6.6	6.9	1.4	7.6
Setaria sp.	Poaceae	-	-	3	-	-	-	-
Saccharum bengalense Retz.	Poaceae	-	-	1.9	3.6	3.9		-
Commelina benghalensis L.	Commelinaceae	-	-	1.6	-	-	-	-
Evolvulus alsinoides (L.) L.	Convolvulaceae	-	-	1.3	-	-	-	6.71
Brachiaria sp.	Poaceae	-	-	-	3.5	-	19.6	-
Boerhavia diffusa L.	Nyctaginaceae	-	-	-	1.7	4.3	-	-
# *Sida acuta* Burm.f.	Malvaceae	-	-	-	-	3	-	-
Dichanthium sp.	Poaceae	-	-	-	-	-	2.3	-
Cyperus sp	Cyperaceae	-	-	-	-	-	-	16.2
Aristida setacea Retz.	Poaceae	-	-	-	-	-	-	10.54
Eranthemum pulchellum Andrews	Acanthaceae	-	-	-	-	-	-	3.63
Crotlaria prostrata Willd.	Fabaceae	-	-	-	-	-	-	2.56
# *Imperata cylindrica* (L.) Raeusch.	Poaceae	-	-	-	-	-	-	2.48
Ischaemum rugosum Salisb.	Poaceae	-	-	-	-	-	-	0.87

Invasive species indicated by #

age. Heterogeneity of tree layer was influenced more by richness than evenness as also reported by Borpujari (2008). Diversity indices of Garhjungle were similar to those observed in the intermediate successional stage of overburden dumps except the within habitat β-diversity.

Beta diversity or species turnover decreased with increase in difference in age of dumps when other dumps are compared with 3yr dump, and increased when dumps are compared with 21yr dump (Table 6). The beta diversity between 3 and 21yr dumps was less than that between 3 and 9yr dumps which was the highest turnover between any two dumps. Lowest beta diversity was observed between 12 and 18yr dumps. Unlike beta diversity increase in similarity index was observed with increase in difference of dump age when other dumps are compared with 3yr dump and decrease when compared with 21yr dump. The 3yr dump was more similar to 21yr dump than 9yr dump; but 21yr dump was more similar to 18yr dump than 3yr dump. Lowest similarity was observed between 3 and 9yr dumps while highest between 12 and 18yr dumps; however difference in age in both the cases is 6 years. Turnover of species was higher between Garhjungle and overburden dumps with highest turnover observed between Garhjungle and 12yr dump. These trends in beta diversity and similarity among the dumps were due to the maximum species replacement from early to intermediate stage followed by early to late and minimum from intermediate to late stage. Similarity index between Garhjungle and overburden dumps decreased from 3 to 21yr dumps with lowest similarity between Garhjungle and 12yr dump.

Diversity measures of shrubs and climbers: During succession from 3 dump to 21yr dump, heterogeneity of shrubs increased from 0.97 to 1.49 and species richness increased from 0.69 to 0.99 (Table 7), but highest heterogeneity and species richness were recorded in intermediate stage, i.e. 9 and 12yr dumps. Within habitat beta diversity also displayed the same trend. Dominance decreased with dump age being the lowest in the intermediate stage while evenness increased with dump age being the highest in the intermediate stage. Higher values of heterogeneity, evenness and beta-diversity but lower dominance index were displayed by Garhjungle when compared with overburden dumps.

Beta diversity or turnover of shrubs decreased or increased with increase in difference of dump age whereas similarity increased at many instances (Table 8). All the dumps showed maximum turnover and lowest similarity with 12yr dump. Minimum turnover with maximum similarity was observed between 18 and 21yr dumps, while maximum turnover with minimum similarity was observed between 3 and 12yr dumps. Total replacement of shrub composition showing full turnover and zero similarity was recorded between Garhjungle and overburden dumps except 12yr dump which showed very low similarity with Garhjungle.

Diversity and similarity measures of herbs and grasses: With increase in dump age from 1 to 21yr dumps, slight increase in Shannon's index was observed initially which later decreased. Species richness also decreased from 4.36 to 2.12 with increase in age, but highest value (4.61) was in 9yr dump (Table 9). Evenness increased but Simpson's dominance index did not vary much from 1 to 21yr dump. Heterogeneity of herb layer was influenced more by evenness. Within habitat beta diversity didn't follow a particular trend with age; but decreased from intermediate stage to later stage of succession. In Garhjungle, diversity indices like heterogeneity and richness were close to the values recorded in overburden dumps of late successional stage; and within habitat beta-diversity was lower than all of the dumps except 3yr dump.

The turnover increased and similarity decreased with the increasing difference in age of the dumps (Table 10). The species turnover rate between 21 and 1yr dumps was more than turnover between 21 and 18yr dumps; but similarity between 18 and 21yr dumps was more than similarity between 1 and 21yr dumps. Maximum turnover was between 1 and 21yr dumps while lowest between 12 and 18yr dumps.

Table 5. Diversity indices of tree species in overburden dumps and Garhjungle

Dump	H'	E	M	Cd	β
3 yr	1.92	1.19	1.36	0.31	4.28
9 yr	2.28	1.04	1.53	0.27	2.77
12 yr	1.52	0.56	2.26	0.6	4.05
18 yr	2.62	0.97	2.63	0.24	3.24
21 yr	2.25	0.75	3.11	0.38	3.57
Garhjungle	1.52	0.66	1.59	0.5	3.03

Table 7. Diversity indices of shrubs and climbers

Dump	H'	E	M	Cd	β
3 yr	0.97	0.6	0.69	0.64	2.6
9 yr	2.07	0.94	1.3	0.29	3.27
12 yr	2.04	0.85	1.6	0.34	3.49
18 yr	1.73	0.80	1.02	0.37	2.67
21 yr	1.49	0.76	0.99	0.48	2.92
Garhjungle	2.41	1.24	1.14	0.22	3.89

Table 6. Beta diversity and similarity of tree species among overburden dumps and Garhjungle

Tree dumps	3 yr		9 yr		12 yr		18 yr		21 yr	
	β_d	IS	β_d	IS	β_d	IS	β_d	IS	β_d	IS
9 yr	0.86	7.69								
12 yr	0.80	11.11	0.50	33.33						
18 yr	0.70	17.65	0.50	33.33	0.27	57.89				
21 yr	0.68	19.05	0.59	26.09	0.54	29.63	0.43	40		
Garhjungle	0.73	15.38	0.79	11.76	0.84	8.7	0.76	13.64	0.80	11.11

Table 8. Beta diversity and similarity of shrubs and climbers in overburden dumps and Garhjungle

Shrubs and climbers	3 yr		9 yr		12 yr		18 yr		21 yr	
Dumps	β_d	IS	β_d	IS	β_d	IS	β_d	IS	β_d	IS
9 yr	0.57	27.27								
12 yr	0.63	23.08	0.6	25						
18 yr	0.38	44.44	0.53	30.77	0.58	26.67				
21 yr	0.5	33.33	0.5	33.33	0.56	28.57	0.33	50		
Garhjungle	1	0	1	0	0.78	12.5	1	0	1	0

Table 9. Diversity indices of herbs and grasses

Dump	H'	E	M	Cd	β
1 yr	3.43	1.01	4.36	0.14	6.52
3 yr	3.66	1.08	3.75	0.14	4.29
9 yr	3.57	1	4.61	0.18	7.61
12 yr	3.16	1.04	3.17	0.16	6.13
18 yr	3.31	1.1	3.11	0.14	6.25
21 yr	3.18	1.2	2.12	0.14	6.36
Garhjungle	3.06	1.02	2.75	0.17	5.97

Table 10. Beta diversity and similarity of herbs and grasses in overburden dumps and Garhjungle

Herbs and grasses	1 yr		3 yr		9 yr		12 yr		18 yr		21 yr	
Dumps	β_d	IS	β_d	IS	β_d	IS	β_d	IS	β_d	IS	β_d	IS
3 yr	0.77	13.21										
9 yr	0.63	22.64	0.51	32.65								
12 yr	0.84	8.51	0.57	27.5	0.46	36.59						
18 yr	0.8	11.11	0.56	28.21	0.49	34.15	0.17	70.83				
21 yr	0.95	2.33	0.68	18.92	0.55	28.95	0.37	45.83	0.41	41.67		
Garhjungle	0.8	11.11	0.72	16.28	0.67	19.57	0.71	17.14	0.7	17.65	0.65	21.43

Similarly the lowest similarity was seen between 21 and 1yr dump, while highest between 18 and 12yr dumps. All the overburden dumps showed high species turnover and low similarity with the adjacent natural forest. With increase in dump age, beta diversity between overburden dumps and Garhjungle slightly decreased, while similarity in species composition between Garhjungle and overburden dumps slightly increased. The late successional stage of the herb layer was comparable to the herb layer of Garhjungle in terms of diversity and density. Gairola and Soni (2011) also reported similarity in herbaceous species of restored mined sites and adjacent natural forest. In a previous study on Sonepur Bazari area of Raniganj, the cover and species richness of grasses and associated herbs reached the level of their surroundings after 20-21 years of succession while tree established more slowly (Kumar et al 2011).

From above analysis, low similarity and high turnover of trees and herbaceous species indicated high spatial heterogeneity among different overburden dumps. Replacement of herbaceous species increased with age while similarity was higher between the dumps of intermediate and late successional stage for trees. Slight decrease in the species turnover during successional changes is generally accepted (Martinez-Ruiz and Fernández-Santos 2005, El-Sheikh 2005). In early and late successional stages, dominance of few species was high for shrubs whereas evenness was high in the tree and herb layers. Herbs displayed lower diversity and higher similarity with adjacent natural forest as compared to trees while shrub and climbers showed complete replacement between overburden dumps and Garhjungle except 12yr dump.

CONCLUSION

Natural succession started quickly on degraded land with initial colonization by grasses belonging to Poaceae and Cyperaceae, and leguminous herbs, which helped in establishment of vegetation. It was also responsible for improving the habitat conditions for later invasion by trees and shrubs. Generic Coefficient of overburden dumps also indicated the possibility of successful revegetation in restored mined area by natural succession. Species richness and heterogeneity for tree layer increased during succession, shrub layer was the most diverse in intermediate stage while herb layer was more diverse and dense in the early successional stage. Many shrubs and climbers appeared in intermediate stage but could not succeed upto late successional stage. High dominance of *Chromolaena odorata*, *Clerodendrum infortunatum* and *Lantana camara* might have prevented successful colonization by other shrubs. Decrease in herb density with increase in tree density, diversity and basal area along the age gradient showed that succession was in progressive direction.

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Phytosociological Assessment of Tree Vegetation in Tropical Moist Deciduous Forest of Veerakkal area, Nilgiris, Western Ghats, India

E.K. Ramya, S. Sharmila and S. Mownika

Department of Botany, Vellalar College for Women (Autonomous), Erode-638 012, India
E-mail: ekramya16@gmail.com

Abstract: A phyto-sociological study was accomplished in the Tropical moist deciduous forest of Manar beat (Veerakkal forest ecosystem), Karamadai Reserve forest, Nilgiris South Division, India during January to December 2018. Nineteen tree species belongs to 13 families were identified. The circumference ranged between 100-180 cm and height between 15 to 25 m. *Pongamia pinnata* and *Terminalia arjuna* depicted the highest important value index (IVI) which defined the dominant species. Community indices Shannon diversity (2.7877), Simpson index (0.1352), Margalef index (4.2513), Menhinick's index (0.2753) and equitability of evenness (2.1813) of the tree species the community indicate the status of biodiversity of tree species. *Dalbergia latifolia* and *Santalum album* species are comes under vulnerable category in 2019, and these species are observed in the ecological survey of sampling plots.

***Keywords*:** Manar beat, IVI, Tree species diversity, Species dominance, Vulnerable

Forest is the natural resources which interact the entire functional biological ecosystem throughout the globe and the Veerakkal forest area of Manar Beat is enriched with biological diversity and natural habitat for wild life. Forest ecosystem is an interdependent with biological and physico-chemical components, the biological system which has produced new organic matter by successive generation of plants and animals (Kimmins 2004). Seasonal changes leads to fluctuation in temperature, soil moisture and light. Thus directly or indirectly impacts on different types of vegetation. As compared with different forest vegetation, tropical forest contributes vital role in its biological values on earth. This tropical forest plays massive role in the ecosystem by proving the valuable services viz., preventing soil erosion, climate change mitigation, species protection and preservation of plants and animals (Armenteras et al 2009). The tropical forest covers only 7% in mainland but it provides life for almost half of the world species (Galley 2014), however at present tropical forests are vanishing at a frightening rate of 0.8 and 2% per annum (Suhs et al 2019). The study area is reserved and protected areas, biodiversity studies have not been conducted for plants especially a majority of taxonomic group and ecosystem types and there is an immense need to assess the existing values of species and the present status, threats which may offers long period of conservation. The current study was performed to assess the status of tree biodiversity in Veerakkal tropical moist deciduous forest in Western Ghats, India.

MATERIAL AND METHODS

Veerakkal reserve forest is a type of Tropical moist deciduous forest located in the Manar beat, Karamadai Range, Nilgiris South Division, Western Ghats, Tamil Nadu, India. The Veerakkal tropical moist deciduous forest area lies between 11° 13.849' of Northern latitude and 76° 45.052' of Eastern longitude with the elevation of 476 m. Mulli and Aathikadavu are the two main river water sources, which later combine to form a Bhavani river passed out through the forest. The Veerakkal forest covers 10.80 hectares. Average annual temperature ranges from 14℃-33℃ and average annual rainfall is 600-850mm.

Meteorological data: Meteorological data of Karamadai forest such as temperature, rainfall, rainy days, wind speed, pressure, relative humidity, cloud, sun hours and sunny days were collected from District Forest Office, Coimbatore Circle, Tamil Nadu, India and from Karamadai weather source (https://www.worldweatheronline.com/lang/en-in/karamadai-weather/tamil-nadu/in.aspx).

Phytosociological methodology: Phyto-sociological analysis of tree species were carried out in the Veerakkal forest area, Manar beat, Karamadai Range, Western Ghats during the month of January to December 2018 followed by Cottom and Curtis (1956) method.

Data collection: For phyto-sociological survey, the size of the belt transact was fixed as 100 × 10 m. Each plot was divided into 100 equal subunits (10 x 10 m each). A total of 10 belt transects were laid randomly to observe the species for their ecological characters. The individuals of each study species in the respective sampling plots were noted to find out the quantitative parameters and community indices of tree diversity. The identification of individual tree species within the sampling plots were based on observations during photographed and noted by their local names at the time of survey, which was done mainly with the help of tribal people, forest guards and range officer. The scientific name of the tree species was determined by scientific literatures, books, articles, floras, monographs and consultations with specialists (Fyson 1915-20, Gamble and Fischer 1967, Matthew 1983). The identity of the tree species were authenticated by Botanical Survey of India, Southern Circle, TNAU Campus, Coimbatore, Tamil Nadu (No.BSI/SRC/5/23/2018/Tech.). The collected and processed herbarium specimen was deposited in the Department of Botany, Vellalar College for women (Autonomous), Erode for future reference. The identified and authenticated species were classified according to their conservation status by using Red data list. The tree species with level of extinction risk was reported i.e., based on the classified data as Vulnearable (Vu) and Least concern (LC) based on IUCN (2019) guidelines.

Data analysis: To analyse the level of diversity in tree vegetation several quantitative parameters like density, frequency, abundance, relative density, relative frequency, relative dominance, basal cover and importance value of the sampled species were followed as per the method of Cottom and Curtis (1956). The total basal area was calculated from the perimeterfor the sum of the total diameter of the trees. It was measured at breast height (1.5 m).

$$\text{Parameter Density} = \frac{\text{Total No. of individuals of a species in all sampling plots}}{\text{Total No. of sampling plots studied}}$$

$$\text{Frequency} = \frac{\text{Total No. of sampling plots in which species occur}}{\text{Total No. of sampling plots studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total No. of individuals of a species in all sampling plots}}{\text{Total No. of sampling plots in which species occured}}$$

$$\text{Relative density} = \frac{\text{No. of individuals of the species}}{\text{No. of individuals of all the species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{No. of occurrence of the species}}{\text{No. of occurrence of all the species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal cover of the species}}{\text{Total basal cover of all the species}} \times 100$$

IVI= Relative density + Relative frequency + Relative dominance

Basal area = (Circumference at breast height)^2/12.56

Basal cover= Basal area × Number of individuals of respected species

Data processing: The collected data was used to find out the community indices like species diversity (H'), species dominance (Cd), equitability of evenness (e), species richness (D), Menhinick's index (D_{mm}) and equitability of index (EH) of species in the ecosystem. It was calculated by using the following equation,

a) Species diversity (Shannon and Wiener 1963)

(H') = - ∑ [(ni / N). ln (ni / N)]

Where, ni= IVI of individual species, N= Total IVI of all the species.

b) Species dominance (Simpson 1949) Cd = Σ (ni/N)^2

Where, ni= IVI of individual species, N= Total IVI of all the species.

c) Equitability of evenness (Pielou 1966)

Evenness (e) = H'/log S

Where, H'= Shannon index, S = Number of species.

d) Species richness (Margalef 1968) D=(S-1)/ln N.

Where, S = Number of species, N= Total number of individuals.

e) Menhinick's index (Whittaker and Levin 1977) D_{mm}=S/ N,

Where, S= Number of species, N= Number of individuals in the sample

f) Equitability of index (Simpson 1949)

(EH)=H'/Hmax = H'/ln S

RESULTS AND DISCUSSION

Meteorological data of study site: Veerakkal forest is a type of tropical moist deciduous forest located in the Manar beat, Karamadai Range, Nilgiris South Division, Western Ghats, Tamil Nadu, India. The study area covers 10.80 hectares. The climatic data such as temperature, rainfall, rainy days, wind speed, pressure, relative humidity, cloud, sun hours and sun days of study site were observed for 12s from January to December 2018 (Table 1). Considering the elevation and proximity, the temperature ranges from 16.3ºC to 36.9ºC. The intensity of solar radiation is generally high in March - May months. The maximum temperature was recorded in the month of April approximately 36.9ºC. The monthly rainfall values ranged from 1.8 mm to 134.9 mm in the study region. The total rainfall for the year 2018 (January to December) was 508.82 mm. The maximum rainfall in the study area was occurred in October (134.9 mm) which occur during 21 days intervals and minimum rainfall was exists in January (1.8 mm). Maximum high rainy days was observed in May with moderate rainfall (125.08 mm) and lowest rainfall and rainy days were observed in January. The average annual wind speed was ranged between 4.3 to 12.7 kmph. The maximum pressure in the area was noted in February and December, and the same were low in May. Annual relative humidity of study area was ranged between 51-70%. Considering of rainfall and rainy days, the cloud conditions were occurred in the range of 10-46 %. Likewise, based on the temperature, the sun hours and sun days were calculated and same were recorded in the range of 181-346 hrs in sun hours observation and 1-26 days for sun days.

Tree species: The present ecological study, Nineteen species (dicots) of 17 genera and 13 families (Angiosperms) were observed in the 10 belt transects in tropical moist deciduous forest (Table 2). The findings have illustrated that a total of 69 individuals were documented during the field

Table 1. Meteorological factors of the study area

Year and month 2018	Temperature (^{o}C)			Rainfall (mm)	Rainy days	Wind speed (kmph)/ average	Pressure (mb)	Relative humidity (%)	Cloud (%)	Sun hours (hr)	Sun days
	Maximum	Minimum	Average								
January	30.2	16.3	23.2	1.8	4	4.3	1012.2	59	14	310	26
February	32.6	18.3	25.4	14.09	5	5.3	1013.0	51	10	280	23
March	34.0	20.3	27.1	39.49	12	5.4	1011.2	47	15	299.5	16
April	36.9	23.7	30.3	23.85	24	5.7	1009.9	51	24	273	1
May	33.7	25.8	29.7	125.08	30	6.3	1008.3	60	23	346	0
June	32.7	25.7	29.2	15.21	13	11.7	1008.7	63	28	314.5	9
July	33.2	25.1	29.1	4.95	5	12.7	1009.1	62	27	298	23
August	32.0	24.2	28.1	30.47	6	11.9	1009.7	64	27	295	20
September	33.6	22.1	27.8	30.98	15	7.2	1010.3	60	18	300	12
October	32.3	20.0	26.1	134.9	21	5.7	1011.5	60	46	200	10
November	30.6	18.1	24.3	44.6	21	5.4	1012.6	69	39	181	9
December	29.3	18.6	23.9	43.4	24	5	1013.0	70	42	207	5

Table 2. Quantitative parameters measured for different tree species of Veerakkal forest area

Botanical name	D	Fr (%)	A	RD	RF	RDO	BA	BC	IVI
Adenanthera pavonina L. (Mimosaceae)	0.5	40	1.25	7.25	6.56	1.35	248.16	124.08	15.16
Albizzia lebbeck Benth. (Mimosaceae)	0.4	40	1.00	5.80	6.56	5.00	1146.7	458.68	17.36
Ailanthus excels Roxb. (Simaroubaceae)	0.1	10	1.00	1.45	1.64	0.56	509.65	50.96	3.65
*Alangium salvifolium*Wang.(Alangiaceae)	0.1	10	1.00	1.45	1.64	0.45	412.38	41.24	3.54
Artocarpus integrifolia L. (Moraceae)	0.3	30	1.00	4.34	4.92	1.84	562.14	168.64	11.10
Azadirachta indica A.Juss. (Meliaceae)	0.5	30	1.14	7.25	4.92	7.56	1387.38	693.69	19.73
Bauhinia racemosa Lam. (Fabaceae)	0.4	40	1.00	5.80	6.56	5.00	1146.7	458.68	17.36
Cordia sinensis Lam. (Boraginaceae)	0.2	20	1.00	2.89	3.27	3.26	1494.99	298.99	9.42
Celtis philippensis Blanco. (Cannabaceae)	0.6	50	1.33	8.69	8.20	9.80	1497.7	898.62	26.69
Dalbergia lanceolaria L.f. (Fabaceae)	0.1	10	1.00	1.45	1.64	2.75	2521.9	252.19	5.84
Dalbergia latifolia Roxb. (Fabaceae)	0.2	20	1.00	2.89	3.27	3.55	1628	325.60	9.71
Ficus bengalensis L. (Moraceae)	0.2	20	1.00	2.89	3.27	5.74	2631.67	526.33	11.90
Ficus religiosa L. (Moraceae)	0.3	20	1.16	4.34	3.27	7.35	2247.69	674.31	14.96
Gardenia resinifera Roth. (Rubiaceae)	0.6	60	1.45	8.69	9.84	10.65	1628	976.80	29.18
Phyllanthus debilis Hook.f. (Euphorbiaceae)	0.2	20	1.00	2.89	3.27	3.80	1744.41	348.88	9.96
Pongamia pinnata (L.)Pierre. (Fabaceae)	0.8	80	1.67	11.59	11.47	11.53	1322	1057.60	34.59
Strychnos nux-vomica L. (Loganiaceae)	0.3	30	1.00	4.34	4.92	2.30	703.68	211.10	11.56
Santalum album L. (Santalaceae)	0.4	30	1.20	5.80	4.92	6.80	1560.09	624.03	17.52
Terminalia arjuna W.& A. (Combretaceae)	0.7	60	1.50	10.14	9.83	10.70	1401.9	981.33	30.67

D- Density; Fr- Frequency; A- Abundance; RD- Relative density; RF- Relative frequency; RDO- Relative dominance; BA- Basal area; BC- Basal cover; IVI- Importance Value Index survey. The most representative family was Fabaceae (4sps.) followed by Moraceae (3 sps). Kacholi (2014) and Srinivasa Rao et al (2015) reported that Fabaceae family contributes the most dominant species for the tree component in Kilengwe Forest, Tanzania and Khammam District, Telangana including those from tropical forest. The most representative genera were *Dalbergia* and *Ficus*. According to the Red data list, two species viz., *D. latifolia* and *S. album* are classified under vulnerable category on the world list. The frequency index (80%) was maximum *Pongamia pinnata* in followed by *Terminalia arjuna* (60%), *Gardenia resinifera* (60%) and *Celtis phillipensis* (50%). On the same time result of as the abundance index (1.67), density (0.8), relative dominance (11.59) indicated that *Pongamia pinnata* was highly dominant in Veerakkal forest, Karamadai range, Tamil Nadu. Only few tree species have good IVI values. The phyto-sociological observation of this study indicates that *Pongamia pinnata* was the dominant species in the Veerakkal forest which had maximum important value index (34.59). The co-dominant species were *Terminalia arjuna*, *Gardenia resinifera* and *Celtis phillipensis* with IVI value of 30.67, 29.18 and 26.69, respectively. The pattern of few dominant species and a number of sub dominant species and rarely occurred species were reported as common in upper montane forest and used for community indices studies (Silva et al 2017, Suhs et al 2019). The species *Alangium salvifolium* and *A. excels* indicates minimum IVI. The total basal area was 25795.14 m^2 ha^{-1} with diameter ranging between 100-180cm and trees height between 15-25m. The *P. pinnata* had highest basal cover area (1057.60 $m^2 ha^{-1}$). This is in corroboration with the work of Shahid and Joshi (2016) and Sarkar (2016).

Diversity indices: Community indices were used to determine the overall status of tree biodiversity indicate significant differences. The highest Shannon's diversity index (H') was observed in *P. pinnata* (0.2486) and the lowest was in *A. excels* and *A. salvifolium* (0.0531). The total diversity index (H') of tree species was 2.7877, whereas total species dominance (Cd) and evenness (e) was as 0.1352 and 2.1813, respectively. The result of community indices indicates that the species *Pongamia pinnata* had more Shannon's index, species dominance and evenness when compare to other species (Table 3). Similar phyto-sociological index values were observed in upper montane forest of Brazil with the range of 2.79 and 2.43 (Higuchi et al 2013, Silva et al 2017). To assess the overall status of biodiversity in Veerakkal tropical moist deciduous forest area, the community indices result indicates that the total species richness was 4.2513 and Menhinick's index was 0.2753. Srinivasa Rao et al (2014) observed that the tree species richness was varied according to the trouble gradients in the different strands. The result of equitability index (0.9482) also indicates that the sampling plots had equal number of individuals of various species in the ecosystem (Table 4). Sarkar (2016) opined that the equitability of evenness in tropical forest signifying a high evenness of individuals distributed among the sampled species.

Table 3. Community parameters for various tree species of Veerakkal forest area

Botanical Name	Shannon index (H')	Species dominance (Cd)	Evenness (e)
Adenanthera pavonina L.	0.1517	0.0026	0.1187
Albizzia lebbeck Benth.	0.1651	0.0034	0.1292
Ailanthus excels Roxb.	0.0531	0.0001	0.0415
Alangium salvifolium Wang.	0.0531	0.0001	0.0415
Artocarpus integrifolia L.	0.1219	0.0014	0.0954
Azadirachta indica A.Juss.	0.1793	0.0043	0.1403
Bauhinia racemosa Lam.	0.1651	0.0034	0.1292
Cordia sinensis Lam.	0.1076	0.0010	0.0842
Celtis philippensis Blanco.	0.2152	0.0079	0.1684
Dalbergia lanceolaria L.f.	0.0753	0.0004	0.0589
Dalbergia latifolia Roxb.	0.1101	0.0010	0.0862
Ficus bengalensis L.	0.1287	0.0016	0.1007
Ficus religiosa L.	0.1497	0.0025	0.1171
Gardenia resinifera Roth.	0.2263	0.0095	0.1771
Phyllanthus debilis Hook.f.	0.1125	0.0011	0.0880
Pongamia pinnata (L.) Pierre	0.2486	0.0133	0.1945
Strychnos nux-vomica L.	0.1265	0.0015	0.0990
Santalum album L.	0.1651	0.0034	0.1292
Terminalia arjuna W.& A.	0.2328	0.0105	0.1822

Table 4. Different community indices for Veerakkal forest area

Community indices	Mean
Species diversity (H')	2.7877
Species dominance (Cd)	0.1352
Equitability of eveness (e)	2.1813
Species richness (D)	4.2513
Menhinick's index (D_{mm})	0.2753
Equitability index (EH)	0.9482

Same column with different superscript were significantly different (P < 0.05)

CONCLUSION

The *Pongamia pinnata* and *Terminalia arjuna* are the dominant tree species in the Veerakkal forest ecosystem. The diversity of tree species is being synchronized by factors like community, stability and evolutionary period as heterogeneity of both micro and macro environment influence the diversification among various communities. The quantitative distribution could act as indicators of anthropogenic disturbances that are affecting the various forest types and such studies would help in understanding the threats that are being faced by the tropical moist forests.

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Efficacy of Different Bioassays for the Assessment of Toxicity of Plant Extracts

Sudhir Kumar, M. Chauhan, Neerja Singh and Manjula K.Saxena

Department of Botany, University of Rajasthan, Jaipur-302 004, India
E-mail: manjulaksaxena@yahoo.com

Abstract: The toxicity of eight weed species was assessed by four bioassays using different organism's viz., wheat (*Triticum aestivum* L), rice (*Oryza sativa* L.), lettuce (*Lactuca sativa* L.) in terrestrial, and duckweed (*Spirodela polyrhiza* L.) in aquatic medium. Among all, wheat bioassay gave the best results. The growth of wheat seedlings in different concentrations (1 to 3% w/v) of aqueous leachate of 5 species, *C. album, E. ciliaris, A. mexicana, T. grandis* and *V hastata* reduced significantly, whereas, *A. ramosa, P. virgatum* and *V. cineraria* were found to be least affected. Lettuce and rice bioassay were not found suitable for ascertaining allelopathy. Duckweed bioassay gave doubtful results in some species. The study suggested the use of wheat bioassay for assessment of allelopathy of plant extracts in India.

Keywords: Allelopathic, Toxicology, Allelochemicals, Bioactivity, Bioassay

The bioassays have been contemplated one of the most widely accepted tools for examining the toxicity of chemicals. It is also frequently used to demonstrate allelopathic activity of allelochemicals. It involves the use of biological organism to test for chemical toxicity. A number of organisms have been used to monitor allelopathy. Wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), lettuce (*Lactuca sativa* L.), mustard (*Brassica nigra* L.), radish (*Raphanus sativus* L.) and duckweed (*Spirodela polyrrhiza* L. Schleid.) were tested for determination of efficacy of various bioassays (Gupta and Saxena 2005). Both plants and animals have been used as test species in bioassays (Sodaeizadeh et al 2010). The crop seeds viz., wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.) and guar (*Cyamopsis tetragonoloba* L.) Taub, moth (*Vigna ungiculata*), weeds like *Verbesina encelioides* and *Tephrosia purpurea* were used as biological test material for bioassay (Rice 2012). Besides, *Chenopodium* sp. and *Portulaca oleracea* was also used in bioassay (Ahmed et al 2004, Al-obaidi 2020). Use of bacterial and fungal bioassays is also quite common in allelopathic studies and generally used to check the toxicity of allelochemicals (Meena 2009, Singh and Saxena 2016, El-Mergawi and Al-Humaid 2019). All different types of bioassays have their own importance as used for different purposes. In order to investigate allelopathic potential, a comparison among 4 bioassays was made to ascertain the differences.

MATERIAL AND METHODS

Eight target species viz*., Chenopodium* sp., *Vernonia* sp., *Verbena* sp., *Argemone* sp., *Amberboa* sp., *Tectona*. (dicot species), *Eragrostis* sp. and *Panicum* sp., (monocot species) were screened for ascertaining their allelopathic potential on 4 test species viz., wheat, lettuce, rice and duckweed using the following Standard bioassays:

Seed germination and seedling growth bioassay: The following three bioassays were performed using **s**eed germination growth experiments in Petri dishes under laboratory conditions were set up using wheat variety Raj. 1482), rice (*Oryza sativa* L**.** variety PR 106), lettuce (*Lactuca sativa*) seeds for wheat, rice and lettuce bioassay, respectively. Different concentrations of aqueous leachates of target weeds ranging 1 to 3% were used. The seeds of wheat, rice and lettuce were surface sterilized with 0.1% $HgCl_2$ solution and washed three times thereafter with sterilized distilled water and dried with filter paper. The pre-sterilized Petri dishes (9cm) were lined with two filter papers. Ten healthy seeds of each were kept at equidistance on the top of filter paper in separate Petri dishes for each treatment replicated three times. As per treatment, 5 ml aqueous leachate (distilled water in control) was added in each Petri dish on first day and 3 ml each on 2, 4 and 6 days after sowing DAS (Days after sowing) in treated an. The Petri dishes were kept in the dark in BOD incubator at 20-22°C for wheat, 18-20°C for lettuce and 35-40°C for rice. The plants were harvested 7 days after sowing and then the parameters viz., percent germination, root and shoot length of seedlings and dry weight were measured.

Duckweed bioassay (*Spirodela polyrrhiza*): In duckweed bioassay, *Spirodela polyrrhiza* of family Lemnaceae was used as biological test material. The duckweed bioassay was performed in small plastic disposable pots in aquatic medium (water). Plastic disposable pots filled with leachate of different concentration (1-3% w/v) for treated sets and distill water for control was used. Ten fresh plants having two fronds with bud were kept in each pot. A total of 20 pots with 5 replicates of each treatment were set during the experiment. The number of fronds in each plant was counted and their dry weights were measured. Plants were harvested on 7, 14, 21 days of the experiment. The data was analyzed using statistically by standard deviation and correlation coefficient between parameters and concentration of aqueous leachate of test species.

RESULTS AND DISCUSSION

Wheat bioassay The germination, root lengths and shoot lengths of wheat seedlings significantly) affected by all weed species except *A. ramosa* and *V. cineraria*. The aq. leachate of the 5 species, *C. album, E. ciliaris, A. mexicana, T. grandis* and *V. hastata* reduced significantly the dry weight of wheat seedlings more than 90 % (Fig. 1), whereas, *A. ramosa, P. virgatum* and *V. cineraria* least affected the growth of seedlings. The toxicity of concentration of aq. leachates and the growth parameters are negatively correlated (r = –0.806 to –0.999). The toxicity increased with enhancement of the concentration of the leachate (Table 7 and 8).

Rice bioassay All parameters of growth of rice seedlings of all species investigated and the concentration of aqueous leachate (Table 1 and 2) are negatively perfectly correlated (r = -0. 8069 to -0.9911) except in dry weight of *C. album* (r = -0.7494). Mostly, all species reduced the growth of rice seedlings more than 90% except two (Fig 1).

Lettuce bioassay The growth parameters and concentration of aq. leachates of all 8 species are significantly perfectly negatively correlated (Tables 3 and 4). However, the toxicity appeared only after 21 days in most cases. Further, all species declined the dry weight of lettuce seedlings significantly (Fig. 1). .

Duckweed bioassay: *A. maxicana* promoted the growth of duckweed to 146% (Fig 1) while all other species inhibited the same. Whereas, *E. ciliaris* did not affect the same. *T. grandis* was highly toxic to the growth of duckweed and decreased the growth to 95%. Duckweed completely died after 21 days at higher concentration (Table 5 and 6).

Bioassays are the first choice to study allelopathic potential of any species (Duke 2015). Besides seed germination bioassays allelopathic potential of aqueous leachates of target plants have also been tested in aqueous medium using aquatic plants and animals. Whole organism bioassay has also been recommended for evaluation of toxicity in terrestrial and aquatic systems with a range of organisms viz., diatoms, algae and aquatic plants (Burgos 2015). The common organisms employed for screening the

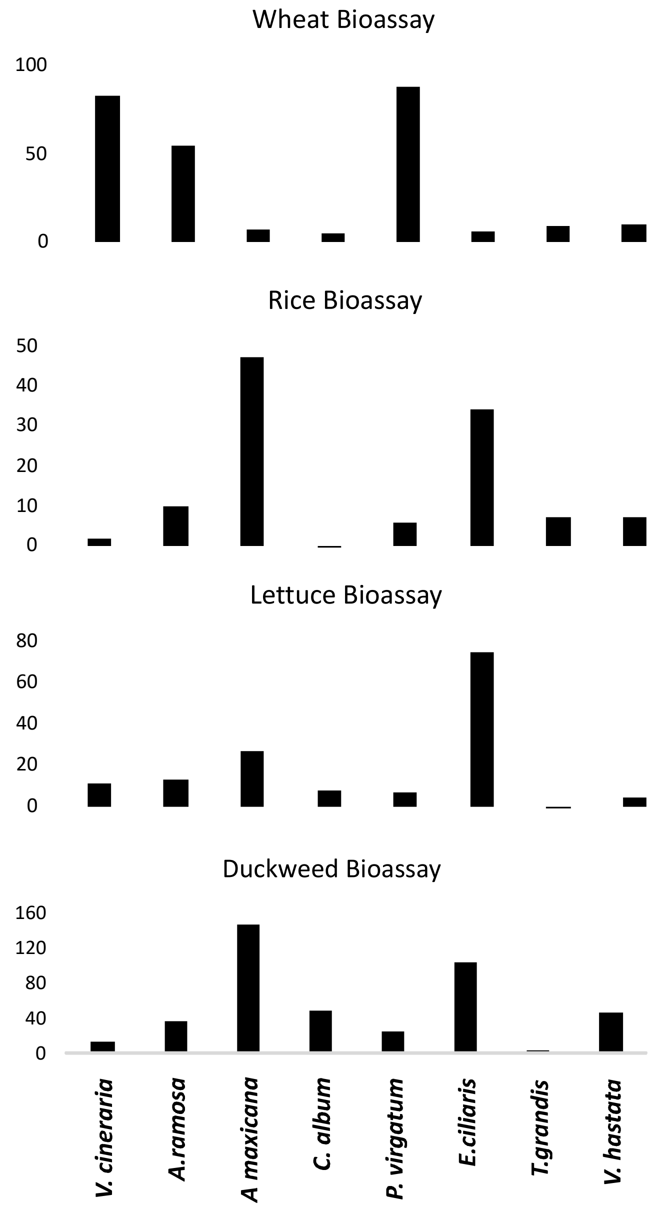

Fig. 1. Dry weight of seedlings and duckweed (% of control) for comparison of four bioassays for allelopathic potential of 8 weeds

toxicity of target allelopathic species are *Hydrilla verticillata* (Shabana et al 2003, Hassan et al 2016), *Myriophyllum* sp., (Feiler 2004), *Lemna* sp. (Mkandawire et al 2014, Ghanem et al 2019), *Spirodela polyrrhiza* (Ziegler et al 2016, Al-balawna et al 2018), *Ceratophyllum* sp. (Sodaeizadeh et al 2010) among plants whereas *Daphnia* sp. (Sotero 2005, Barata et al 2008), Brine shrimp larvae *Artemia salina* (Molina-Salinas et al 2006, Rajabi et al 2015, Sarah 2017), amphibian egg (Seneviratne et al 2015), fish (Burkholder 2001, Paolo et al 2015) among aquatic animals.

Individual species responded differently in various bioassays. All bioassays displayed toxicity of *Tectona*

Table 1. Allelopathic potential of some plant species (rice bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Vernonia cineraria					
G (%)	100±0.00	70.00±8.1	65.00±12.9	62.5±5.00	–0.9304*
RL (cm)	9.74±0.54	5.35±0.04	4.56±0.12	4.47±0.65	–0.9733**
SL (cm)	8.46±0.49	4.12±0.07	3.20±0.29	3.17±0.02	–0.8939
T. DW (g)	2.190±0.0	1.075±0.0	1.058±0.00	0.037±0.0	–0.8637
Amberboa ramose					
G (%)	97.50±0.00	95.00±2.88	92.50±2.50	87.5±4.75	–0.9796**
RL (cm)	9.74±0.54	7.58±0.33	6.22±0.18	5.44±0.38	–0.9911**
SL (cm)	8.46±0.49	5.05±0.52	4.59±0.46	3.21±0.29	–0.9718**
T. DW (g)	1.190±0.00	1.146±0.05	0.120±0.01	0.116±0.05	–0.9012
Argemone *Mexicana*					
G (%)	98.75±1.25	97.50±2.50	95.00±2.88	92.50±2.50	–0.9882**
RL (cm)	9.74±0.54	4.12±0.317	3.17±0.08	2.85±0.12	–0.9148*
SL (cm)	8.46±0.49	3.30±0.13	3.06±0.05	2.70±0.02	–0.8638
T. DW (g)	2.190±0.00	1.043±0.01	1.040±0.00	0.038±0.00	–0.8660
Chenopodium album					
G (%)	93.33±3.33	90.00±5.73	87.5±4.78	77.5±5.00	–0.9385*
RL (cm)	9.74±0.54	5.25±0.12	4.27±0.11	3.34±0.05	–0.9637**
SL (cm)	8.46±0.49	3.86±0.34	3.64±0.30	3.32±0.14	–0.8566
T. DW (g)	2.190±0.00	0.052±0.00	0.034±0.00	0.006±0.00	–0.7494

G (%) - Germination, RL - Root length, SL - Shoot length, T.DW - Total Dry Weight, Mean± S.E., GIR - Germination inhibition rate, r - correlation coefficient* & **significant at 0.05% & 0.01% level
where $t = r\sqrt{n-2}\,/1-r^2$

Table 2. Allelopathic potential of some plant species on rice (rice bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Eragrostis ciliaris					
G (%)	98.00±2.00	77.50±5.00	72.5±5.00	70.00±8.16	–0.9174*
RL (cm)	9.74±0.45	4.99±0.55	3.50±0.32	3.26±0.43	–0.9386*
SL (cm)	8.46±0.49	4.64±0.75	3.95±0.35	2.90±0.27	–0.9677*
T. DW (g)	2.190±0.00	0.102±0.00	0.092±0.00	0.061±0.05	0.8479
Panicum virgatum					
G (%)	97.50±2.50	92.50±4.08	90.00±4.08	90.00±4.78	–0.9152
RL (cm)	9.74±0.54	5.03±0.67	4.72±0.56	3.66±0.49	–0.9281*
SL (cm)	8.46±0.49	5.19±0.93	4.53±0.72	3.62±0.54	–0.9642*
T. DW(g)	2.190±0.00	0.083±0.071	0.053±0.050	0.043±0.37	–0.8581
Tectona grandis					
G (%)	100±0.00	93.30±3.33	90.00±5.77	88.00±4.65	–0.9691*
RL (cm)	6.75±0.06	5.45±0.00	4.43±0.001	3.45±0.017	–0.9214*
SL (cm)	6.68±0.002	6.55±0.012	6.04±0.008	3.90±0.021	–0.8658
T. DW (g)	2.198±0.101	0.182±0.000	0.163±0.101	0.154±0.03	–0.8068
Verbena hastata					
G (%)	100. ±0.00	96.77±3.33	94.00±4.78	93.30±3.33	–0.9694*
RL (cm)	5.93±0.00	5.51±0.00	4.92±0.00	4.02±0.00	–0.9749**
SL (cm)	5.61±0.07	5.15±0.26	4.53±0.02	3.59±0.016	–0.9744**
T. DW (g)	2.198±0.101	0.182±0.00	0.163±0.102	0.154±0.04	–0.8991

See Table 1 for details

Table 3. Allelopathic potential of some plant species on lettuce (lettuce bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Chenopodium album					
G (%)	100±0.00	72.5±5.00	65.00±5.77	62.5±5.00	–0.9210*
RL (cm)	3.20±0.29	2.82±0.21	2.52±0.14	1.39±0.013	–0.9141
SL (cm)	4.99±0.55	2.77±0.09	2.41±0.05	1.49±0.00	–0.9767**
T. DW (g)	1.146±0.05	0.120±0.011	0.116±0.05	0.091±0.00	–0.8306
Verbena hastata					
G (%)	100±0.00	65.00±12.96	65.00±5.77	62.5±5.00	–0.8173
RL (cm)	1.57±0.35	1.58±0.065	0.141±0.01	0.33±0.00	–0.7638
SL (cm)	2.136±0.688	1.567±0.982	0.326±0.032	0.299±0.63	–0.9368*
T. DW (g)	1.397±0.065	0.368±0.249	0.358±0.166	0.056±0.08	–0.9451*
Vernonia cineraria					
G (%)	100±0.00	72.5±5.00	70.00±8.61	65.00±12.96	–0.9002
RL (cm)	2.58±0.284	1.87±0.242	1.19±0.709	0.893±0.17	–0.9964**
SL (cm)	2.83±0.490	1.68±0.631	0.658±0.26	0.542±0.28	–0.9720**
T. DW (g)	1.21±1.140	0.358±0.036	0.263±0.30	0.132±0.03	–0.9697*
Argemone Mexicana					
G (%)	100±0.00	70.00±8.16	65.00±5.77	62.5±5.00	–0.8920
RL (cm)	2.58±0.284	1.68±0.631	0.568±0.22	0.452±0.28	–0.7597
SL (cm)	2.83±0.490	1.59±0.265	0.657±0.09	0.466±0.02	–0.9877**
T. DW (g)	1.21±1.140	0.379±0.064	0.358±0.03	0.327±0.02	–0.8321

See Table 1 for details

Table 4. Allelopathic potential of some plant species on lettuce (lettuce bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Amberboa ramosa					
G (%)	100±0.00	77.5±5.00	70.25±5.00	70.00±8.16	–0.9106**
RL (cm)	2.58±0.284	1.59±0.265	0.657±0.019	0.466±0.020	–0.8754
SL (cm)	2.83±0.490	1.473±0.385	1.380±0.175	0.543±0.046	–0.9536*
T. DW(g)	1.21±1.140	0.379±0.064	0.244±0.00	0.155±0.051	–0.9668*
Eragrostis ciliaris					
G (%)	100±0.00	83.33±6.77	80.00±5.87	76.77±3.33	–0.9236*
RL (cm)	2.58±0.490	1.591±0.347	1.362±0.234	0.219±0.614	–0.9022*
SL (cm)	2.83±0.490	1.106±0.660	10051±0.761	1.025±0.002	–0.8129
T. DW(g)	1.21±1.140	0.119±0.040	0.097±0.021	0.084±0.00	–0.9700*
Tectona grandis					
G (%)	100±0.00	7.25±5.00	70.00±8.16	65.00±5.77	–0.9002*
RL (cm)	2.58±0.284	0.88±0.353	0.55±0.414	0.00±0.00	–0.9753*
SL (cm)	2.83±0.490	0.30±0.589	0.06±0.07	0.00±0.00	–0.9705*
T. DW(g)	1.21±1.140	0.517±0.109	0.06±0.001	0.00±0.00	–0.9700*
Panicum virgatum					
G (%)	100±0.00	90.00±5.77	83.00±6.77	80.00±5.87	–0.9817**
RL (cm)	2.58±0.28	1.003±0.179	0.323±0.041	0.356±0.046	–0.9330*
SL (cm)	2.83±0.490	1.606±0.262	0.626±0.391	0.665±0.40	–0.9372*
T. DW(g)	1.21±1.140	0.813±0.708	0.963±0.033	0.903±0.07	–0.5437

See Table 1 for details

grandis in the present study. *Eragrostis* sp. exhibited allelopathic potential in all bioassays with variable degree of toxicity (Fig. 1). *Argemone maxicana* behaved differently in different bioassays (Table 1, 3 and 6). It exhibited strong allelopathic potential in seed germination and seedling growth bioassays but enhanced the growth of duckweed. Nevertheless, the three bioassays, wheat, lettuce and rice showed its toxic nature. Further, the allelopathic effects of this species using seed germination bioassay have been reported in a number of studies (Namkeleja et al 2013, 2014, Brahmachari 2013, Favaretto 2018). Duckweed bioassay gave different results than seed germination bioassay and hence doubtful. *Lactuca sativa* seeds germinate very fast and homogenous (Campagna et al 2016). Therefore, lettuce bioassay is common where temperature favours its growth. However, in India, only 3 months winter temperature is suitable for this bioassay which is limiting factor. The present study showed that lettuce and rice bioassay significantly reduced the growth of almost each target species. Both are sensitive bioassay and available for short period for research. Lettuce did not show good growth in local climate in winters in the present study. Another limitation with this bioassay is that seeds could germinate only for short duration in the month of December and January. The use of duckweeds in water bioassay has become the first choice as the small size of plant makes its handling easy. Besides, this bioassay can be performed in a limited space within a short time. It shows vegetative budding for producing more fronds. It is very convenient handy organism for testing the toxicity of chemicals and allelochemicals in aqueous medium. It is frequently used in allelopathic studies as a tool to investigate allelopathic potential (Kumar and Saxena 2010). It can be grown *in vivo* as well as *in vitro* conditions. The growth rate of this plant is very fast. Further, it gets flourished very quickly in nitrogen and phosphate rich water. Duckweed was investigated thoroughly for its use in checking the toxicity of water quality (Al-balawna et al 2018). It has been frequently used to monitor bioremediation studies (Ziegler et al 2016). It is perfect bioassay to assess the toxicity of heavy metals and chemicals. It is available for six months during summer. Rice bioassay was not found reliable as it exhibited great variation in all the 8 target species in the present study. In addition to that it can be grown only during summer months. Wheat seeds in India can be grown throughout the year under normal laboratory conditions in Petri plates. Therefore, it is proved the most suitable seed bioassay among four.

Table 5. Allelopathic potential of some plant species on duckweed (duckweed bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Eragrostis ciliaris					
G (%)	2.85±0.029	2.59±0.026	2.43±0.025	1.88±0.023	–0.9020*
RL (cm)	3.35±0.42	3.31±0.012	3.07±0.00	0.81±0.00	–0.9287*
SL (cm)	4.43±0.164	4.13±0.026	2.70±0.228	0.07±0.652	–0.9320*
T. DW (g)	2.271±0.03	2.210±0.01	1.360±0.04	0.591±0.02	–0.7893
Panicum virgatum					
G (%)	2.88±0.02	2.96±0.02	3.058±0.096	3.78±0.012	–0.8239
RL (cm)	3.32±0.016	3.46±0.10	3.75±0.01	3.93±0.021	–0.9342
SL (cm)	4.07±0.01	4.13±0.08	4.23±0.19	4.78±0.15	–0.7068*
T. DW (g)	2.279±0.02	2.286±0.01	2.310±0.07	2.349±0.04	–0.7198*
Amberboa ramosa					
G (%)	3.03±0.014	2.84±0.021	2.52±0.316	2.07±0.00	–0.9845**
RL (cm)	3.39±0.03	2.97±0.42	2.61±0.54	1.31±0.09	–0.9649**
SL (cm)	3.93±0.029	2.78±0.044	2.29±0.498	0.96±0.32	–0.9267*
T. DW (g)	2.260±0.13	2.193±0.09	1.460±0.23	0.836±0.03	–0.8739*
Vernonia cineraria					
G (%)	2.55±0.20	2.36±0.29	2.12±0.33	1.90±0.05	–0.8620
RL (cm)	3.18±0.17	3.10±0.08	3.05±0.08	0.39±0.01	–0.9452*
SL (cm)	4.40±0.25	3.98±0.13	3.09±0.12	Dead	–0.8274*
T. DW (g)	2.26±0.09	2.180±0.02	1.950±0.01	0.32±0.06	–0.8110

See Table 1 for details

Table 6. Allelopathic potential of some plant species on duckweed (duckweed bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Tectona grandis					
G (%)	2.29±0.71	2.22±0.21	2.09±0.01	1.62±0.04	–0.8223*
RL (cm)	3.52±0.69	2.01±0.05	1.63±0.02	Dead	–0.8302
SL (cm)	4.24±0.73	1.97±0.00	Dead	Dead	–0.9320*
T. DW (g)	2.281±0.02	1.720±0.01	0.607±0.10	0.111±0.00	–0.9537*
Verbena hastata					
G (%)	2.93±0.15	2.80±0.10	2.64±0.09	2.50±0.02	–0.9328**
RL (cm)	3.28±0.18	3.15±0.13	3.09±0.07	Dead	–0.7511
SL (cm)	4.40±0.38	4.10±0.35	3.31±0.15	Dead	–0.8993*
T. DW (g)	2.279±0.06	2.220±0.04	2.005±0.05	1.062±0.02	–0.9321*
Chenopodium album					
G (%)	2.92±0.17	2.85±0.12	2.70±0.08	2.57±0.05	–0.7567
RL (cm)	3.25±0.017	3.17±0.08	3.06±0.04	1.82±0.02	–0.9742**
SL (cm)	4.42±0.37	4.12±0.37	3.30±0.13	1.04±0.08	–0.7899*
T. DW (g)	2.268±0.21	2.207±0.09	1.970±0.015	1.103±0.06	–0.8897*
Argemone mexicana					
G (%)	2.49±0.00	2.85±0.12	2.94±0.03	3.21±0.04	–0.8062*
RL (cm)	3.25±0.241	3.17±0.08	3.56±0.020	4.14±0.02	–0.8633*
SL (cm)	4.35±0.024	4.12±0.37	4.65±0.02	4.83±0.02	–0.9732**
T. DW (g)	2.268±0.21	2.207±0.09	3.199±0.11	3.313±0.06	–0.9011*

See Table 1 for details

Table 7. Allelopathic potential of some plant species on wheat (wheat bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Eragrostis ciliaris					
G (%)	92.50±4.78	87.50±4.78	67.50±8.53	50.00±4.08	–0.9845**
RL (cm)	10.0±0.355	8.1±0.169	4.9±0.852	1.56±0.124	–0.9443*
SL (cm)	11.0±0.368	9.3±0.12	5.4±0.169	0.26±0.047	–0.8677
T. DW (g)	1.236±0.94	1.172±0.803	1.111±0.691	1.089±0.617	–0.9827**
Panicum virgatum					
G (%)	92.50±4.78	90.00±4.08	82.50±4.78	75.00±6.45	–0.9758**
RL (cm)	8.5±0.094	3.4±0.286	3.1±0.38	1.22±0.16	–0.9626**
SL (cm)	9.5±0.081	2.6±0.05	1.46±0.047	1.43±0.074	–0.8246
T. DW (g)	1.69±0.463	0.193±0.012	0.188±0.01	0.102±0.022	–0.8858
Amberboa ramose					
G (%)	100±0.00	98.00±2.00	94.00±4.78	88.00±4.65	–0.9772**
RL (cm)	15.03±0.60	13.31±0.216	11.1±0.778	5.53±0.325	–0.9190*
SL (cm)	13.30±0.49	11.40±0.152	11.00±0.21	10.40±0.232	–0.9480*
T. DW (g)	2.230±0.94	1.307±0.160	1.227±0.03	1.209±0.999	–0.8381
Vernonia cineraria					
G (%)	100±0.00	98.00±2.00	96.75±3.35	94.00±2.00	–0.9885**
RL (cm)	12.95±0.05	12.90±0.612	11.73±0.38	5.50±0.173	–0.8487
SL (cm)	12.56±0.66	13.31±0.038	11.44±0.05	7.83±0.094	–0.8708
T. DW (g)	2.361±0.16	2.113±0.164	2.018±0.16	1.968±0.160	–0.9488*

See Table 1 for details

Table 8. Allelopathic potential of some plant species on wheat (wheat bioassay)

Growth parameters	Control	Concentrations of aq. leachate (w/v)			r
		1%	2%	3%	
Tectona grandis					
G (%)	100±0.00	96.77±3.33	93.03±8.33	90.00±5.77	-0.9997**
RL (cm)	8.87±0.90	2.79±0.92	2.50±0.90	0.35±0.15	0.9441*
SL (cm)	9.08±0.85	2.74±0.731	2.38±0.92	0.45±0.18	-0.9566*
T. DW (g)	2.38±0.18	0.14±0.12	0.09±0.11	0.02±0.01	-0.9527*
Verbena hastate					
G (%)	100±0.00	98.00±2.00	94.00±2.00	93.3±3.33	-0.9700*
RL (cm)	11.25±0.05	6.90±0.44	5.48±0.10	5.28±0.47	-0.9269*
SL (cm)	9.08±0.85	5.30±0.94	5.79±0.84	5.12±0.19	-0.8579
T. DW (g)	2.23±0.18	0.37±0.15	0.35±0.15	0.22±0.01	-0.8877
Chenopodium album					
G (%)	100±0.00	93.03±8.33	90.00±0.00	76.77±3.33	–0.9556*
RL (cm)	11.40±0.07	10.12±0.87	7.79±0.56	2.72±0.08	–0.9018*
SL (cm)	16.10±0.07	16.9±0.06	11.46±0.05	4.36±0.10	–0.8843
T. DW (g)	2.252±0.04	0.214±0.01	0.193±0.01	0.119±0.00	–0.8749
Argemone mexicana					
G (%)	100±0.00	98.00±2.00	96.00±3.33	94.00±	-0.9879**
RL (cm)	6.74±0.06	6.66±0.01	6.03±0.00	3.91±0.02	-0.8475
SL (cm)	6.20±0.00	5.44±0.00	5.44±0.01	3.44±0.01	–0.8860
T. DW (g)	2.19±0.00	0.18±0.00	0.18±0.10	0.15±0.03	–0.8068**

See Table 1 for details

CONCLUSION

Wheat seedling growth bioassay was found best among four, where toxicity ranged from 6-94% of control. Moreover, it can be grown throughout the year. Lettuce and rice bioassay were sensitive bioassays and available for short period. Similarly, duckweed bioassay gave contrast results in case of *A. maxicana*. Therefore, among all the test species, wheat was found most suitable for bioassay to screen target species for investigation of their allelopathic potential.

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Phytochemical Screening and Characterization of *Meliadubia* Leaves Extract for Antimicrobial Activity against *Escherichia coli* and *Staphylococcus aureus*

Mustafa Mudhafar, Ismail Zainol, C.N. Aiza Jaafar[1], H.A. Alsailawi[2], Alhussein Arkan Majhool and Mofaq M.B. Alsaady[3]

Department of Chemistry, UniversitiPendidikan Sultan Idris, Proton City, 35900 Tanjung Malim, Perak, Malaysia
[1]Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43000 Serdang Selangor
[2]Department of Biology,, Universiti Pendidikan Sultan Idris, Proton City, 35900 Tanjung Malim, Perak, Malaysia.
[3]Faculty of Applied Science and Technology, University Tun Hussein Onn Malaysia, Pagoh Campus, 84600, Pagoh, Johor, Malaysia
E-mail:almosawy2014@gmail.com

Abstract: In this study, the leaves of *Meliadubia* were extracted through the hot-extraction method using distilled water as a solvent. The crude extract of *M. dubia* was evaluated for their chemical group compounds using phytochemical screening for the chemical group compounds. Meanwhile, Gas chromatography (GC), Energy-dispersive X-ray spectroscopy (EDX) and Fourier-transform infrared spectroscopy (FTIR) were used to conform to the fictional groups in the leave of *M. dubia*. Phytochemical screening analysis was done using common procedures and had shown the presence of alkaloids, carbohydrates, tannins, steroids, and flavonoids. Twenty-two compounds were identified in the GC-Mass spectrometry. The highest compounds were Pyridine, 2,3,4,5-tetrahydro-3-methyl (17.03 %), 1-azabicyclo (3.1.0) hexane (12.16 %), and 2-Undecanol (7.63 %), while the lowest compounds were Heptafluorobutyric acid, n-tetradecyl ester (0.79 %) and 4-Methyl-3-pentenal (0.79 %). The EDX analysis presented two elements, which were carbon (53 %) and oxygen (46 %). The *M. dubia* band at 1668 cm^{-1} refers to the amide I C=O stretching, and the peak at 2140 cm^{-1} is associated to the alkyne group that exists in the phyto-constituents of *M. dubia* extract. Meanwhile, the peak that was monitored at 3301 cm^{-1} corresponds to the amide A (N-H). The observed peaks are mainly discovered as flavanoids and terpenoids that exist significantly in the plant extract. The antibacterial activities investigated against gram-negative bacteria, *Escherichia coli* (*E.coli*) and gram-positive bacteria, *Staphylococcus aureus* (S. *aureus*). The results had presented the factional activity for *M. dubia* against both pathogens.

Keywords: *Melia dubia*, Phytochemical screening, Antimicrobial activity, GC-mass

The use of medicinal plants in the development of a drug is crucial to the human as they are being used to treat various kinds of diseases (Mustafa et al 2018). Traditional treatment from the wild plants had been always referred to guide the researcher to discover the best medications to create a healthy life for humans and animals (Ahmadipour et al 2016). However, there are still a few more medicinal plants that are still hidden and undiscovered, which requires further scientific evaluation (Mudhafar and Ismail 2019). *Melia dubia* belongs to the Meliaceae family. It is significantly distributed in India, Iran, Pakistan, Argentina, Brazil, Bermuda, China, Australia, and Malaysia (Saravanan et al 2013, Ram et al 2014, Parthiban et al 2019). Traditionally, *M. dubia* leaves were used as a medicine for various kinds of treatment such as insect pests, wound healing (Koul et al 2000). Different parts of *Melia dubia* have been extracted and utilized for any kinds of skin infections such as the microbial and gastrointestinal tract (Purushothaman et al 1984), hypoglycaemic, and antidiabetic (Susheela et al 2002). *M. dubia* has many properties that have been investigated in the previous studies (Mudhafar et al 2019), however, there is no study about a phytochemical screening leaves to identify the chemical components of the extract. In the present study phytochemical screening of *M. dubia* leaves have been done via using standard procedures along with investigated the biological properties of the leaves via identified its antibacterial activity against gram-negative bacteria, such as *Escherichia coli* and gram-positive bacteria, such as *Staphylococcus aureus.*

MATERIAL AND METHODS

Washed many times by distilled water to remove all of the dust and fungus and were. The sun-dried 7 days and were cut down to small pieces and keep it in future work. 25 g of the leaves were extracted with 200 ml of distilled water in 250 ml conical flask. The leaves were boiled for 20 minutes and filtered to get the crude extract. The extract of the leaves was stored at 4°C for future work (Vijayan et al 2019).

The phytochemical screening was carried out for *Melia dubia* leaves Any difference in hues or the appearance of precipitate in solution was utilized as demonstrative of positive reaction to these tests. Common procedures have been used for alkaloids, saponins, carbohydrates, cardiac glycosides, tannins, steroids, terpenoids flavonoids and coumarins.

The leaves of were characterized by using several equipment such as Gas chromatography-Mass spectrometry (GC-MS, Shimadzu GC-14B) analyzer, FTIR (Fourier-transform infrared spectroscopy) by Termo Scientific Perkin Elmer Model: Spectrum 100 Spectrometers, and EDX (Energy-dispersive X-ray spectroscopy) using FESEM instrument used was Hitachi SU8020.

Antibacterial activities: Agar Preparation: An amount of 8 g nutrient broth 20 g agar powder was dissolved in 1000 mL distilled water, then sterilized by an autoclave for 20 min at 121°C. Then, it was cooled to 55°C and 25 ml of cooled media was added to the plate and left for some time to solidify, and stored at 4 °C in the dark for further experimentation.

Antimicrobial test: The test bacterial strains were transferred from the stock cultures as streaked on nutrient agar (NA) plates and incubated for 24 h. Well, separated bacterial colonies were then used as inoculums. Bacteria were transferred using a bacteriological loop to autoclaved nutrient agar that was cooled to about 45°C in a water bath mixed by gently swirling the flasks. The medium was then poured to sterile Petri plates, allowed to solidify and used for the biotest (Jain et al 2009). A fresh culture of inoculums of each culture was streaked on nutrient agar media in a petri dish. Different concentration of crude extract has been used to investigate the antibacterial activity. Filter paper discs (about 6 mm in diameter), containing the test compound at the desired concentrations, were placed on the agar surface. The petri dishes were incubated in 37°C conditions. Antibacterial agent diffuses into the agar and inhibits germination and growth of the test microorganism and then the diameters of inhibition growth zones are measured. In this test, the distilled water was used as a negative control, while the ampicillin was used as a positive control. 5, 10, 20, 30 and 50 $\mu g ml^{-1}$ concentrations of *M. dubia* crude were mixed with the distilled water to dissolve. Then, the mixtures were poured onto a filter paper of 6 mm and placed in the petri dish. As mentioned previously, the antibacterial activities of the *M. dubia* crude was affirmed based on the method of disk diffusion. A ruler was used to measure the ability of *M. dubia* crude to prevent bacterial growth against both bacteria.

RESULTS AND DISCUSSION

Alkaloids, carbohydrates, tannins, steroids, and flavonoids were detected in the phytochemical screening of leaves. These chemical group compounds have the ability to be an as reducing agent to convert the metal from its salt by changing its charge from +1, +2 to zero. In the present study, the leaves *Meliadubia* has been shown to present the major chemical group compounds in which they are able to work as a reducing agent (Table 1).

According to Allen et al (2016), the compounds may be volatile or semi-volatile organic compounds. *Melia dubia* leaves underwent the GC-MS analysis to identify the exact composition of the leaves and the content of the compound, which can be determined based on the area of the peak, the retention time, and the molecular formula. Based on the analysis, 22 compounds were discovered in the leaves' composition. Three of these compounds exhibited high percentage in the leaves, which are 1-azabicyclo (3.1.0) hexane with the composition of 12.16%, Pyridine, 2, 3, 4, 5-tetrahydro-3-methyl with 17.03%, and 2-Undecanol with 7.63%. The molecular formulas of these compounds are; $C_{18}H_{29}F_7O_2$ and $C_6H_{10}O$ respectively. Generally, the overall composition of these compounds was 0.79% (Table 2). The EDX technique detects the X-ray beams emitted from the sample during the process of the bombardment to characterize the composition of the element from the sample. The outcome of the technique highlighted the elements with the atomic number, which ranges from beryllium to uranium, to indicate that the relative x-ray counts at a certain energy level of the sample's constituent can assist in obtaining the quantitative result (Zhao et al 2019). Besides that, EDX also helps to identify the percentage of the elements that exist in the crude of leaves. The two elements that had been discovered in the crude were oxygen (O) and carbon (C). These elements were associated with the organic

Table 1. Phytochemical screening of M*eliadubia* leaves

Phytochemical test Alkaloid test	Indicator	Result
Mayer's	Appearance of white or creamy precipitate	Positive
Wagner's,	Appearance of reddish- brown precipitate	Positive
Dragendroff's	Aprominent yellow precipitate	Positive
Saponins Test	Not foam on the surface of the mixture	Negative
Carbohydrates	formation of violet ring	Positive
Cardiac glycosides	No appearance of greenish blue colour	Negative
Tannins test	Appearance of blue black colouration	Positive
Steroids test	Appearance of green fluorescent	Positive
Terpenoids test	No appearance of reddish brown colouration	Negative
Flavonoids test	Appearance of yellow colour	Positive
Coumarins test	No appearance of yellow coloration	Negative

compounds that exist naturally in the plant (Fig. 2).

Besides EDX, the Fourier Transform Infrared Spectroscopy (FTIR) was also used as it was known to be a substantial analytical method as it can detect a few functional groups in the compounds. It was discovered that there were significant impacts to the chemical bond in a liquid once it interacted with the infrared light. The chemical bond will elongate, contract, and absorb the radiation when other molecules were present at a particular wavelength. Therefore, the main functional groups in the compound were recorded. Based on the record, the FTIR spectra noted the *M.*

Fig. 1. Fresh and dried leaves of *Meliadubia*

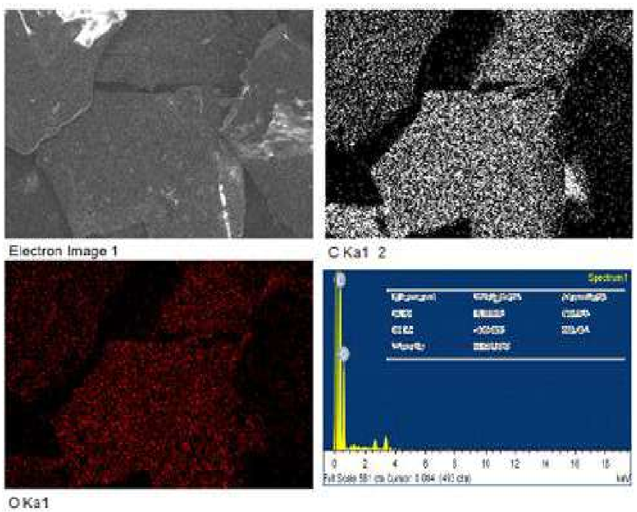

Fig. 2. EDX mapping of leaves *Meliadubia*

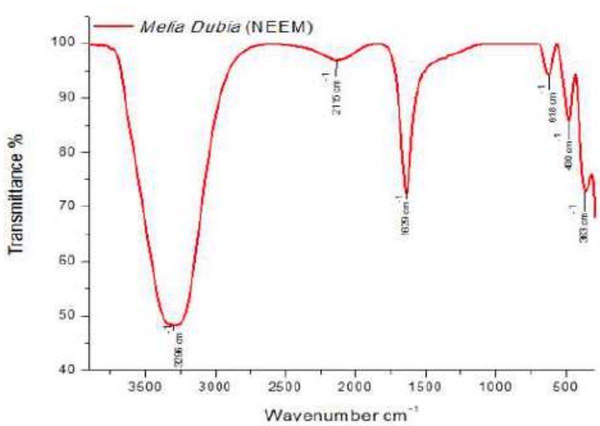

Fig. 3. FTIR spectroscopy of *Meliadubia* leaves

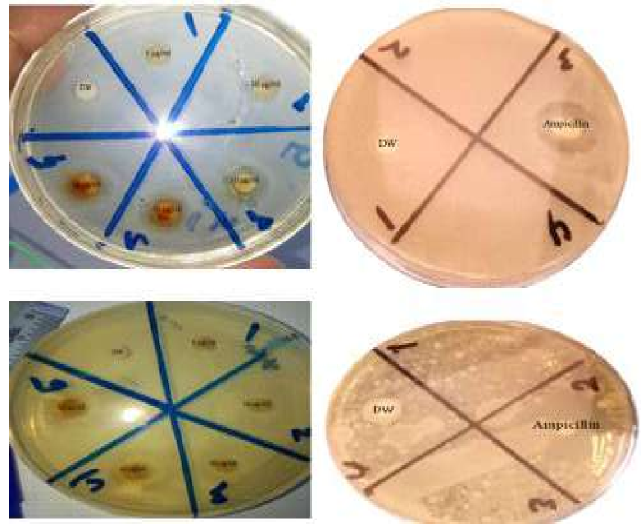

Fig. 4. Antibacterial activities of extract of plant and control samples against *E. coli* and B) AgNPs against *S. aureus*

Table 2. Main Components (%) of *M. dubia* leaves

R. Time	Composition (%)	Compound	Molecular formula
9.887	3.29	Acetyl cyanide	C_3H_3NO
9.887	3.29	2-Propynenitrile, 3-fluoro-	C_3FN
9.887	3.29	Ethyl isocyanide	C_3H_5N
10.154	12.16	1-azabicyclo(3.1.0)hexane	C_5H_9N
10.154	17.03	Pyridine, 2,3,4,5-tetrahydro-3-methyl-	$C_6H_{11}N$
10.264	1.45	1,2,3,6-Tetrahydropyridine	C_5H_9N
10.319	1.96	1-Methoxy-2-propyl acetate	$C_6H_{12}O_3$
12.079	1.02	Tans-1-Propenylcyclopropane	C_6H_{10}
12.361	3.88	1,6-Heptadiene	C_7H_{12}
13.037	7.62	2-Undecanol	$C_{11}H_{24}O$
13.131	1.49	2-Furanmethanamine	C_5H_7NO
13.171	1.35	Acetamide, N-2-propynyl-	C_5H_7NO
13.288	2.59	Acetonitrile, 2,2'-iminobis-	$C_4H_5N_3$
13.343	2.42	Cyclobutanone, 2-methyl-2-oxiranyl-	$C_7H_{10}O_2$
13.587	2.73	2-Hexenal	$C_6H_{10}O$
13.343	2.42	1-Butene, 2-ethyl-3-methyl-	C_7H_{14}
13.367	1.32	2-Pentanone, 3-methylene-	$C_6H_{10}O$
13.516	1.78	2(5H)-Furanone, 5-methyl-	$C_5H_6O_2$
13.642	0.79	Heptafluorobutyric acid, n-tetradecyl ester	$C_{18}H_{29}F_7O_2$
13.642	0.79	4-Methyl-3-pentenal	$C_6H_{10}O$
13.673	1.95	1,1,2,3-Tetramethylcyclopropane	C_7H_{14}
13.775	1.32	1,1,3-Trimethylcyclopentane	C_8H_{16}

dubia band at 1668 cm-1 that referred to amide I C=O stretching (Liu et al., 2018). The peak of 2140 cm^{-1} was associated with the alkaline group that exists in the phyto constituents of *M. dubia* (Kumar et al 2018). At 3301 cm^{-1}, the peak was assigned to the amide A (N-H). Generally, the detected peaks are known to be as flavanoids and terpenoids that exist significantly in the extract of plants (Mu et al 2016).

It was reported that the distilled water inhibition was zero in both bacteria. Meanwhile, the inhibition zones of ampicillin were 28.6 against *E. coli* and 22.1 against *S. aureus.* Overall, the inhibition bacteria growth of the *M. dubia* was 10, 11, 13, 15 and 16 mm against *E. coli* and 8, 10, 12, 13, 15 mm against *S. aureus*.

CONCLUSION

The aqueous solutions of *M. dubia* have been shown to have 22 compounds in the GC-mass spectroscopy. Three of these compounds have been shown high availability. FT-IR was identified to factional groups that belonged to phyto-constituents of extract. Antibacterial activity of extract has been investigated, which can use it as an antibacterial agent in the medical and biological filed.

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Physical and Antimicrobial Properties of *Cissus quadrangularis* Stem Extract Incorporated Edible Films

K.N. Hanumantharaju, K. Thangavel, D. Amirtham and C. Indu Rani

Department of Food process Engineering, TNAU, Coimbatore-561 204, India
E-mail: rajuknhgowda@gmail.com

Abstract: *Cissus quadrangularis,* is widely accepted natural medicine for bone setting in Indian Ayurveda. The GC-MS analysis of this plant stem extract also confirmed the presence of phyto chemicals such as octadrine, piperidinol, phytol in it. Edible films (EFs) at different concentration of corn starch, glycerol and *C. quadrangularis* stem extract using Box Behnken method under Response Surface methodology. Thickness of the prepared EFs varied between 79-136µm and theopacity of the prepared EFs in the range of 20.31-30.45%. Tensile strength (S) (0.98-5.49 MPa) of the EFs was decreased significantly with increase in glycerol content. Increase in plant extract concentration significantly decreased TS of the EF. Water vapor permeability ($0.739 * 10^{-7}$ g/m. s. pa - $10.9 * 10^{-7}$ g/m. s. pa) of the EFs significantly decreased with increased starch, glycerol and plant extract concentrations. EFs with 15% plant extract showed antimicrobial effect on *E. coli* bacteria. Optimized EF formulation contains 3.33, 20 and 15 per cent starch, glycerol and *C. quadrangularis* stem extract.

***Keywords*:** Edible film, Corn starch, Glycerol, *Cissus quadrangularis,* Plant extract

Edible films protect the fresh fruits and vegetables, cut fruits and minimally processed fruits by maintaining its structural integrity towards integrated product. This make them better alternate to the synthetic polymer packaging materials (Chiumarelli and Hubinger 2012). Several naturally available polysaccharides, proteins and lipids are used as a source for edible film preparation. Among those, starch is a promising packaging material due to its tasteless, odorless, transparent, inherent and better film forming character (Choiet al 2016). Starch can be obtained from the several sources like potato, tuber, cassava and corn. Corn starch widely produced cheap source of polysaccharide available all over the world (Laycock and Halley 2014) andcontains all essential amino acids and digestible proteins, except tryptophan (Duconseille et al 2015). Despite having numerous advantages as a film, but it does not have thermoplastic property. Hence, it cannot be used as a packaging material directly, without plasticizer (Dang and Yoksan 2015). Addition of plasticizer improves the flexibility but decreases the mechanical resistance (Azeredo et al 2012). Physical and mechanical barrier properties of the film also depend on the concentration of the plasticizer (Sahariet al 2012). Glycerol is the most promising plasticizer, due to its better compatibility with starch. Now a days EFs functionality was increased by incorporating antimicrobial agents, antioxidants, functional ingredients such as probiotics, minerals and vitamins (Campos et al 2011). Some of the plants, animals, bacteria, algae and fungi are rich source of antimicrobial component. Among them plant antimicrobials have higher efficacy in food applications (Ulbin-Figlewicz et al 2013). In that aspect, *Cissus quadrangularis* (Devil bone) stem contains rich source of antioxidant and antimicrobial properties due to the presence of polyphenolic compounds. Saponins, flavonoids (Indran et al 2014). So far, no work has been conducted on the use of *Cissus quadrangularis* stem extract and its effect on the EF properties. Hence this study was undertaken to develop and characterize the EF at varying concentration of corn starch, glycerol and *Cissus quadrangularis* stem extract.

MATERIAL AND METHODS

Preparation of plant extract: The *Cisuus quadrangularis,* plants were collected from the local forest near Marudamalai and authenticated at the Botanical Survey of India, Coimbatore, Tamil Nadu. Plant extract was obtained by following the procedure prescribed by Hanumantharaju et al (2018).

GCMS analysis of the *Cissus quadrangularis* stem extract: GC-MS analyses of plant extract samples were performed on GC-MS analyzer (Model: TRIPLUS RSH, Thermo Fisher Scientific). The specification of column used in GC-MS was TR5MS, 0.25mm ID, 0.25uf, 30mm dimension. The temperature of ion source in DSQ II was maintained at 2000°C. Initial temperature in Trace GC Ultra was set to 400°C withhold time of one minute. Temperature in the inlet and MS transfer line was maintained at 207° C and 265°C, respectively. Full scanning mode was used at a scan rate of 500 amu/s and mass range between 15 to 120. Manual injection of sample was done in the sampling port in an air tight syringe and 50 µl volume of sample was injected.

Pre-injection and post injection flush was given using nitrogen gas to avoid contamination. The time for pre-injection and post injection flushing was 5 s and 30 s, respectively.

Preparation of edible films containing *C. quadrangularis* extract: Edible coating solution was prepared by following the procedure mentioned by Hanumantharaju et al (2018) using starch (3, 4 and 5%), glycerol (20, 30 and 40% for each gram of starch) and *C. quadrangularis* extract (5, 10 and 15%).The 40±1.5 ml of film forming solution was poured into 14 cm diameter borosil petri plates and plates were placed in a ventilated hot air oven at 65°C for 3-4.5 h. After complete drying of these films, they were removed from the petri plates using scalpel and forceps. Prepared film samples were packed in polythene sheets and stored in an air tight container to prevent moisture absorption.

Edible Film Properties

Film thickness: Hand-held micrometer (Mitutoyo micrometer) was used to measure the Film thickness at different parts of the film.

Opacity: A Hunter lab flex colorimeter was used to measure the opacity of the prepared film. The colorimeter was calibrated using standard white and black background. Opacity of the prepared films was calculated according to the following equation (Fadini et al 2013):

$$O_p = \left(\frac{OpN}{OpB} \right) \times 100$$

Where, Op is the opacity of the film (%), Op^N is the opacity of the film against a black background and Op^B is the opacity of the film against a white background.

Tensile strength: Tensile strength of the film was determined using Universal testing machine (Lloyd instruments LRX plus, UK) and standard procedure was followed as prescribed by Matta et al (2015).

Water vapor permeability (WVP): Permeation cells which is filled with a great amount of anhydrous silica gel (RH = 10%) provided with air gap of less than 6mm, was sealed by the prepared film using parafilm. Then the prepared permeation cells were placed in desiccators with a constant RH (52%) and temperature (30°C). Initial weight and weight of the film for every 2 h for 24 h were measured. The changes in their weight recorded was plotted against time. WVP was determined as mentioned by Nouri and Nafchi (2014).

Antimicrobial property: The *E. coli* inoculum for the experiment was prepared in fresh Nutrient broths. The standardized inoculum was inoculated in the Petri plates prepared earlier and sterile swabs were used to spread the culture on top of petri plates to ensure uniform spreading of culture after which the inoculums were left to dry at room temperature with the lid closed. The developed different composite film discs (3 cm diameter) of each treatment were placed on the surface of the previously inoculated agar culture media. Petri dishes with microorganism and discs of different composite films were incubated at 35±1°C for 24 h to allow the diffusion of antimicrobial compounds from the film. The antimicrobial activity of developed composite film was determined by measuring the inhibition zone around (Horita et al 2016).

Statistical analysis: A box-behnken statistical tool under response surface methodology was selected, because of its best fit for three factorial full design and estimation under quadratic model.

RESULTS AND DISCUSSION

GCMS analysis of the *Cissus quadrangularis* stem extract: The main components present in the *C. quadrangularis* stem extract were phenolic compounds octadrine, piperidinol, phytol, phenylephrine benzenediol, 3-Ethoxyamphetamineand 1-Guanidinosuccinimide are the precursors for Vitamins E and K1, and common antioxidants. Phenolic compounds are also found to be an effective vaccine adjuvant with no adverse auto-immune effect. Similarly, Shah (2011) also confirmed the presence of phytochemicals in the *C. quadrangularis* extract.

Film thickness and opacity: The thickness of the films was in the range of 79 to 136 µm. Opacity of the films was in range of 20.31 to 30.45 %. The starch has significant) effect on increasing the opacity (Fig. 1).

High concentration of starch opens the glucosides rings, this branched glucoside rings restricts the passage of light through the film (Fadini et al 2013). The increase in glycerol content increases the film opacity due to, polymer matrix formed by the addition of glycerol which hinders the light to pass through. The addition of plant extract significantly increased the film opacity due to the phenolic compounds in the extract which absorbed most of the light. Intermolecular interaction of the chemical compounds in the extract also hindered the light to pass through. Best fir second order quadratic equation for opacity (R^2= 0.989) is as follows.

Opacity (%) =25.56+2.63*A+ 0.62 * B+ 2.01*C+ 0.49 *A^2+ 0.31*B^2- 0.29 *C^2+ 0.39*A*B + 0.38*A*C+ 0.050*B*C …………(1)

Tensile strength: Tensile strength is the maximum tensile stress that the film can sustain when tensile forces are being exerted on the film continuously (Fig. 2).

Film with 5,20 and 10 percent of starch, glycerol and plant extract showed the highest tensile strength (5.49 MPa). The film with 3, 40 and 10 percent starch, glycerol and plant extract showed the lowest tensile strength (0.98 MPa). Films with high starch concentrations showed high tensile strength as compared to the lower starch concentration films. This may be due to the availability of starch molecules for intermolecular bonding within the film. The tensile strength of the film decreased **s**ignificantly with addition of plasticizer and plant extract. This may be due to the intermolecular forces which led to the phase separation between the molecules, decreasing the tensile strength of the film. Addition of plant extract increased the heterogeneity of the film and thus it reduced the film tensile strength (Nouri et al 2014). Best fit second order quadratic equation (R^2= 0.897) is as follows.

$$TS\ (MPa) = 3.02+ 1.11*A- 0.62*B- 0.75 *C- 0.52*A^2+ 0.43*B^2+ 0.032*C^2 +0.31*A*B-0.20*A*C+ 0.14*B*C \quad ......(3)$$

Water vapor permeability: Water vapor permeability varied from 0.739 * 10^{-7} g/m. s. pa to 10.9 * 10^{-7} g/m. s. pa. The WVP of the films increased with increase in starch concentration. Increase in starch concentration increases the starch molecules affinity towards water but this reduces the intermolecular bond matrix between the polymer chains (Fig. 3). Similar trend was observed by Moreno et al (2014).

The films with lower glycerol content showed lower WVP than the films with higher glycerol. This could be related to the fact that increment of glycerol promoted the mobility and flexibility of starch network chain due to structural modification of polymer chain which decreased the intermolecular interaction (Fakhreddinet al2016). The WVP of the film increased significantly

with addition of plant extract. This may be due to the interaction between the hydrogen and covalent interaction between the starch network and the polyphenolic compounds present in the extract. The interaction increases the availability of hydrogen groups to form a hydrophilic bond with water which subsequently lead to the increase in WV transmission of the films. Best fit second order quadratic equation (R^2= 0.979) for WVP as follows.

$$WVP(10^{-7} g/m.s.Pa) =5.28+ 4.27*A+ 0.83*B+ 0.79*C+ 0.45*A^2- 0.40*B^2+ 0.054*C^2- 0.16*A*B+0.035*A*C- 0.24*B*C \quad ......(4)$$

Antimicrobial property: Disk diffusion assay revealed that specimens with 15 percent plant extract concentration

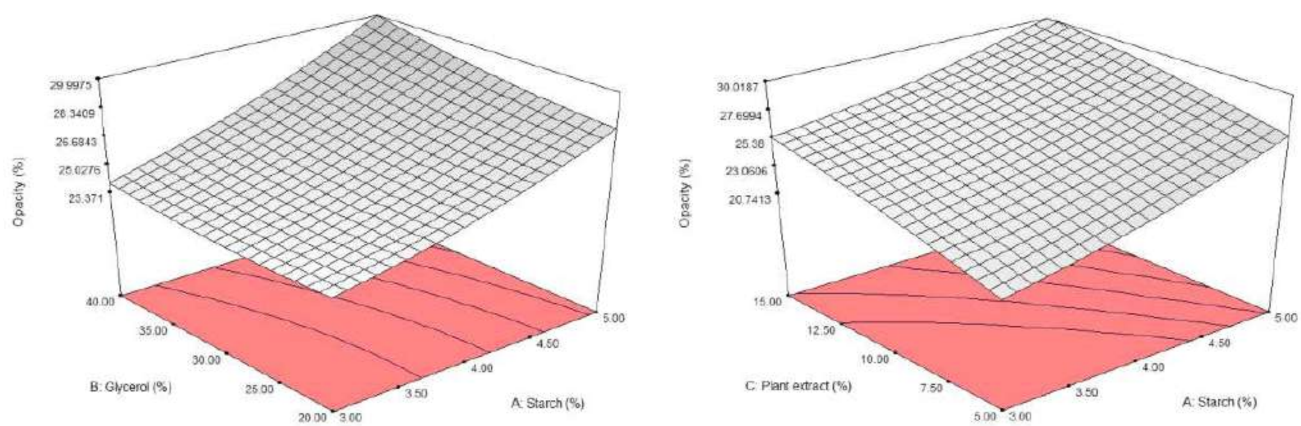


Fig. 1. Opacity of the films at varying concentration of starch, glycerol and *C. quadrangularis* stem extract

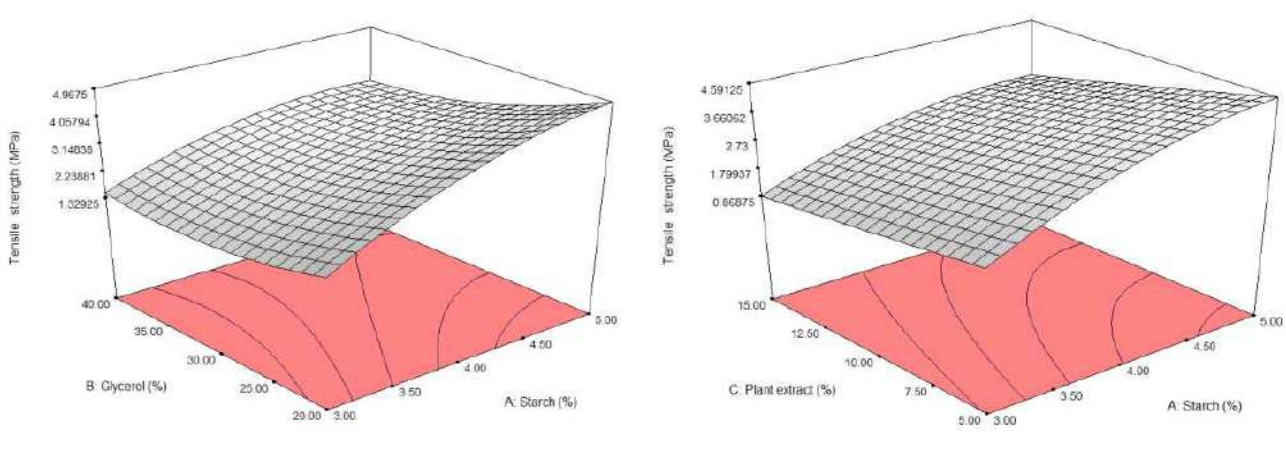
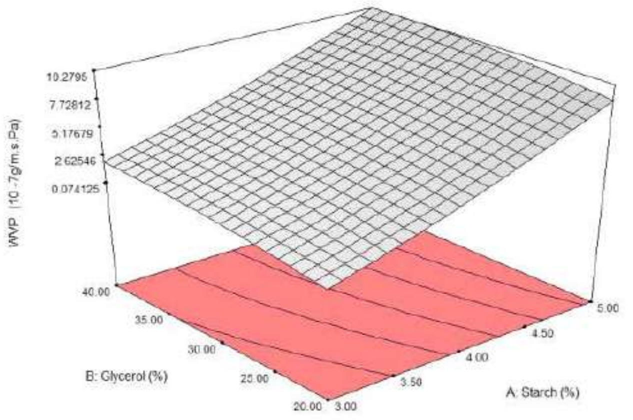


Fig. 2. Tensile strength of the films at varying concentration of starch, glycerol and *C. quadrangularis* stem extract



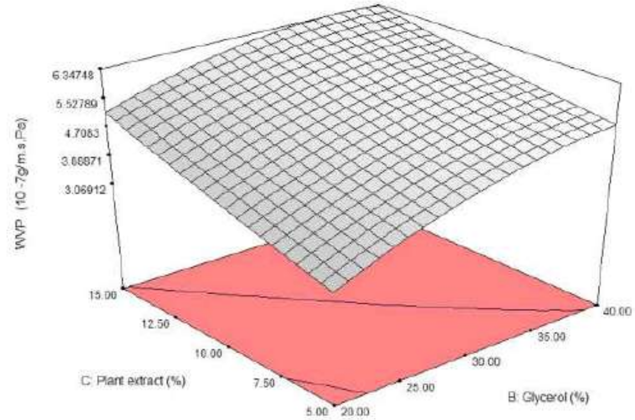


Fig. 3. Water vapor permeability of the films at varying concentration of starch, glycerol and *Cissus quadrangularis* stem extract

showed anti-bacterial effect against *E-coli.* Film with 3, 30 and 15 percent starch, glycerol and plant extract showed higher inhibition zone of 1.5mm.Similarly, minimum inhibition zone of 0.5 mm was observed in 5, 30 and 15 percent starch, glycerol and plant extract. The studies confirmed the presence of antimicrobial compounds in the extract, and also the active compounds are effective against microbial growth at higher concentration. Kaya *et al* (2018) observed that, *Pistacia terebinthus* seed extract incorporated edible chitosan-based films showed inhibition zone against gram-negative bacteria such as *P. microbilis, P. vulgaris, P. aeruginosa* and *E. coli*. Antimicrobial activity of the film might be due to presence of flavonoids and poly-phenolic compounds in the plant extract.

The best fit quadratic equation (R^2=0.821) is as follows.

Inhibition zone (mm) = $-0.12 * A - 0.013 * B + 0.54 * C - 0.038 * A^2 + 0.038 * B^2 + 0.54 * C^2 - 0.25 * A * C - 0.025 * B * C$ ..(5)

The numerical optimization by the Box Behnken method gave higher desirability for the edible coating formulation containing 3.33% starch, 20.00% glycerol and 15.00 % *Cissus quadrangularis* stem extract.

CONCLUSION

This study confirmed the presence of phytochemicals in the *Cissus quadrangularis* stem extract. The film prepared at different concentration of starch, glycerol and *cissus quadrangularis* stem extract have remarkable effect on EF properties. In this film formulation increase in starch concentration significantly increased the opacity, TS and WVP. Increase in glycerol content increased opacity, WVP and WS, and decreased the TS of the film. Increased plant extract concentration decreased the TS of the EF. Opacity and WVP of the prepared EF samples were increased with increased plant extract concentration. Films with 15% plant extract showed antimicrobial property on *E. coli* bacterial. In future these films can be used for fruits and vegetable as an antimicrobial packaging material.

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Economic Feasibility of *Melia dubia*- Sorgham Sudan Grass Based Silvi-pasture Systems

D.R. Prajapati, N.S. Thakur, Narendra Singh[1], R.P. Gunaga and V.R. Patel[2]

Department of Silviculture and Agroforestry, College of Forestry,
[1]Department of Agricultural Economics, NM College of Agriculture,
[2]Department. of Animal Nutrition, Vanbandhu College of Veterinary Sciences and Animal Husbandry
Navsari Agricultural University, Navsari, Gujarat-396 450, India
E-mail: dhvlfor@gmail.com

Abstract: The present investigation was undertaken to assess the economic feasibility of *M. dubia* (2×2, 3×2, 3×3, 4×2, 4×4 m)-Sorgham Sudan Grass (SSG) silvi-pasture and sole SSG cropping systems. Among silvi-pasture systems [*M. dubia* (2 x 2 m)-SSG, *M. dubia* (3 x 2 m)-SSG, *M. dubia* (3 x 3 m)-SSG, *M. dubia* (4 x 2 m)-SSG, *M. dubia* (4 x 4 m)-SSG and sole SSG, highest net total returns of Rs. 164135 ha^{-1} (BCR-2.61) were obtained from *M. dubia* (4 x 2 m)-SSG system and lowest net returns of Rs. 84177 ha^{-1} from sole SSG cropping system. Similarly, the NPV (@ 12%), BCR, IRR (@ 10%) and PBP was better for *M. dubia* (4 x 2 m)-SSG silvi-pasture system hence most economically viable systems compared to other silvi-pasture and sole SSG cropping systems.

Keywords: *Melia dubia*, Sorghum sudan grass, Economics, Net returns

India with 2.29 per cent of total geographical area of the world sustains about 10.71 % of the total livestock population (Anonymous 2016). Large livestock population requires sufficient forage/fodder for their sustainable productivity. However, estimates (Anonymous 2011) indicated that, there is a huge deficit of green fodder and dry fodder in the country. Over the years, deficit of green and dry fodder is showing increasing trend from 62.76 per cent (666 million MT.) in year 2010 to 64.21 per cent (759 million MT) in current year *i.e.* 2020. This deficit of fodder is the result of shrinkage of open land for cattle grazing (Roy et al 2019), urbanization, and extending area under cultivation, waste land management, and introduction of high yield cattle, which requires feeds in large quantity and of good quality as well. Hence, there is need to develop land use systems to bridge demand and supply gap of green and dry forage. Silvi-pasture is a practice of agroforestry where timber or fodder tree species forage grasses (Thakur et al 2007, Chauhan et al 2014, Prajapati et al 2019), and or livestock are intentionally integrated on same piece of land. Sometimes forage component is managed adopting cut and carry method where animals are not allowed to graze in the system (Gupta et al 2012). This agroforestry system is ought to augment the demand for fodder as well as wood of the rural communities and industries if adopted on large scale (Thakur et al 2015a, b).

Apart from the forage demand, the current raw materials production for pulp and paper is 2.76 million tons, against the demand of 5.04 million tons, which is about a shortfall of 45 percent. The projected demand by 2020 is 13.2 million tons, which is still more staggering (Palsaniya et al 2009). Forage yield under silvi-pasture system is higher and of high nutritional value in comparison to sole forage grass cropping systems (Cruz 1996 and 1997, Chauhan et al 2008). Therefore, silvi-pasture system is being advocated with potential to enhance livestock productivity by ensuring sufficient nutritious fodder and timber production.

Melia dubia Cav., an indigenous tree species of India, is being adopted by famers owing to its fast-growing nature allowing harvest at short rotation. It has high-quality termite and fungus resistant timber (Suprapti et al 2004) used in furniture, fuel wood, agricultural implements, house construction and as an alternative pulp and plywood species (Parthiban et al 2009, 2019), leaves and fruit pulp as fodder and feed (Sukhadiya et al 2019, 2020). It has been reported to have ephemeral or no allelopathic effect on under-storey crops (Kumar et al 2017, Thakur et al 2017 a, b, Parmar et al 2018). It has been found amenable agroforestry ideotype and few vegetable and medicinal crops have been reported to grow well under different spatial arrangements (Thakur et al 2019, Mohanty et al 2019).

In this backdrop, a new silvi-pasture system *M. dubia*-Sorghum Sudan Grass was established for forage and timber production. Sorghum Sudan Grass (SSG), is a hybrid made from a cross between *Sorghum bicolor* and *Sorghum bicolor* var. sudanese and has been reported to have production potential up to 95 tonnes ha^{-1} (Pandey and Roy 2011). It is invariably suggested that adoption of any agroforestry technology is believed and adopted if it is economically viable

(Thakur et al 2016, Bhusara et al 2016, Mohanty et al 2017). Hence, *M. dubia*-SSG being new tree-crop combinations was evaluated for its economic feasibility in south Gujarat.

MATERIAL AND METHODS

The present study was carried out in College of Forestry, Navsari Agricultural University, Navsari (20˚55'23''N latitude and 72˚54'29''E longitude with the elevation of 10 m above msl), Gujarat during June-October, 2019. SSG was intercropped under 5-year old *M. dubia* spaced at 2×2, 3×2, 3×3, 4×2, 4×4 m and sole cropping systems representing each as treatment with four replicas. The experiment was conducted in randomized block design and the treatments were: T_1 [*M. dubia* (2×2 m) + SSG], T_2 [*M. dubia* (3×3 m) + SSG], T_3 [*M. dubia* (3×2 m) + SSG], T_4 [*M. dubia* (4×4 m) + SSG], T_5 [*M. dubia* (4×2 m) + SSG], T_6 [sole Sorghum Sudan Grass]. SSG was broadcasted @ 25 kg ha^{-1} in the July-2019 in each plot under *M. dubia* and in open plot (control). Standard agro-techniques were followed to manage SSG (Pandey and Roy 2011). The SSG forage was harvested twice (1st at 55 days and 2nd at 95 days after sowing) and cumulative yield was considered in economic analysis. In case of *M. dubia*, standing biomass at the age of 5 years was taken into account. *M. dubia* wood biomass was computed following the standard formula: Biomass = Specific gravity × Volume [Volume (m^3 tree^{-1}) = $g^2 \times h/4\pi$ where, g = Girth at Breast Height (cm), h = height of tree (m)]. The individual tree biomass (average of 36 trees under each land-use system) was converted to per hectare basis in each system considering 5% mortality.

Prices of inputs and cost of cultivation of *M. dubia*-SSG based silvi-pasture systems are given in Table 1 & 2. The gross and net returns from SSG forage and wood biomass production (per hectare under each land use system) was worked out on the basis of prevailing market rates of fresh SSG forage and *M. dubia* wood (Table 1). The net returns from silvi-pasture systems are based on the annual standing biomass of *M. dubia* up to the age of 5 years. The net present value (NPV), benefit-cost ratio (BCR), internal rate of returns (IRR @ 10%) and payback period (PBP) were calculated following standard formulae.

Table 1. Prevailing of inputs prices (Rs.) used and outputs from silvi-pasture systems

Commodity	Price (Rs.)
I. Cost of per unit inputs	
SSG seeds	60 kg^{-1}**
M. dubia seedlings cost	12 seedling^{-1}*
Urea	5.50 kg^{-1}**
SSP	7.3 kg^{-1}**
Labour wages	178 day^{-1}*
Tractor hiring charges per hour	450 h^{-1}*
Irrigation	40 h^{-1}*
Cultivator	300 h^{-1}*
Rotavator	650 h^{-1}*
Mini tractor	170 h^{-1}*
Harvesting of SSG	1780 harvest^{-1}*
II. Per unit output price	
Fresh SSG forage	3 kg^{-1}*
M. dubia wood	4000 t^{-1} #

*http://www.nau.in; **as per local retailer in Navsari Gujarat; #https://m.indiamart.com/proddetail/melia-dubia-plant-15696436348.html

RESULTS AND DISCUSSION

Results (Table 3) pointed out that among *M. dubia*-SSG silvi-pasture and sole SSG cropping systems, on account of SSG forage production, highest net returns of Rs. 96687 ha^{-1} were gained from *M. dubia* (4 x 2 m)-SSG system, followed *M. dubia* (4 x 4m)-SSG system and minimum (Rs. 44527ha^{-1}) were from *M. dubia* (2 x 2 m)-SSG system. On account of *M. dubia* wood biomass (annual average of 5 years) under silvi-pasture systems, highest net returns of Rs. 71937 ha^{-1} were accrued from *M. dubia* (3 x 2 m)-SSG system, followed by *M. dubia* (4 x 2 m)-SSG system and minimum (Rs. 26472) from *M. dubia* (4 x 4 m)-SSG system (Table 3).

Overall, *M. dubia* (4 x 2 m)-SSG system provided maximum total net returns to the tune of Rs. 164135 ha^{-1}, followed by *M. dubia* (3 x 2 m)-SSG system (Rs. 128814 ha^{-1}). Sole SSG cropping system provided lowest net returns (Rs. 84177 ha^{-1}). Jilariya et al (2019) reported net returns of Rs. 3, 36, 360 ha^{-1} from *M. dubia-Aloe vera* based silvi-medicinal systems, which are higher compared to present study. Chandra et al (2020) in rainfed conditions of Hyderabad, have reported net returns from *M. dubia* (6 years of age planted at 5 x 4 m) Rs. 166775 ha^{-1} and from *M. dubia*- Pearl millet agri-silviculture system to the tune of Rs. 169732 ha^{-1} with BCR of 5.36.

Meena (2015) has reported average net returns of Rs. 79,652 ha^{-1} from ber based horti-pasture system. Verma and Thakur (2011) have reported returns ranging from 20286 to 58614 ha^{-1} from agroforestry systems involving tree-crop combinations of Peach-*Morus/Grewia-Setaria-Mucuna pruriens*. Various fruit/fodder/grass-based agroforestry systems have been reported to provide better returns as compared to simple agroforestry systems or many other monocultures in western Himalayas (Thakur et al 2011, Thakur and Verma 2012). The variation in net returns from different agroforestry systems may be due to nature, age and prevailing market rates of outputs.

Table 2. Cultivation and maintenance cost (Rs./ha) of Sorghum Sudan grass (SSG) and *M. dubia*

I. Sorghum Sudan grass		Land use systems					
		T_1	T_2	T_3	T_4	T_5	T_6
A. Fixed cost							
1	Seeds needed @ 25kg ha^{-1}	25	25	25	25	25	25
2	Cost of seeds	1500	1500	1500	1500	1500	1500
3	land preparation/laying out	19140	19840	19840	19840	19840	19840
4	Sowing	356	356	356	356	356	356
B. Variable cost							
	Intercultural operations						
1	Weeding (after each harvest) 10 mandays	3560	3560	3560	3560	3560	3560
2	Fertilizers (Urea and SSP)	3941	3941	3941	3941	3941	3941
3	Irrigation(Irrigation cost + 2 Labours $irrigation^{-1}$)	756	756	756	756	756	756
4	Harvesting	3560	3560	3560	3560	3560	3560
	Total cost of cultivation	32813	33513	33513	33513	33513	33513

II. *M. dubia* (up to 5 years)					
A. Fixed costs	T_1	T_2	T_3	T_4	T_5
Seedling cost	30000	20000	13333	15000	7500
Pit digging	7500	5000	3333	3750	1875
Land preparation	1140	1140	1140	1140	1140
Planting cost (Rs.0.75 $plant^{-1}$)	1875	1250	833	938	469
Total A	40515	27390	18640	20828	10984
B. Variable costs					
Fertilizers (Urea)	593	395	263	296	148
Maintenance cost (Pruning weeding, cultural operations)	5657	5657	5657	5657	5657
Total B	6250	6052	5920	5953	5805
C. Fixed costs					
Depreciation on implements	720	480	360	480	360
Interest on working capital @ 8%	500	484	474	476	464
Total fixed costs	1220	964	834	956	824
Interest on fixed capital @ 8%	3299	2230	1520	1705	906
D. Total cost of cultivation	51284	36636	26914	29441	18521

T_1 = *M. dubia* (2 x 2 m)-SSG, T_2 = *M. dubia* (3 x 2 m)- SSG, T_3 =*M. dubia* (3 x 3 m)- SSG, T_4 =*M. dubia* (4 x 2 m)- SSG, T_5 = *M. dubia* (4 x 4 m)- SSG, T_6 = Sole SSG

Table 3. Gross and net returns (Rs. ha^{-1}) from *M. dubia*-SSG based silvi-pasture and sole cropping systems

Land use systems	SSG				*M. dubia*					Total net returns from land use systems
	Total forage yield (t ha^{-1})*	Cost of cultivation	Gross returns	Net returns	Wood biomass (t ha^{-1})**	Cost of cultivation**	Gross returns**	Net returns**	Net returns (ha^{-1} $year^{-1}$)	
T_1	25.78	32813	77340	44527	67.42	51284	269680	218396	43679	88206
T_2	30.13	33513	90390	56877	99.08	36636	396320	359684	71937	128814
T_3	34.80	33513	104400	70887	64.23	26914	256920	230006	46001	116888
T_4	43.40	33513	130200	96687	91.67	29441	366680	337239	67448	164135
T_5	40.93	33513	122790	89277	37.72	18521	150880	132359	26472	115749
T_6	39.23	33513	117690	84177	0	0	0	0	0	84177

T_1=*M. dubia* (2 x 2m)-SSG, T_2=*M. dubia* (3 x 2m)-SSG, T_3=*M. dubia* (3 x 3m)-SSG, T_4=*M. dubia* (4 x 2m)-SSG, T_5=*M. dubia* (4 x 4m)-SSG, T_6=Sole SSG; *Forage yield of two harvests; **up to 5 years of age

Table 4. Economic feasibility of *M. dubia*-SSG based silvi-pasture and sole cropping systems

Land use systems	Benefit cost ratio (BCR)	Net present value (NPV; Rs.)	Internal rate of return (IRR; %)	Payback period (PBP; year)
M. dubia (2 x 2 m)-SSG	1.05	-4769	5	0.24
M. dubia (3 x 2 m)-SSG	1.84	40057	84	0.14
M. dubia (3 x 3 m)-SSG	1.93	39230	93	0.17
M. dubia (4 x 2 m)-SSG	2.61	74638	161	0.13
M. dubia (4 x 4 m)-SSG	2.22	45815	122	0.19
Sole SSG	2.51	37183	151	0.28

Crop enterprise budgets are subject to prevailing weather conditions of 2018-19. Inputs are evaluated at the prevailing market rates. Fixed costs such as land rent, depreciation, etc. are not included. Benefits have been calculated on the prevailing forage and wood rates. The benefit: cost ratio for a particular crop and inter-crop comparisons should therefore, be viewed cautiously

Results on economic feasibility of *M. dubia*-SSG silvi-pasture and sole SSG cropping based on BCR, NPV, IRR and PBP (Table 4) indicated that among *M. dubia*-SSG silvi-pasture and sole SSG cropping systems, the maximum BCR (2.61), NPV (Rs. 74638), IRR (161 %), and lowest PBP (0.13 years) was estimated from *M. dubia* (4 x 2 m)-SSG system, followed by sole SSG system with BCR (2.51), and IRR (151 %), however it showed lower NPV (37183) and higher PBP (0.28 years) compared to most of the silvi-pasture land use systems. The economic feasibility analysis expressed that silvi-pasture systems are more viable compared to sole SSG cropping. Among all the systems under study, higher net returns were obtained from *M. dubia*-SSG (4 x 2 m and 3 x 2 m) based silvi-pasture and hence, found economically superior compared to rest of the land use systems in the study. Nandal and Kumar (2010) gained the highest NPV (67326), B:C ratio (1.75:1) and IRR (55%) from *Melia azedarach* based agroforestry system involving dhaincha-barseem as intercrop and are comparable to present study. The economics of agroforestry systems vary with the nature of components, prevailing edpho-climatic conditions and market rates of outputs derived.

CONCLUSION

The present study indicates that SSG forage intercropping with *M. dubia* at the spatial arrangements of 4 x 2 m contributed highest net returns followed by *M. dubia* (3 x 2 m) with SSG and suggested that *M. dubia*-SSG based silvi-pasture can give better economic returns compared to sole SSG cropping. Similarly, NPV, IRR, PBP and BCR analysis also expressed that *M. dubia* (4 x 2 m)-SSG silvi-pasture systems could be the most economically viable system. Although, BCR from sole SSG cropping systems was higher compared to silvi-pasture systems except *M. dubia* (4 x 2 m)-SSG, however, this system showed low NPV and higher PBP. Hence, intercropping SSG under *M. dubia* spaced at 4 x 2 or 3 x 2 m is economically more viable.

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Quantitative Analysis and Regeneration Status of Forest Trees Species in Kumaun Central Himalaya

Amit Mittal, Nandan Singh[1] and Ashish Tewari[1]

Department of Allied Sciences, Graphic Era Hill University, Bhimtal Campus, Nainital-263 126, India
[1]Department of Forestry and Environmental Science, Kumaun University, Nainital-263 001, India
E-mail: amitforestry26@gmail.com

Abstract: The aim of the present study was to assess the diversity and regeneration status of three dominant forest types located between 413 and 2345 m in the Kumaun Himalaya. Quadrats methods was used for phytosociological analysis and assessment of regeneration status was based on seedling, sapling and trees density. The total tree density varied between 140 and 617 ha^{-1} in sal dominated forest, 295 and 855 ha^{-1} in chir-pine dominated forest and 245 and 555 ha^{-1} banj oak dominated forest. The value of species diversity (H') was between 1.62 and 2.39 for tree layer in sal dominated forest. The H' (r^2= 0.96) and CD (r^2= 0.91) were correlated positively with density of trees in banj oak dominated forest. The relative proportion of seedling varied between 38.89 and 67.35% *Shorea robusta,* 47.89 and 53.33% of *Pinus roxburghii* and 33.33 and 43.64% of *Quercus leucotrichophora* forests.

***Keywords*:** Composition, Density, Disturbance, Diversity, Regeneration

Himalaya is one of the youngest and largest mountain system of the world and is considered as the great repository of biological and cultural diversity (Negi and Dhyani 2011), home of unique ecosystem, plants, animal and other organism and the richest biodiversity zone (Rawal et al 2018). The vegetation of Himalayan region ranges from tropical dry deciduous forest in the foothills upto alpine meadow above the timberline (Bhatt and Bankoti 2016). The Himalayan forest are suffering from severe climatic and anthropogenic disturbances. Drought and fire are common in tropical and sub-tropical forest and heavy grazing, frozen soil, snow cover and low temperature are common in temperate and alpine forest (Singh et al 2019) while deforestation, collection of fuel wood, fodder and other non-wood forest products are other common factor (Singh et al 2015).

Regeneration is an important phenomenon of development process, which indicates its composition, structure, stand distribution and future crop. Lack of sufficient regeneration is a common problem of many Himalayan species (Tewari et al 2016, 2017). The future composition of forests depends highly on regeneration potential status of species within a forest stand in space and time (Henle et al 2004). Species regeneration is the function of three major components: ability of develop new seedlings, capability seedling and sapling to survive and ability of seedling and sapling to grow (Singh et al 2019). Population structure of a species in a forest can convey partly its regeneration behavior in relation to the reproductive strategy.

The entire Himalayan region is highly vulnerable to the impacts of global warming; the forest ecosystem in Himalaya can be seriously impacted by global climate change (Singh and Mittal 2019). In recent times, some studies have been carried in different region of Himalaya on tree-ring width of Teak in relation to rainfall and temperature by Sinha (2012), geo-statistical analysis of forest by Mandal and Chattarjee (2020), validation of carbon contents in Tropical grassland by Chaturvedi et al (2020), tree diversity and ecological status of *Madhuca latifolia* by Nayak and Sahoo (2020) and Kumar et al (2020), dendrochronological potential study by Upadhyay (2019). The extent to which plant species will be able to adapt to climate change is a central question for ecologists around the globe and is of great importance for conservation and resource management. The present study describes tree species diversity in three forest types and regeneration status of sal, chir-pine and banj oak forest in Kumaun Central Himalaya along an altitudinal transect.

MATERIAL AND METHODS

Three sites each were selected in each in sal, chir-pine and banj oak dominated forests in the Nainital forest division of Kumaun Central Himalaya. The study sites were located between 413 and 2345m between 29° 18′ and 29° 24′ N and 79° 19′ and 79°30′ E situated in tropical and sub-tropical zone. Average annual precipitation for oak and pine dominated forest was 2258 mm of which two third occurred during rainy (mid-June to mid-September) and 1201 mm for sal dominated forest. Mean annual temperature for oak and pine dominated forests sites was 15.2°C and 23.4°C for sal dominated forest sites during the study period. Anthropogenic disturbance lopping of trees for timber, fuel wood, fodder and removal of litter by local people in the region are common.

Vegetation analysis: Quadrats were placed for carrying out the phytosociological analysis of tree species for all the three layers of forest vegetation i.e. trees, saplings and seedlings in the selected sites. The quadrats were laid randomly at each site. In each study site all individual were measured by placing 30 quadrats of 10x10m for trees and 5x5m for saplings and 60 quadrats of 1x1m for seedling (Saxena and Singh 1982). The vegetational data were quantitatively analyzed for density, abundance and total basal area (Curtis and McIntosh 1950). Species diversity was computed using Shannon and Weiner diversity index (H') (Shannon and Weaver 1963). Concentration of dominance was calculated by using the Simpson's index (Simpson 1949).

Population structure: The population structure of different tree species was assessed as seedling, sapling and tree. In each site individuals of each species were measured for CBH (1.37 m from the ground). The trees were sampled as above: 30 cm, sapling: 11-30 cm and seedling < 10cm CBH. The population structure were developed and represented as the relative density percentage (Knight 1975).

Regeneration: The regeneration status of species was determined based on the relative proportion of adults, saplings and seedlings (Singh et al 2019). To assess the regeneration status of species it was categories as good, moderate, poor, absent and fresh regeneration.

RESULTS AND DISCUSSION

Phytosociological analysis: In Himalayan region a wide variation in species richness across sites with similar tree crown cover may indicate that several other factors, such as history of disturbance, leaf chemistry of canopy and spatial arrangement of individuals can verify diversity (Singh et al 2014). The study area is expected to show an intermediate situation with respect to climate, soil moisture and vegetational characters (Singh and Singh 1987, Srivastava 2002). The sal mixed broadleaved forest of low elevation is characterized by a warm climate while banj-oak mixed forest at mid elevation is characterized by a moderate to cold climate.

Sal dominated forest sites: Four tree species were recorded from the three study sites. The total density of all the tree species varied between 140 and 617 ha^{-1} across all the sites. The individual density of trees varied between 22 and 530 ha^{-1} it was maximum for *Shorea robusta* and minimum for *Syzygium cumini* (Table 1). The total basal cover of all the tree species ranged from 6.82 to 72.55 m^2/ha it was maximum for *S. robusta* = 72.08 m^2 ha^{-1} and minimum for *S. cumini* = 0.033 m^2/ha across all the sites. The total density of

Table 1. Phytosociological analysis in different sites of *Shorea robusta* dominated forest

Site	Density (ind. ha^{-1})			Total basal srea (m^2 ha^{-1})			IVI		
	S-I	S-II	S-III	S-I	S-II	S-III	S-I	S-II	S-III
Tree Layer									
Shorea robusta	310	530	100	38.47	72.08	6.44	126.45	146.51	186.15
Mallotus philippinensis	80	40	40	1.53	0.39	0.38	86.41	65.61	113.85
Tectona grandis	40	25	-	0.11	0.05	-	64.34	48.25	-
Syzygium cumini	25	22	-	0.04	0.03	-	22.80	39.63	-
Total	455	617	140	40.16	72.55	6.82	300	300	300
Sapling Layer									
Shorea robusta	90	40	25	0.04	0.24	0.006	119.59	111.5	167.5
Mallotus philippinensis	55	60	10	0.007	0.01	0.0008	82.42	158.5	136.4
Tectona grandis	15	12	-	0.0002	0.0005	-	42.98	30	-
Syzygium cumini	15	-	-	0.0002	-	-	55.01	-	-
Total	175	112	35	0.05	0.25	0.007	300	300	300.9
Seedling Layer									
Shorea robusta	825	760	70	0.64	3.04	0.004	152.22	142.4	196.8
Mallotus philippinensis	225	80	28	0.029	0.07	0.002	80.17	72.4	103.3
Tectona grandis	60	35	-	0.0006	0.01	-	33.01	47.2	-
Syzygium cumini	30	15	-	0.0002	0.0001	-	34.54	38.2	-
Total	1140	890	98	0.67	3.13	0.006	299.94	300.2	300.2

all the saplings ranged from 35 to 175 ha^{-1}. The individual density of saplings varied between 10 and 90 ha^{-1} it was maximum for *S. robusta* and minimum for *Mallotus philippinensis.* The total basal cover of saplings varied between 0.007 and 0.25 m^2/ha. The total density of seedling was between 98 and 1140 ha^{-1} across all the sites. On the basis of IVI across all the layers and sites *S. robusta* was the dominant species followed by *M. philippinensis.* Srivastava et al (2002) reported the tree density between 330 and 530 ha^{-1} in sal mixed broadleaved forests and Kapkoti et al (2016) reported the tree density between 650 and 911 ha^{-1}. *M. philippinensis* the under canopy species of sal forest had relatively low density (40 to 80 ha^{-1}).

The value of species diversity (H') was between 1.62 and 2.39 for tree layer, 1.21 and 1.90 for sapling layer and 1.82 and 2.37 for seedling layer. Similarly, the value of concentration of dominance (CD) ranged from 0.59 to 0.74 for tree layer, 0.37 to 4.36 for sapling layer and 0.56 to 0.73 for seedling layer. The H' (r^2= 0.92) and CD (r^2= 0.89) correlated positively with density of trees. Similarly, the sapling and seedling density also showed a correlation positively with H' and CD.

Chir-Pine dominated forest sites: Four tree species were recorded from the three study sites. The total density of all the tree species varied between 295 and 855 ha^{-1} across all the sites. The individual density of trees varied between 25 and 480 ha^{-1}, it was maximum for *Pinus roxburghii* and minimum for *Quercus leucotrichophora* (Table 2). The total basal cover of all the tree species ranged from 43.76 to 69.14 m^2 ha^{-1} across all the sites. The total basal cover of individual tree species was maximum for *P. roxburghii* = 45.51 m^2 ha^{-1} and minimum for *Rhododendron arboreum* = 0.05 m^2 ha^{-1}. The total density of all the saplings ranged from 80 to 237 ha^{-1}. The individual density of saplings varied between 12 and 120 ha^{-1} it was maximum for *P. roxburghii* and minimum for *R. arboreum* (Table 2). The total basal cover of saplings ranged between 0.10 and 0.18m^2 ha^{-1}. The total density of seedling was between 320 and 758 ha^{-1}. On the basis of IVI across all the layers and sites *P. roxburghii* was the dominant species followed by *Myrica esculenta.* Kumar and Ram (2005) reported the density of *P. roxburghii* between 60 to 500 indi ha^{-1} in Kumaun central Himalaya and Pananjay et al (2012) in montane zone of Garhwal Himalaya. In a Van Panchayat forest Pandey and Lodhiyal (2015) reported the *P. roxburghii* density between 340 - 530 ha^{-1}, which was slightly higher than the values of present study. The species diversity was between 1.24 and 1.90 for tree layer, 0.96 and 2.09 for sapling layer and 1.58 and 2.51 for seedling layer. Similarly, the value of concentration of dominance ranged from 0.38 to 0.59 for tree layer, 0.30 to 3.25 for sapling layer and 0.49 to 0.78 for seedling layer. The H' (r^2= 0.87) and CD (r^2= 0.76) correlated positively with density of trees. Similarly, the

Table 2. Phytosociological analysis in different sites of *Pinus roxburghii* dominated forest

Site	Density (ind. ha^{-1})			Total basal srea (m^2 ha^{-1})			IVI		
	S-I	S-II	S-III	S-I	S-II	S-III	S-I	S-II	S-III
Tree Layer									
Pinus roxburghii	480	300	220	41.28	45.51	42.3	133.54	112.45	232.65
Myrica esculenta	180	110	50	13.46	5.02	0.78	64.54	66.41	48.52
Quercus leucotrichophora	120	85	25	12.18	6.64	0.68	59.81	58.98	18.92
Rhododendron arboreum	75	35	-	2.22	0.5	-	42.11	62.16	-
Total	855	530	295	69.144	57.67	43.76	300	300	300.09
Sapling Layer									
Pinus roxburghii	75	120	62	0.026	0.15	0.01	98.4	134.5	179.4
Myrica esculenta	80	80	18	0.052	0.03	0.0003	111.6	104.2	121.4
Quercus leucotrichophora	25	25	-	0.0033	0.003	-	34.8	45.7	-
Rhododendron arboreum	35	12	-	0.004	0.0004	-	55.6	15.6	-
Total	215	237	80	0.086	0.18	0.010	300.4	300	300.8
Seedling Layer									
Pinus roxburghii	510	480	280	0.512	0.48	0.03	151.4	198.5	181.7
Myrica esculenta	120	90	40	0.11	0.05	0.01	83.1	56.5	118.4
Quercus leucotrichophora	80	32	-	0.0027	0.01	-	43.5	23.5	-
Rhododendron arboreum	48	30	-	0.020	0.01	-	22.4	21.5	-
Total	758	632	320	0.65	0.55	0.04	300.4	300	300.1

sapling and seedling density also showed a correlation positively with H' and CD.

Banj oak dominated forest sites: Seven tree species were recorded from the three study sites. The total density of all the tree species varied between 245 and 555 ha^{-1} across all the sites. The individual density of trees varied between 15 and 250 ha^{-1} it was maximum for *Q. leucotrichophora* and minimum for *Lyonia ovalifilia* (Table 3). The total basal cover of all the tree species ranged from 24.59 to 70.71 $m^2 ha^{-1}$ across all the sites. The total basal cover of individual tree species was maximum for *Q. leucotrichophora* and minimum for *L. ovalifilia.* The total density of all the saplings ranged from 65 to 300 ha^{-1}. The individual density of saplings varied between 10 and 180 ha^{-1} it was maximum for *R. arboreum* and minimum for *Alnus nepalensis* (Table 3). The total basal cover of saplings ranged between 0.007 and 0.063m^2/ha. The value of the total density of seedling was between 75 and 1094 ha^{-1}. On the basis of IVI across all the layers and sites *Q. leucotrichophora* was the dominant species followed by *Q. floribunda*. Himalayan broad-leaved forests are mainly dominated by oak (*Quercus* species). The density and TBA value of present study were comparatively lower than the values reported by Singh and Rawat (2012) from the Garhwal Himalaya of oak = 415 ha^{-1} and 88.06 $m^2 ha^{-1}$ and Pandey and Lodhiyal (2015) reported between 520-840 ha^{-1} in Jungali Van Panchayat which was also higher than the present study values. The value of H' was between 1.01 and 1.41 for tree layer, 1.38 and 1.96 for sapling layer and 1.06 and 3.22 for seedling layer. Similarly, the value of CD ranged from 0.31 to 0.43 for tree layer, 0.42 to 0.61 for sapling layer and 0.33 to 1.0 for seedling layer. The H' (r^2= 0.96) and CD (r^2= 0.91) correlated positively with density of trees. Similarly, the sapling and seedling density also showed a correlation positively with H' and CD.

The oak dominated forest showed highest species diversity whereas chir-pine and sal dominated forest was characterized by low species diversity. Oak dominated forest showed greater variation in all three layers tree, sapling and seedling species diversity similar results also observed by

Table 3. Phytosociological analysis in different sites of *Quercus leucotrichophora* dominated forest

Site	Density (ind. ha^{-1})			Total basal srea (m^2 ha^{-1})			IVI		
	S-I	S-II	S-III	S-I	S-II	S-III	S-I	S-II	S-III
Tree Layer									
Quercus leucotrichophora	250	190	110	48.22	21.77	15.82	151.98	210.55	153.54
Quercus floribunda	150	-	65	19.2	-	8.45	59.26	-	71.84
Rhododendron arboretum	100	50	-	2.64	0.76	-	46.15	35.41	-
Myrica esculenta	-	80	-	-	2.06	-		54.04	-
Alnus nepalensis	40	-	-	0.6	-	-	30.15	-	-
Lyonia ovalifilia	15	-	-	0.05	-	-	12.56	-	-
Aesculus indica	-	-	70	-	-	10.402	-	-	74.62
Total	555	320	245	70.71	24.59	34.68	300.1	300	300
Sapling layer									
Quercus leucotrichophora	60	50	40	0.016	0.06	0.004	75.6	209.5	200.7
Quercus floribunda	50	-	-	0.010	-	-	55.6	-	-
Rhododendron arboretum	180	18	25	0.019	0.00	0.003	146.5	90.7	99.3
Alnus nepalensis	10	-	-	0.0002	-	-	22.3	-	-
Total	300	68	65	0.047	0.06	0.007	300	300.2	300
Seedling layer									
Quercus leucotrichophora	240	160	75	0.16	0.004	0.05	79.5	209.8	202.8
Quercus floribunda	550	-	-	0.60	-	-	156.4	-	-
Rhododendron arboretum	180	60	-	0.15	0.04	-	36.5	89.9	98.0
Alnus nepalensis	26	-	-	0.007	-	-	5.6	-	-
Fraxinus micrantha	45	-	-	0.01	-	-	9.5	-	-
Litsea umbrosa	35	-	-	2.10	-	-	7.5	-	-
Lyonia ovalifilia	18	-	-	0.0001	-	-	4.9	-	-
Total	1094	220	75	3.06	0.04	0.05	299.9	299.7	300.8

Singh et al (2014) in Kumaun Himalayan region. The highest species diversity in oak dominated forest may be due to the favorable climatic conditions, thick humus soil rich in nutrients and sufficient soil moisture, while low species diversity in chir-pine dominated may be due to acidic soils poor in nutrients, low soil moisture and occasional fires during summer season. While some other factors can also affect the species diversity such as, immature seed fall, increase biotic pressure and close of the tree canopy which arrest the regeneration of the some tree species. The opening of canopy increase the number of sapling species in the high disturbed forest (Singh et al 2014).

Population Structure and Regeneration Pattern

Sal dominated forest sites: Across all the sites of *S. robusta* and associated species regenerating well but the conversion from seedling to sapling was very low. All species followed the regeneration pattern of seedling > sapling < adult. Across all the sites of *S. robusta* the relative proportion varied between 38.89 and 67.35% for seedling, 3.01 and 7.35% for sapling and 25.31 and 55.56% for adults (Fig. 1). The relative proportion of *M. philippinensis* ranged from 41.18 to 62.50% for seedling 15.28 to 33.33% for sapling and 22.22 to 58.82% for adults. The relative proportion of *T. grandis* ranged from 48.61 to 52.17% for seedling 13.04 to 16.67% for sapling and 34.72 to 34.78% for adults. Similarly, the relative proportion of *S. cumini* ranged from 24.19 to 42.86% for seedling, 21.43 to 40.32% for sapling and 35.48 to 35.71% for adults (Fig. 1).

Chir pine dominated forest sites: Across all the sites of *P. roxburghii* and associated species regenerating well but the conversion from seedling to sapling was very poor. All tree species followed the regeneration pattern of seedling > sapling < adult. Across all the sites the relative proportion of *P. roxburghii* varied between 47.89 and 53.33% for seedling 7.04 and 13.33% for sapling and 33.33 and 45.07% for adults (Fig. 2). The relative proportion of *M. esculenta* ranged from 31.58 to 37.04%, 16.67 to 28.57% and 39.29 to 47.37% for seedling, sapling and adults. The relative proportion of *Q. leucotrichophora* ranged from 22.54 to 35.56% for seedling 11.11 to 17.61% for sapling and 53.33 to 100% for adults. Similarly, the relative proportion of *R. arboreum* ranged from 30.38 to 38.96%, 15.58 to 22.15% and 45.45 to 47.47% for seedling, sapling and adults (Fig. 2).

Banj-Oak dominated forest sites: Across all the sites the seedlings of *Q. leucotrichophora* and *R. arboreum* showed the presence, while the seedlings of associated species of *Q. leucotrichophora* were absent. The species showed poor or

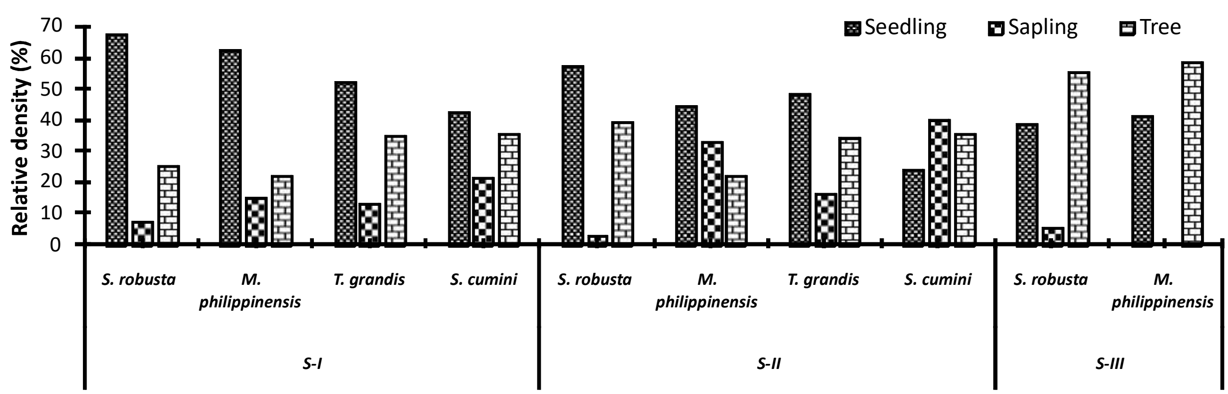

Fig. 1. Population structure of sal dominated forest tree species across all the sites

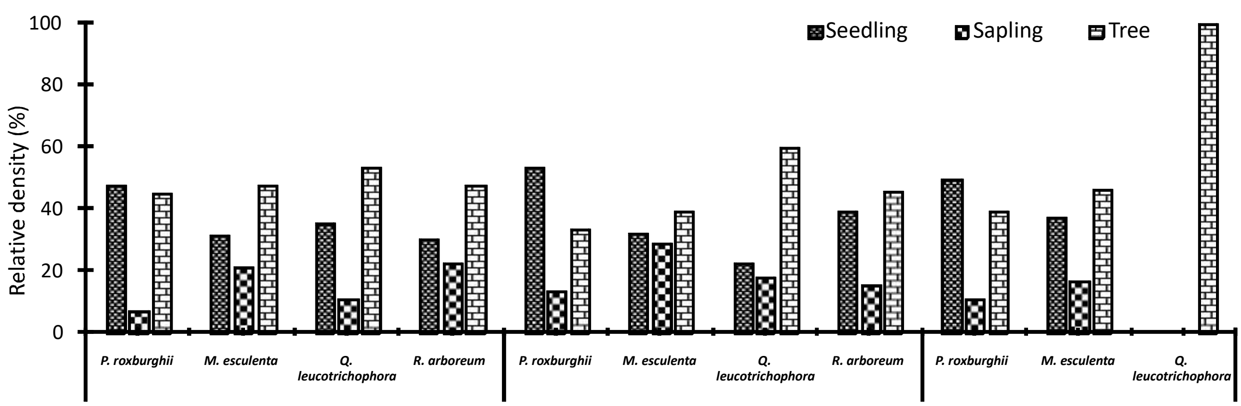

Fig. 2. Population structure of chir pine dominated forest tree species across all the sites

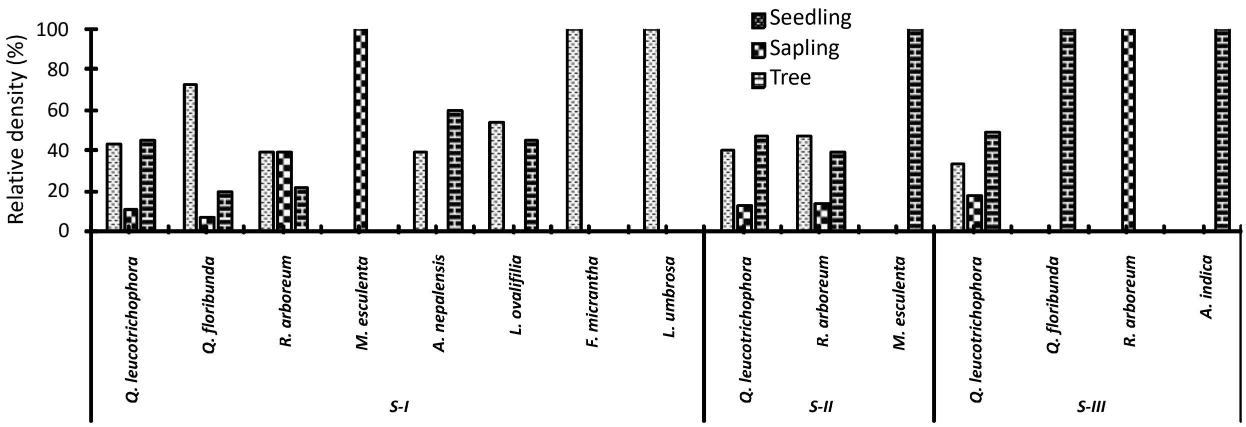

Fig. 3. Population structure of banj oak dominated forest tree species across all the sites

absent regeneration and followed the pattern of seedling > sapling < adult or seedling↔ sapling → adults. The relative proportion of *Q. leucotrichophora* varied between 33.33 and 43.64 for seedling 10.91 and 17.78 for sapling and 45.45 and 48.89 for adults (Fig. 3). The relative proportion of *Q. floribunda* was 73.33, 6.67, 20-80 percent and of *R. arboreum* was 46.88, 14.06, 39.06 for seedling, sapling and adults. *Myrica esculenta* present in sapling and adults stage while *Aesculus indica* present only in adults stage. *Alnus nepelensis* and *Lyonia ovalifilia* absent in sapling stage and *Fraxinus micrantha* and *Litsea umbrosa* present only in seedling class (Fig. 3).

The regeneration status of studied species was low. The seedling density of all the species was high but conversion of seedling into sapling was relatively poor. Poor regeneration of *Quercus* species in Himalayan mountain forests was also reported by other workers from time to time (Singh et al 2019) and anthropogenic disturbance was attributed for this. Kumar and Sharma (2014) have reported that due to human and animal impact, forest species are showing inadequate regeneration of younger individuals. According to Singh and Singh (1992) grazing by cattle is the one of the fundamental cause of why oak species are facing to regenerate in the central Himalayan forest. Occasional fire and drought are responsible for low number of sapling and young individuals of sal dominated forest. As most of the human population in Uttarakhand is concentrated between 800 to 2000m was the forests are severely impacted by human activity. *P. roxburghii* mixed broad leaved, deciduous and mixed broad leaved forest have high disturbance because these forest were in close proximity to human habitation and suffered from the chronic disturbance (Kumar and Ram 2005). The entire Himalayan forest requires proper conservation and management strategy, so that the seedlings and saplings could survive and replace adult trees in future.

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Estimation of Quantity and Economic Benefits Flowing From Non-Timber Forest Products: A Study from Valsad North and South Forest Divisions of Gujarat State, India

Rajkumar Yadav, Ishan Pandya[1], R.D. Kamboj and Sweta Rajpurohit

Gujarat Ecological Education and Research (GEER) Foundation,
[1]Aakash Institute, Gandhinagar-382 007, India
E-mail: rajbot99@gmail.com

Abstract: The diversity and quantity of NTFPs in any area can provide the availability of economic benefits flowing from the NTFPs. So, in the current study, an attempt has been carried out to know the total quantity of collection and total economic benefits of NTFPs existing in Valsad North Forest Division (VNFD) and Valsad South Forest Division (VSFD). An analysis of the surveyed information and its findings revealed that VNFD and VSFD collectively, housed total 24 types of NTFPs (23 of vegetal products and 1 from the animal product) which has a total quantity of 10643610.6 kg annum^{-1} and 7581813 bundle annum^{-1} (leaves) of *Diospyros melanoxylon* Roxb. The monetary value of these NTFPs was assessed to be Rs. 230.4 lakhs annum^{-1} which contributed to the economies of two forest division i.e. VNFD and VSFD. Therefore, the study revealed that the economic benefits and NTFPs diversity may affect the subsistence and daily consumption of forest dwellers living in forest areas of VNFD and VSFD.

***Keywords*:** Economic, Estimation, NTFPs, VSFD, VNFD

Food and Agriculture Organisation has defined the Non- Timber Forest Products (NTFPs) as “Goods of biological origin other than wood derived from forest” (FAO 2014). It has a positive impact on forest conservation because the harvesting of NTFPs have a lower impact on the forest ecosystem than timber harvesting and it can provide an array of social and economic benefits, particularly to community operation, and can, therefore, be an important component of forest ecosystem management (Bhat and Tiwari 2012). The NTFPs may be in the form of roots, stem, barks, gums, resins, leaves, flowers, dye, seeds, fruits, honey, lac, and medicinal plant etc. which are an important source of livelihood for 350 millions peoples across the world whereas, in India total 50 million peoples are dependent on NTFPs for their regular economic benefits (MOEF 2010, Bhat and Tiwari 2012, Mukul et al 2014). A total of 3000 plant species yield NTFPs in India, out of which only 128 types of NTFPs are being utilised for commercial purpose (Maithani 1994 and Murthy et al 2005). These NTFPs have long been used as subsistence by local communities living nearby forest area worldwide and in India; over 75% of revenue comes from the export of forest produce accounted by NTFPs (Bhat and Tiwari 2012). In various studies carried out by researchers revealed that increased used of forest resources for consumption purposes as well as for income generation to sustain livelihood during adverse time (Rawat et al 2018). There are various NTFPs being collected for self- consumption or income which are neither recorded nor accounted for the determination of the economic benefits. Therefore, the current study was carried out to assess the total economic benefits of NTFPs accruing by local people in the south Gujarat region especially the Valsad North Forest Division (VNFD) and Valsad South Forest Division (VSFD).

MATERIAL AND METHODS

Study area: VNFD and VSFD forest Divisions are the parts of the Valsad Forest Circle located in Navsari and Valsad district, respectively. VNFD and VSFD lie between 72° 44' to 73°29'E (longitude) and 20° 59' to 20° 07' N (latitude) of the southern part of Gujarat state. As per Champion and Seth (1968) forest type classification, VNFD and VSFD are occupied with three forest types (1) Southern tropical moist deciduous forest (2) Mixed dry deciduous forest and (3) Littoral and swamp forest. However, littoral and swamp forests have not been considered in the current study (Fig. 1).

During the present study, a total of 10% villages having three forest density classes i.e., very dense, moderate dense and open forest were selected for the household survey. The village selection from different density classes were carried out using stratified random sampling methodology to avoid the biasness of the similar type of village selection. The totals of 18 villages were selected each from Valsad North and Valsad South Forest Divisions. Field visit was organised for household cum questionnaire surveys in respective forest divisions to know the types and quantity of NTFPs collection by forest dwellers. The household survey was done with Rapid Rural Appraisal (RRA) in which head of the village and the members of village forest committee (VFC) were involved. The selection of household was done to represents the diversity of all communities of the selected village to avoid biasness of similar type of community selection. Thus, using above mention methodology, a total 604 and 706 households have been surveyed in Valsad North and Valsad South Forest Divisions, respectively.

RESULTS AND DISCUSSION

Quantification and Valuation of NTFPs in VNFD and VSFD: Forest dwellers of both forest divisions extract a variety of NTFPs in the form of fruits, seeds, gum, leaves, flowers and other miscellaneous forms such as honey and tuber. The total of 24 types of NTFPs (23 of vegetal products and 1 from animal product) have

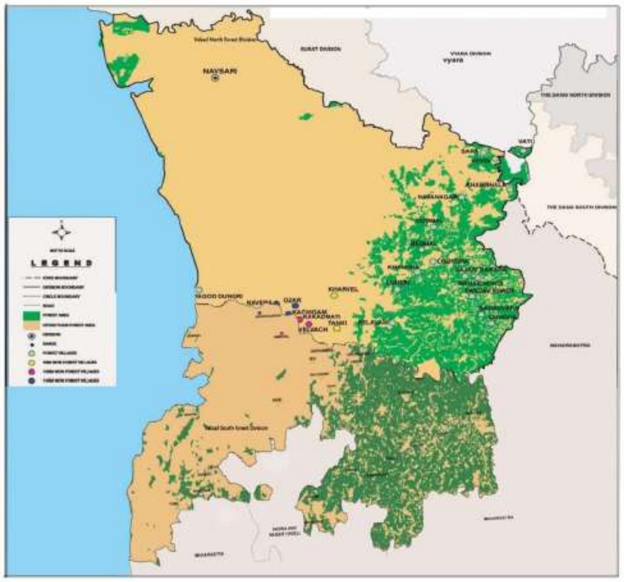

Fig. 1. Surveyed forest villages in VNFD and VSFD

been identified which are being extracted by local people living in the vicinity of VNFD and VSFD. The numerous studies in different areas of Gujarat state documented total number of NTFPs around 24- 50 in different forest divisions of Gujarat with 1-3 animal and rest of plant orgine (Yadav et al 2019a and Yadav et al 2019d). In the current study, major species of different NTFPs (Table 1) are categorised into different categories of flowers (*Madhuca longifolia* var. *latifolia* (Roxb.) A. Chev.) fruits and seeds (*Anacardium occidentale* L., *Carissa spinarum* L., *Syzygium cumini* (L.) Skeels etc. see Table 1), leaves (*Diospyros melanoxylon* Roxb.), miscellaneous NTFPs (*Chlorophytum tuberosum* (Roxb.) Baker., and honey) and Gum (*Firmiana simplex* (L.) W. Wight. and *Lannea coromandelica* (Houtt.) Merr.). The quantum of different types of NTFPs collection in the VNFD and VSFD were estimated to be around 10643610.6 kg $annum^{-1}$ from fruits and seeds, gum, flowers, miscellaneous form of NTFPs while around 7581813 bundle $annum^{-1}$ from the *Diospyros melanoxylon* Roxb. leaves. The category wise quantity of NTFPs $annum^{-1}$ include 444581.4 and 3931.37 kg, 7581813 bundle, 612944.6 and 2903.69 kg from fruits and seeds, gum, flowers and miscellaneous form of NTFPs, respectively.

Table 1. Estimated collection and economic value of NTFPs from Valsad North and Valsad South Forest Divisions

Name of species	Vernacular name of NTFPs and part used	Total estimated collection (kg)	Total estimated value in Rs. Lakhs $annum^{-1}$
NTFPs in form of fruits and seeds			
Diospyros melanoxylon Roxb.	Timru fruit	7577.14	1.14
Carissa spinarum L.	Karamda fruit	48205.7	9.64
Anacardium occidentale L.	Kaju fruit	22564.75	11.28
Syzygium cumini (L.) Skeels	Jambu fruit	21072.83	6.32
Garuga pinnata Roxb.	Kakad fruit	30122.18	2.11
Meyna laxiflora Robyns	Adav fruit	20255.36	3.04
Grewia tiliifolia Vahl	Dhamna fruit	16610.54	3.32
Schleichera oleosa (Lour.) Merr.	Kusum fruit	10274.1	0.723
Aegle marmelos (L.) Correa	Bili fruit	8097.69	1.21
Zizyphus sp.	Bore fruit	3614.5	0.36
Phyllanthus emblica L.	Amla fruit	3986.79	0.6
Mangifera indica L.	Amba fruit	2574.18	1.8
Sapindus emarginatus Vahl	Aritha fruit	2093.45	0.21
Bridelia retusa (L.) A. Juss.	Asan fruit	1237.1	0.06
Tamarindus indica L.	Khati amli fruit	1780.01	0.18
Buchanania cochinchinensis (Lour.) M.R. Almeida	Charoli fruit	477.31	0.29
Madhuca longifolia var. *latifolia* (Roxb.) A. Chev.	Mahuda seed	237911.3	33.31
Senna tora (L.) Roxb.	Puwadiya seed	6126.5	0.4
Total		444581.4	75.99
NTFPs in form of gum			
Sterculia urens Roxb.	Kadayo gum	3427.06	6.21
Lannea coromandelica (Houtt.) Merr.	Modad gum	504.31	0.15
Total		3931.37	6.36
NTFPs in form of leaves			
Diospyros melanoxylon Roxb.	Timru Leaves	7581813*	60.65
Total		7581813	60.65
NTFPs in form of flowers			
Madhuca longifolia var. *latifolia* (Roxb.) A. Chev.	Mahuda flower	612944.6	79.69
Total		612944.6	79.69
NTFPs in form of miscellaneous			
Honey	Madh	1987.21	3.97
Chlorophytum tuberosum (Roxb.) Baker	Musali tuber	916.48	3.2
Total		2903.69	7.71
Grand Total		-	230.4

From the total quantity of collection, the estimated value of different NTFPs was Rs. 230.4 lakh annum^{-1}, which showed the highest economic contribution from flowers, followed by fruits and seeds, leaves and miscellaneous NTFPs. The total estimated value of NTFPs in two forest divisions were found to be lesser than observed by the Yadav et al (2018, 2019 a,b,d). The estimated value of current study is higher than Rs124.41 lakh annum^{-1} (Yadav et al 2019c), which have been estimated from South Dangs Forest Division (SDFD). Category wise analysis indicated that in the NTFPs, 35% of total monetary value was derived from flower, 33% form fruits and seeds, 26 % from leaves, 3% from miscellaneous NTFPs and 3% from gums.

CONCLUSION

The current study revealed that VNFD and VSFD are housed with a various types of NTFPs considered as vegetal and animal products which reflect its remarkable economic benefits to people living the area. In the study, the highest economic benefits, were derived from flower followed fruits and seeds, leaves miscellaneous NTFPs and gums. However, the diversity of NTFPs and its total economic benefits in the Valsad North and Valsad South Forest Divisions were found to be lesser than the other adjoining forest divisions and Forest Circle such as SNFD, CFD, GFD and SFC. So, in the Valsad North and Valsad South Forest Divisions, there is need of enhancing the growth and yield of NTFPs by planting different NTFPs producing plant species which could increase diversity, yield and economic benefits of NTFPs. In addition to that, there should be systematic accounting of NTFPs quantity at regular intervals. Such activity would help in estimating the subsistence of local forest dwellers living in the forest area.

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Prediction of Allometric Models of Stand Biomass of *Betula* sp. in Eurasia

Vladimir Andreevich Usoltsev[1,2], Seyed Omid Reza Shobairi[1*], Amirhossein Ahrari[3], Meng Zhang[4] and Viktor Petrovich Chasovskikh[1]

[1]*Ural State Forest Engineering University, 620100 Yekaterinburg, Sibirskiy Trakt, 37, Russia*
[2]*Botanical Garden of Ural Branch of RAS, 620144 Yekaterinburg, ul. 8 Marta, 202a, Russia;* [3]*Remote Sensing Expert, Iran*
[4]*Research Center of Forestry Remote Sensing & Information Engineering*
Central South University of Forestry and Technology, Changsha 410004, China
**E-mail: Omidshobeyri214@gmail.com*

Abstract: When using the unique in terms of the volume of database on the level of stand of the genus *Betula* sp., the trans-Eurasian additive allometric models of biomass of stands for Eurasian birch forests are developed for the first time, and thereby the combined problem of model additivity and generality is solved. The additive model of forest biomass of *Betula*is harmonized in two ways: it eliminated the internal contradictions of the component and the total biomass equations, and in addition, it takes into account regional differences of forest stands not only on total, aboveground and underground biomass, but also on its component structure, i.e. it reflects the regional peculiarities of the component structure of biomass.

Keywords: Allometric models, Biological productivity, Biomass of tree and forests, *Betula*, Sample plots

In recent years, the world forest ecology is experiencing unprecedented information splash in the assessment of forest biological productivity in relation to climate change observed since 1960-80ies, predicted at the end of the 19th century in the works of "the father of global warming" Svante Arrhenius (1896). The current hype surrounding the problem of breached the carbon balance of the biosphere and questionable hopes for his recovery by means of a total afforestation of planet, passes into the common paradigm of sustainable development, which the first is biosphere-stabilizing function of forests, bu ttraditional resource forest management is seen as a subordinate task. Estimating of biological productivity or carbon-depositing ability of forests is going on the global level, and its increase is one of the major factors of climate stabilization.

The modern methods of modelling the biological productivity of trees and tree stands have been developed towards additivity of biomass components (Bi et al 2010, Dong et al 2015) and towards transition from "pseudo-generic" allometric models to really generic, involving regionalization of biomass models by introducing dummy variables (Fu et al 2012), that usually fulfilled on local sets of actual biomass of trees and tree stands. The database of forest stand biomass for the main forest species in Eurasia (Usoltsev 2010, 2013), that has enabled these modern methodologies to be implemented on the entirely different, higher level, namely to begin modelling additive biomass on transcontinental level. The additive principle is implemented only for local models of forest stand biomass (Bi et al 2010). Its complexity and structural unwieldiness of analytical expression, apparently, are the reason that nowadays it is not implemented at the continental level, for example, by the dismemberment of a general additive biomass model on a set of compatible regional sub-models, marked by dummy variables or in some other way. Previously (Usoltsev et al 2017a,b) the transcontinental additive biomass models of forest stands of Norway spruce (*Picea* sp.) and fir (*Abies* sp.) growing on the territory of Eurasia were first proposed, that are generic additive models for these species i.e. without taking into account their regional specificities.

In this article, the first attempt to develop transcontinental harmonized allometric models of birch (genus *Betula* sp.) forest stand biomass, which combine both mentioned by Jacobs and Cunia (1980) approaches, namely, ensuring the principle of additivity of biomass component composition and localizating (dismemberment) of biomass additive model on regions of Eurasia by introducing dummy variables. In other words, an attempt is made to solve the problems of combining additivity and totality of models. These models will provide the basis for the development of trans-continental regional standards for evaluation biomass of trees and forest stands.

MATERIAL AND METHODS

Of the database mentioned the material in a number of 520 sample plots with estimations of birch forest stand biomass (t/ha) is extracted. Genus *Betula* sp. is introduced by five species (correspondingly *B. alba* L., *B. tortuosa* Ldb., *B.*

platyphylla Suk., *B. ermanii* Cham., *B. costata* Trautv.), distributed across 11 eco-regions and designated respectively with the 11 dummy variables from X_0 to X_{10} (Table 1). The distribution of sample plots, on which the birch forest biomass is measured in ecoregions of Eurasia, is shown in Figure 1.

Analysis of biomass forest stands is made on the basis of allometric additive models. According to the structure of disaggregation three-step model (Tang et al 2000, Dong et al2015), biomass value, estimated by the total biomass equation, exploded into components according to the scheme presented in Figure 2. The coefficients of the regression models for all three steps are evaluated simultaneously, which ensures additive biomass of all the components-total, intermediate and initial (Dong et al 2015).

Fig. 1. Allocation of sample plots with measured biomass (t ha^{-1}) of 520 stands of birch (genus *Betula* sp.) on the territory of Eurasia

RESULTS AND DISCUSSION

The initial allometric model is calculated;

$$\ln P_i = a_i+b_i(\ln A)+c_i(\ln A)^2+ d_i(\ln H)+e_i(\ln D)+f_i(\ln N)+ \Sigma g_{ij}X_j, \quad (1)$$

where *Pi* – biomass of *i*-th component, t per ha; *A* – stand age, years; *H* – mean stand height, m; *D* – mean tree diameter, cm; *N* – tree number, 1000ha^{-1}; *a-g* – regression coefficients; *i* – index of biomass component: total (t), aboveground (a), roots (r), crowns (c), stems above bark (s), needles (f), branches (b), stem wood (w) and stem bark (bk); *j* - index (code) in the block of dummy variables coding the ecoregions, from 0 to 10 (see Table 1).

Model (1) after anti-log transformation is given to the form

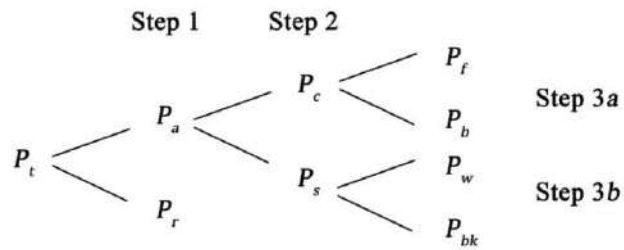

Fig. 2. The pattern of disaggregating three-step proportional weighting additive model. Designation: *Pt, Pr, Pa, Pc, Ps, Pf, Pb, Pw* and *Pbk* are stand biomass respectively:total, underground (roots), aboveground, crown (needles and branches), stems above bark (wood and bark), needles, branches, stem wood and stem bark correspondingly, t ha^{-1}

Table 1. The encoding scheme of the regional actual biomass data sets of 520 birch forest stands

Region *	Species of. *Betula* sp.	Block of dummy variables										Ranges of:				Plot quantity
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	Stand age (yrs)	Tree number (1000 ha^{-1})	Mean diameter cm)	Mean height (m)	
WME	*B. alba* L.	0	0	0	0	0	0	0	0	0	0	8÷80	0.35÷14.15	1.8÷28.5	2.1÷26.5	89
ERn	*B. alba* L.	1	0	0	0	0	0	0	0	0	0	10÷110	0.69÷27.6	1.9÷20.3	2.0÷25.1	41
ERs	*B. alba* L.	0	1	0	0	0	0	0	0	0	0	5÷95	0.28÷304.0	1.1÷31.2	1.7÷30.3	161
Ural	*B. alba* L.	0	0	1	0	0	0	0	0	0	0	5÷67	0.77÷42.9	1.1÷22.0	2.6÷23.4	44
WSst	*B. alba* L.	0	0	0	1	0	0	0	0	0	0	5÷100	0.29÷43.4	2.0÷33.0	3.1÷25.8	66
MSn	*B. alba* L. *B. tortuosa* L.	0	0	0	0	1	0	0	0	0	0	37÷100	0.38÷5.92	5.0÷24.0	4.0÷23.6	20
MSs	*B. alba* L.	0	0	0	0	0	1	0	0	0	0	15÷100	0.33÷10.17	4.4÷30.2	1.5÷25.1	68
ES	*B. alba* L. *B. ermanii* Ch.	0	0	0	0	0	0	1	0	0	0	13÷175	0.26÷83.6	1.0÷32.4	2.0÷19.0	9
FEs	*B. costata* Tr.	0	0	0	0	0	0	0	1	0	0	60÷190	0.15÷5.34	25.0÷48.2	15.3÷26.1	10
Ch	*B. platyphylla* S.	0	0	0	0	0	0	0	0	1	0	35÷100	0.50÷1.64	12.3÷20.0	10.6÷20.0	5
Jap	*B. platyphylla* S. *B. ermanii* Ch.	0	0	0	0	0	0	0	0	0	1	10÷47	0.27÷20.06	2.7÷23.5	4.3÷22.5	7

*WME – West and Middle Europe; ERn – European part of Russia,northern territory;ERs – European part of Russia, southern territory;Ural – Midle and Southern Ural;WSst – Western Siberia, steppe and forest-steppe; MSn – Middle Siberia, northern territory; MSs – Middle Siberia, southern territory; ES - Eastern Siberia, northern taiga; FEs – Far East, southern territory (Primorie); Ch – Northeast China; Jap – Japanese islands

$$P_i = a_i A^{b_i} A^{c_i(\ln A)} H^{d_i} D^{e_i} N^{f_i} e^{\Sigma g_{ij} X_j} \quad (2)$$

Characteristic of equations (1) obtained by its approximation using actual biomass data, after the introduction of correction to the logarithmic transformation after Baskerville (1972) and the subsequent anti-log transformation to (2) are given in the Table 2. All the regression coefficients of the equations (2) with numerical variables are significant at the level of probability of 0.95 or higher, and the equations are adequate to actual data.

The equations (2) are modified according to the algorithm proposed by chinese researchers (Dong et al 2015) (Table 3), and the final transcontinental additive model of birch biomass component composition on the level of forest stand is given in the Table 4. The model is valid in the range of actual data of stand age, mean tree height, mean stem diameter and tree density, listed in the Table 1, and is characterized by a double harmonization: one of which provides the principle of biomass component additivity, and the second one relates to the introduction of dummy variables, localizing the model according to ecoregions of Eurasia.

At the next stage of the study, a comparison of the adequacy of additive model (Table 4) and independent equations shown in the Table 2. For the correct comparing the sample plots with incomplete biomass component structure are deleted from the initial harvest data, i.e. only those records are left in which the data are available on both aboveground and underground biomass. The equations 2 are approximated according to such "methodized" data, and their final forms are given in the Table 5. As the "methodized" additive model, and "methodized" independent equations, are tabulated according to actual mass-forming indices of the

Table 3. The structure of three-step additive model built by proportional weighting (Dong et al 2015)

Step 1	$Pa = \dfrac{1}{1+\dfrac{a_r D^{br} H^{Cr}}{a_a D^{ba} H^{Ca}}} \times P_t$	$Pr = \dfrac{1}{1+\dfrac{a_r D^{br} H^{Cr}}{a_a D^{ba} H^{Ca}}} \times P_t$
Step 2	$Pc = \dfrac{1}{1+\dfrac{a_s D^{bs} H^{Cs}}{a_c D^{bc} H^{Cc}}} \times P_a$	$Ps = \dfrac{1}{1+\dfrac{a_c D^{bc} H^{Cc}}{a_s D^{bs} H^{Cs}}} \times P_a$
Step 3a	$Pf = \dfrac{1}{1+\dfrac{a_b D^{bb} H^{Cb}}{a_f D^{bf} H^{Cf}}} \times P_c$	$Pb = \dfrac{1}{1+\dfrac{a_f D^{bf} H^{Cf}}{a_b D^{bb} H^{Cb}}} \times P_c$
Step 3b	$Pw = \dfrac{1}{1+\dfrac{a_{bk} D^{bbk} H^{Cbk}}{a_w D^{bw} H^{Cw}}} \times P_s$	$Pbk = \dfrac{1}{1+\dfrac{a_w D^{bw} H^{Cw}}{a_{bk} D^{bbk} H^{Cbk}}} \times P_s$

See Figure 2 and equation 1 for details

modified data and the obtained values are compared with harvest biomass data using the formula:

$$R^2 = 1 - \frac{\sum_{i=1}^{N} (Y_i - \overline{Y}_i)^2}{\sum_{i=1}^{N} (Y_i - \overline{Y}_i)^2} \qquad (2)$$

where Y_i is observed value; $\hat{Y}_i$ is predicted value; $\bar{Y}$ is the mean of N observed values for the same component.

The results of comparison of the adequacy of two modeling indicate that the adequacy of the two systems of equations for aboveground biomass, underground one and stem biomass are similar and the indices of additive equations for mass of crown, needles and branches are slightly worse (Table 6). The ratio of actual values and derived ones by tabulating independent and additive stand

Table 2. Characteristic of initial allometric equations for birch stands

Biomass component	Independent variables and the regression model coefficients															$adjR^2$*
P_t	2.3124	$A^{-0.1332}$	$H^{0.7126}$	$D^{0.9612}$	$N^{0.3588}$	$e^{-0.1815X1}$	$e^{-0.0816X2}$	$e^{-0.0775X3}$	$e^{0.0661X4}$	$e^{0.3945X5}$	$e^{-0.0498X6}$	$e^{-0.1197X7}$	$e^{0.1164X8}$	$e^{-0.3918X9}$	$e^{-0.1753X10}$	0.871
Step1																
P_a	0.2549	$A^{0.0108}$	$H^{0.9030}$	$D^{1.2480}$	$N^{0.6494}$	$e^{-0.1516X1}$	$e^{-0.0801X2}$	$e^{-0.0091X3}$	$e^{-0.0204X4}$	$e^{0.3098X5}$	$e^{0.0039X6}$	$e^{-0.0822X7}$	$e^{0.1106X8}$	$e^{-0.0593X9}$	$e^{-0.0457X10}$	0.914
P_r	1.0952	$A^{-0.0407}$	$H^{0.0956}$	$D^{1.1485}$	$N^{0.3720}$	$e^{-0.2283X1}$	$e^{-0.1424X2}$	$e^{-0.2414X3}$	$e^{0.2012X4}$	$e^{1.1840X5}$	$e^{-0.1361X6}$	$e^{0.1736X7}$	$e^{-0.1831X8}$	$e^{-0.6657X9}$	$e^{-0.2145X10}$	0.604
Step 2																
P_c	0.2001	$A^{-0.0124}$	$H^{0.2602}$	$D^{1.3483}$	$N^{0.5597}$	$e^{-0.1540X1}$	$e^{-0.0767X2}$	$e^{-0.0698X3}$	$e^{0.1202X4}$	$e^{0.2007X5}$	$e^{-0.0350X6}$	$e^{-0.1553X7}$	$e^{0.3886X8}$	$e^{0.0674X9}$	$e^{-0.0807X10}$	0.750
P_s	0.1376	$A^{0.0388}$	$H^{1.1076}$	$D^{1.1667}$	$N^{0.6653}$	$e^{-0.1950X1}$	$e^{-0.1092X2}$	$e^{-0.0131X3}$	$e^{-0.0592X4}$	$e^{0.2511X5}$	$e^{0.0004X6}$	$e^{-0.0960X7}$	$e^{0.0470X8}$	$e^{-0.0790X9}$	$e^{-0.0457X10}$	0.916
Step 3a																
P_f	0.1013	$A^{-0.2180}$	$H^{0.3149}$	$D^{1.1582}$	$N^{0.5968}$	$e^{0.4276X1}$	$e^{0.2404X2}$	$e^{0.1721X3}$	$e^{0.2360X4}$	$e^{0.5130X5}$	$e^{-0.0860X6}$	$e^{-0.0706X7}$	$e^{0.2496X8}$	$e^{0.1213X9}$	$e^{-0.0978X10}$	0.576
P_b	0.1077	$A^{0.0577}$	$H^{0.3090}$	$D^{1.3592}$	$N^{0.5348}$	$e^{-0.3063X1}$	$e^{-0.1497X2}$	$e^{-0.1323X3}$	$e^{0.1195X4}$	$e^{0.1323X5}$	$e^{-0.0064X6}$	$e^{-0.1586X7}$	$e^{0.3405X8}$	$e^{0.0681X9}$	$e^{-0.0374X10}$	0.774
Step3b																
P_w	0.0605	$A^{0.0259}$	$H^{1.5599}$	$D^{0.9264}$	$N^{0.6999}$	$e^{-0.0257X1}$	$e^{-0.0545X2}$	$e^{-0.0343X3}$	$e^{-0.0912X4}$	$e^{0.7036X5}$	$e^{0.1160X6}$	$e^{0.1125X7}$	$e^{0.0471X8}$	$e^{0.0403X9}$	$e^{0.1949X10}$	0.946
P_{bk}	0.0380	$A^{0.0388}$	$H^{1.3128}$	$D^{0.7136}$	$N^{0.5922}$	$e^{-0.3615X1}$	$e^{-0.0878X2}$	$e^{-0.0074X3}$	$e^{0.1872X4}$	$e^{0.2607X5}$	$e^{0.3638X6}$	$e^{-0.5749X7}$	$e^{0.1232X8}$	$e^{-0.0709X9}$	$e^{0.0639X10}$	0.859

biomass models (Fig. 3) shows the degree of correlativeness of the actual and calculated values and, in many cases, the absence of visible differences in the structure of residual variances obtained on two named models. More or less the value of R^2 of one or the other model is determined by the random position of actual values of maximum stand biomass in confidence range and uneven dispersion, namely accidental because of their small number and the greatest contribution to the residual variance.

The additive model built (Table 4) includes four numeric independent variables. When its tabulating, there is a problem, which is that we can know and give the value of

Table 4. Three-step additive model of biomass component composition for birch forest stands, built by proportional weighing

$$Pt = 2.3124\,A^{-0.1332}H^{0.7126}D^{0.9612}N^{0.3588}e^{-0.1815X1}e^{-0.0816X2}e^{-0.0775X3}e^{0.0661X4}e^{0.3945X5}e^{-0.0498X6}e^{-0.1197X7}e^{0.1164X8}e^{-0.3918X9}e^{-0.1753X10}$$

Step 1	$Pa = \frac{1}{1+4.2973\,A^{-0.0514}H^{-0.8074}D^{-0.0995}N^{-0.2774}e^{-0.0767X1}e^{-0.0623X2}e^{-0.2322X3}e^{0.2216X4}e^{0.8742X5}e^{-0.1400X6}e^{0.2558X7}e^{-0.2937X8}e^{-0.6064X9}e^{-0.1688X10}} \times Pt$
	$Pr = \frac{1}{1+0.2327\,A^{0.0514}H^{0.8074}D^{0.0995}N^{0.2774}e^{0.0767X1}e^{0.0623X2}e^{0.2322X3}e^{-0.2216X4}e^{-0.8742X5}e^{0.1400X6}e^{-0.2558X7}e^{0.2937X8}e^{0.6064X9}e^{0.1688X10}} \times Pt$
Step 2	$Pc = \frac{1}{1+0.6875\,A^{0.0512}H^{0.8474}D^{-0.1816}N^{0.1056}e^{-0.0410X1}e^{-0.0325X2}e^{0.0568X3}e^{-0.1794X4}e^{0.0504X5}e^{0.0354X6}e^{0.0594X7}e^{-0.3417X8}e^{-0.1464X9}e^{0.0350X10}} \times Pa$
	$Ps = \frac{1}{1+1.4546\,A^{-0.0512}H^{-0.8474}D^{0.1816}N^{-0.1056}e^{0.0410X1}e^{0.0325X2}e^{-0.0568X3}e^{0.1794X4}e^{-0.0504X5}e^{-0.0354X6}e^{-0.0594X7}e^{0.3417X8}e^{0.1464X9}e^{-0.0350X10}} \times Pa$
Step 3*a*	$Pf = \frac{1}{1+1.0638\,A^{0.2756}H^{-0.0060}D^{0.2011}N^{-0.0619}e^{-0.7339X1}e^{-0.3901X2}e^{-0.3044X3}e^{-0.1165X4}e^{-0.3807X5}e^{0.0796X6}e^{-0.0880X7}e^{0.0909X8}e^{-0.0531X9}e^{0.0605X10}} \times Pc$
	$Pb = \frac{1}{1+0.9401\,A^{-0.2756}H^{0.0060}D^{-0.2011}N^{0.0619}e^{0.7339X1}e^{0.3901X2}e^{0.3044X3}e^{0.1165X4}e^{0.3807X5}e^{-0.0796X6}e^{0.0880X7}e^{-0.0909X8}e^{0.0531X9}e^{-0.0605X10}} \times Pc$
Step 3*б*	$Pw = \frac{1}{1+0.6275\,A^{0.0128}H^{-0.2471}D^{-0.2128}N^{-0.1077}e^{-0.3358X1}e^{-0.0334X2}e^{0.0269X3}e^{0.2784X4}e^{-0.4428X5}e^{0.2478X6}e^{-0.6875X7}e^{0.0760X8}e^{-0.1112X9}e^{-0.1309X10}} \times Ps$
	$Pbk = \frac{1}{1+1.5937\,A^{-0.0128}H^{0.2471}D^{0.2128}N^{0.1077}e^{0.3358X1}e^{0.0334X2}e^{-0.0269X3}e^{-0.2784X4}e^{0.4428X5}e^{-0.2478X6}e^{0.6875X7}e^{-0.0760X8}e^{0.1112X9}e^{0.1309X10}} \times Ps$

Table 5. The characteristics of "methodized" independent allometric equations for birch stands

Biomass component	Independent variables and the regression coefficients of the model													
P_t	2,3124	$A^{-0,1332}$	$H^{0,7126}$	$D^{0,9612}$	$N^{0,3588}$	$e^{-0,1815X1}$	$e^{-0,0816\,X2}$	$e^{-0,0775\,X3}$	$e^{0,0661\,X4}$	$e^{0,3945\,X5}$	$e^{-0,0498\,X6}$	$e^{-0,1197\,X7}$	$e^{0,1164\,X8}$	$e^{-0,3918\,X9}$	$e^{-0,1753\,X10}$
P_a	1,6517	$A^{-0,2090}$	$H^{0,8778}$	$D^{0,9361}$	$N^{0,3510}$	$e^{-0,1431\,X1}$	$e^{-0,0550\,X2}$	$e^{-0,0165\,X3}$	$e^{-0,0069\,X4}$	$e^{-0,6064\,X5}$	$e^{-0,0722\,X6}$	$e^{-0,2394\,X7}$	$e^{0,2173\,X8}$	$e^{-0,3372\,X9}$	$e^{-0,1601\,X10}$
P_r	1,0952	$A^{-0,0407}$	$H^{0,0956}$	$D^{1,1485}$	$N^{0,3720}$	$e^{-0,2283\,X1}$	$e^{-0,1424\,X2}$	$e^{-0,2414\,X3}$	$e^{0,2012\,X4}$	$e^{1,1840\,X5}$	$e^{-0,1361\,X6}$	$e^{0,1736\,X7}$	$e^{-0,1831\,X8}$	$e^{-0,6657\,X9}$	$e^{-0,2145\,X10}$
P_c	1,1172	$A^{-0,1776}$	$H^{0,2397}$	$D^{0,9756}$	$N^{0,2975}$	$e^{-0,0648\,X1}$	$e^{-0,0078\,X2}$	$e^{-0,1091\,X3}$	$e^{0,0754\,X4}$	$e^{-0,7359\,X5}$	$e^{-0,2624\,X6}$	$e^{-0,5189\,X7}$	$e^{0,7750\,X8}$	$e^{-0,0917\,X9}$	$e^{-0,0870\,X10}$
P_s	0,9788	$A^{-0,2058}$	$H^{1,0103}$	$D^{0,9320}$	$N^{0,3677}$	$e^{-0,1655\,X1}$	$e^{-0,0752\,X2}$	$e^{-0,0080\,X3}$	$e^{-0,0320\,X4}$	$e^{-0,5999\,X5}$	$e^{-0,0420\,X6}$	$e^{-0,1966\,X7}$	$e^{0,0914\,X8}$	$e^{-0,3836\,X9}$	$e^{-0,1809\,X10}$
P_f	0,4269	$A^{-0,4483}$	$H^{0,4385}$	$D^{0,7928}$	$N^{0,4014}$	$e^{0,5982\,X1}$	$e^{0,3858\,X2}$	$e^{0,2480\,X3}$	$e^{0,2668\,X4}$	$e^{0,0045\,X5}$	$e^{0,2816\,X6}$	$e^{-0,0717\,X7}$	$e^{0,0151\,X8}$	$e^{0,1340\,X9}$	$e^{-0,0361\,X10}$
P_b	0,6606	$A^{-0,1105}$	$H^{0,2412}$	$D^{1,0120}$	$N^{0,2620}$	$e^{-0,2149\,X1}$	$e^{-0,0941\,X2}$	$e^{-0,2147\,X3}$	$e^{0,0854\,X4}$	$e^{-0,8552\,X5}$	$e^{-0,3673\,X6}$	$e^{-0,5935\,X7}$	$e^{0,7557\,X8}$	$e^{-0,1344\,X9}$	$e^{-0,0521\,X10}$
P_w	0,0605	$A^{0,0259}$	$H^{1,5599}$	$D^{0,9264}$	$N^{0,6999}$	$e^{-0,0257\,X1}$	$e^{-0,0545\,X2}$	$e^{-0,0343\,X3}$	$e^{-0,0912\,X4}$	$e^{0,7036\,X5}$	$e^{0,1160\,X6}$	$e^{0,1125\,X7}$	$e^{0,0471\,X8}$	$e^{0,0403\,X9}$	$e^{0,1949\,X10}$
P_{bk}	0,0380	$A^{0,0388}$	$H^{1,3128}$	$D^{0,7136}$	$N^{0,5922}$	$e^{-0,3615\,X1}$	$e^{-0,0878\,X2}$	$e^{-0,0074\,X3}$	$e^{0,1872\,X4}$	$e^{0,2607\,X5}$	$e^{0,3638\,X6}$	$e^{-0,5749\,X7}$	$e^{0,1232\,X8}$	$e^{-0,0709\,X9}$	$e^{0,0639\,X10}$

Table 6. The comparison of adequacy indices of independent and additive equations for birch stand biomass calculated with their regionalization by introducing dummy variables

Index	Biomass components								
	P_t	P_a	P_r	P_s	P_w	P_{bk}	P_c	P_b	P_f
Independent equations									
R^2	0.950	0.958	0.768	0.958	0.959	0.677	0.793	0.808	0.672
Additive equations									
R^2	0.950	0.952	0.770	0.955	0.957	0.664	0.685	0.671	0.599

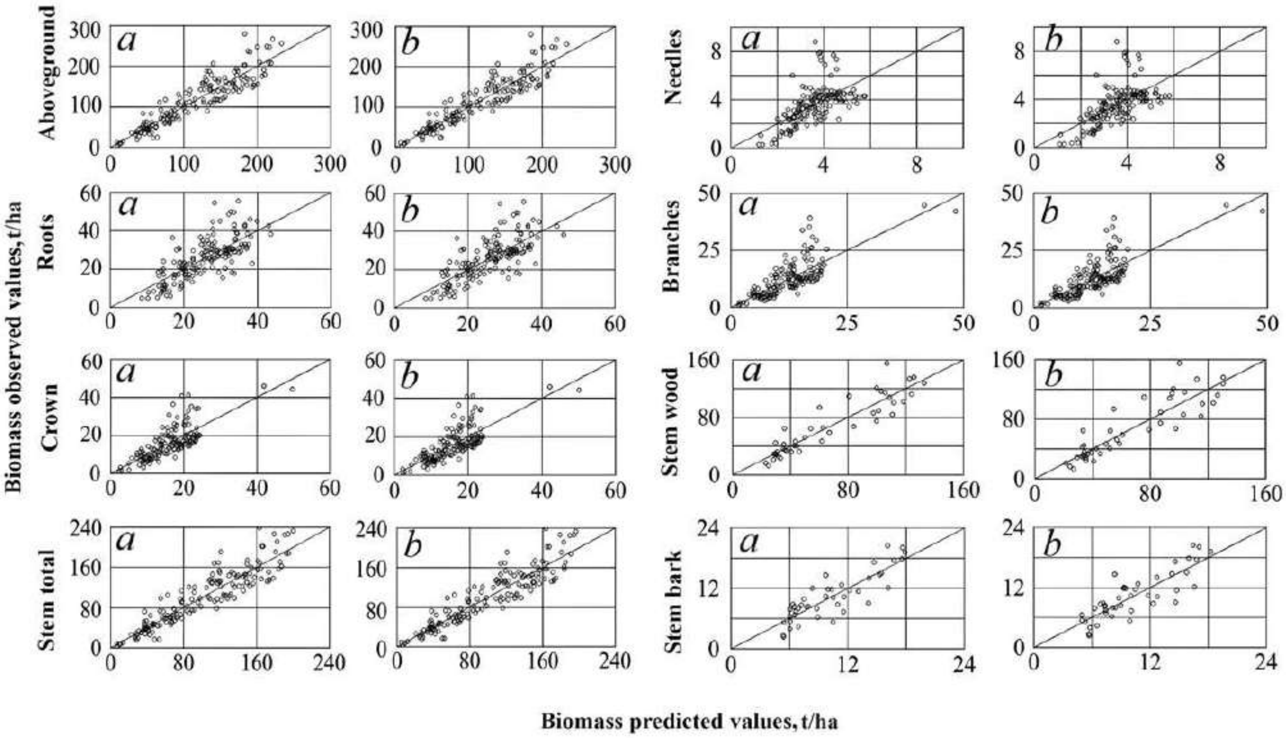

Fig. 3. The ratio of observed values and the values derived by calculation of independent (a) and additive (b) models of birch stand biomass

Table 7. Characteristics of auxiliary recursive equations for mass-forming indices

Mass-forming indices	Independent variables and the regression coefficients of the model														$adjR^2$
ln*H*	-0,0217	0,7812ln*A*	-	-	-0,5836*X1*	-0,0720*X2*	-0,1720*X3*	-0,1480*X4*	-0,7952*X5*	-0,2341*X6*	-0,7854*X7*	-0,5169*X8*	-0,4123*X9*	0,0198*X10*	0,669
ln*D*	-1,1075	0,3700ln*A*	0,8906ln*H*	-	-0,1841*X1*	-0,2138*X2*	-0,1628*X3*	-0,1072*X4*	-0,3604*X5*	-0,0708*X6*	-0,2018*X7*	0,1380*X8*	0,1007*X9*	-0,0516*X10*	0,940
ln*N*	3,8571	-0,0983ln*A*	1,0101ln*H*	-2,2386ln*D*	0,1218*X1*	0,2071*X2*	0,1503*X3*	0,0031*X4*	-0,3848*X5*	-0,1110*X6*	-0,0637*X7*	0,3165*X8*	-0,0928*X9*	-0,2960*X10*	0,888

stand age only of four variables, and the remaining three variables can be entered into the table in the form of calculated values obtained by the system of auxiliary recursive equations (Usoltsev et al 2017b). Such equations are approximated using the original data and are shown in the Table 7.

The results of sequential tabulations of the equations of the Table 7 and 4 give the unacceptably voluminous table, the size of which exceeds the format of journal article. Therefore, a comparative analysis of the biomass structure of larch stands of different ecoregions we limit by the stand age of 50 years (Table 8). According to the table 8, the greatest values of total biomass (202 t ha^{-1}) correspond to the European regions adjacent to the Atlantic coast, and the lowest (65-94 t ha^{-1}) – to northern taiga regions of Russia. An intermediate position in terms of total biomass (140-177 t ha^{-1}) occupy birch stands of the southern part of their Eurasian areal. The biomass indices of different ecoregions differed not only in absolute value but also in biomass ratios of different components; for example, the proportion of foliage in the aboveground biomass is maximum (3.6-4.6%) in the northern taiga of Russia and is minimum (1.9-2.1%) in birch forests adjacent to the Atlantic and Pacific coasts.

CONCLUSION

When using the unique in terms of the volume of database on the level of a stand of the genus *Betula* sp., the trans-Eurasian additive allometric model of biomass for birch forests is developed for the first time, and thereby the combined problem of model additivity and generality is solved. The additive model of forest biomass of *Betula* is harmonized in two levels, one of which provides the principle

Table 8. Fragment of additive transcontinental table of birch stand biomass for the age of 50 years, localized on the ecoregions of Eurasia

Region	Species	H (m)	D (cm)	N (1000 ha^{-1})	Stand biomass (t ha^{-1})								
					Pt	*Pa*	*Pc*	*Pf*	*Pb*	*Pr*	*Ps*	*Pw*	*Pbk*
WME	*B. alba* L.	20.8	21.0	0.8	201.5	162.3	22.7	3.4	19.4	39.2	139.6	119.5	20.1
ERn	*B. alba* L.	11.6	10.4	2.3	83.9	65.4	11.7	3.6	8.1	18.5	53.7	47.0	6.7
ERs	*B. alba* L.	19.3	15.9	1.6	177.2	147.6	20.0	4.4	15.6	29.6	127.6	109.8	17.8
Ural	*B. alba* L.	17.5	15.3	1.5	155.6	131.0	17.7	3.7	14.0	24.6	113.3	96.1	17.2
WSst	*B. alba* L.	17.9	16.5	1.1	177.0	134.9	22.7	3.9	18.8	42.1	112.1	91.0	21.1
MSn	*B. alba* L. *B. tortuosa* L.	9.4	7.2	2.5	93.6	49.9	9.0	2.3	6.7	43.7	40.9	35.7	5.2
MSs	*B. alba* L.	16.5	15.8	1.0	137.1	110.4	16.6	2.4	14.1	26.7	93.8	76.0	17.8
ES	*B. alba* L. *B. ermanii* Ch.	9.5	8.5	2.4	65.2	44.4	8.1	1.6	6.5	20.7	36.3	32.7	3.6
FEs	*B. costata*Tr.	12.4	15.2	1.3	138.3	111.1	26.7	4.0	22.8	27.2	84.4	69.8	14.6
Ch	*B. platyphylla* S.	13.8	16.1	0.8	81.1	68.5	13.8	2.2	11.6	12.6	54.7	46.6	8.1
Jap	*B. platyphylla* S. *B. ermanii* Ch.	21.2	20.3	0.6	154.5	127.4	17.3	2.4	14.9	27.1	110.1	95.7	14.4

of additivity of biomass components, and the second one is associated with the introduction of dummy independent variables localizing model according to eco-regions of Eurasia. The proposed model and corresponding table for estimating stand biomass make them possible to calculate birch stand biomass on Eurasian forests when using measuring taxation.

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Planktonic Diversity of Artificial Pond in Lower Shiwaliks

Sarbjeet Kour and Rajan Verma*

Department of Zoology, University of Jammu-180 006, India
E-mail: rajan.verma9891@gmail.com

Abstract: The phytoplankton and zooplankton species diversity of an aquatic ecosystem is highly influenced by the variation in the physico-chemical characteristics of the water body they inhabit. Present study was conducted so as to study the seasonal diversity of phytoplankton as well as zooplankton species and their relation with physico-chemical parameters in an artificial pond situated at Botanical garden of University of Jammu. In the present investigation, seventeen abiotic parameters of the pond were analyzed on the seasonal basis. A total of eleven phytoplankton species belonging to two classes viz. Chlorophyceae and Bacillariophyceae were observed. Chlorophyceae was represented by 4 families i.e. Desmidiaceae, Zygnemataceae (each represented by two species), Ulotrichaceae and Oedogoniaceae (each represented by one species). Among zooplankton, 21 species were reported seasonally of which seven species were of rotifera, 7 of protozoa, 4 of cladocera, 2 of copepoda and 1 of ostracoda. Through the present study, it was concluded that the seasonality and distribution of planktonic species diversity was a key function of the physico-chemical characteristic such as water temperature, transparency, nitrates and phosphates of the water body as change in these parameters greatly influence the occurrence of biotic community in the pond.

Keywords: Physico-chemical, Plankton diversity, Phytoplankton, Zooplankton, Seasonal variation

Plankton refers to diverse collection of small-sized (usually measured in microns), aquatic living organisms characterized predominantly by free-floating, non-motile or too weak to swim against the water current. They are defined by their characteristic feature of free floating movement rather than their systematic biological classification and therefore, include vast diversity of organisms like algae, bacteria, protozoa, diatoms and also metazoans like crustaceans, molluscs and coelenterates (Kampf and Chapman,2016). Plankton act as base for sustaining the food web in aquatic environment. They are broadly classified into Phytoplankton and Zooplankton. Phytoplankton are autotrophs and can be characterized by the presence of chlorophyll to capture sunlight and perform photosynthesis. They are chief carbon fixer on the earth surface. They transform the inorganic food into organic food in the aquatic ecosystem. It is mainly composed of algal members of bacillariophyta, chlorophyta, cyanophyta, euglenophyta, pyrrophyta and chrysophyta. Zooplankton include animal like creatures that are characterized by small-sized body and swimming at the mercy of water currents. They act as important link between the primary producer and the secondary consumer in the aquatic food web. They may be holoplankton (permanent plankton that are planktonic for their entire life-cycle) or meroplankton (temporary plankton like eggs and larvae of members of benthos and nektons). Zooplankton mainly include protozoa, copepoda, cladocera, ostracoda and rotifera. Protozoan are single-celled, heterotrophic eukaryotic organisms that mainly feed on organic matter. Copepoda are group of micro-crustaceans that are bilaterally symmetrical and have cylindrical body shape. Cladocera are called as water flea and have laterally flattened, bivalve carapace characterized by two pairs of antennae and five pairs of leaf-like limbs on body. Ostracoda refer to a class of crustacean, commonly called as mussel shrimp that are characterized by laterally compressed body having bivalve carapace. Rotifera also called as wheel animalcules, usually microscopic, pseudocoelomate organisms characterized by corona at their anterior end. Certain planktonic species acts as important bio-indicators of aquatic environment such as *Brachionus* sp. (Ismail and Adnan 2016, Gannon and Stemberger 1978), *Mesocyclops* sp. (Rajagopal et al 2000), *Daphnia* sp. (Dhanasekaran et al 2017). Zooplankton can also be used in biomonitoring of environment pollution as they can withstand the harsh environmental conditions (Bhandarkar and Paliwal 2017). Rotifers (Lubzens 1987) and Copepods (Piasecki et al 2004) can also be used as natural food in aquaculture for the growth of fish larvae.

Phytoplankton (Gogoi 2019) and Zooplankton (Patra et al 2011) diversity get highly influenced by the seasonal variation in the physico-chemical parameters of water. The physico-chemical characteristic of an aquatic environment imparts great influence on the distribution and abundance of planktonic diversity. Present work had been conducted so as to analyse the inter-relationship that occurred between abiotic and biotic parameters of a small pond situated at University of Jammu, Jammu region. For this purpose, the physico-chemical parameters and the inhabitant planktonic fauna (including both phytoplankton and zooplankton) was documented.

MATERIAL AND METHODS

To analyze the abiotic and biotic parameters water sample was collected on seasonal basis for the period of 1 year (January, 2019-December, 2019) from a selected pond, at Botanical garden of the University of Jammu (Fig. 1 and 2). The pond is situated at 32°43'12°N and 74°51'58°E. It is spread over a small stretch of 150-200 meter with a shallow depth range of 3-4 ft. Depth of water remains mostly low during different seasons and optimum water level is regulated by supply from the tap water. Pond remains covered by thick vegetation cover of macrophytes such as *Pistia* sp., *Eichhornia* sp. and *Salvinia* sp.

Abiotic parameters: Seventeen parameters viz. Atmospheric temperature, water temperature, depth, transparency, pH, dissolved oxygen, BOD, free carbon dioxide, carbonates, bicarbonates, chlorides, magnesium, calcium, total hardness, phosphates, nitrates and sulphates were analysed. Parameters like atmospheric temperature, water temperature, transparency, depth, pH were analyzed before collecting the water sample while dissolved oxygen, free carbon dioxide, carbonates and bicarbonates were analyzed at the site and rest of the parameters were determined in the laboratory. Atmospheric and water temperature was measured by mercury centrigrade thermometer. Depth and transparency was observed by using secchi disc and the graduated rope. pH was measured by using digital pH meter. Abiotic parameters viz. Dissolved oxygen, free carbon dioxide, BOD, carbonates, bicarbonates, calcium, magnesium and chlorides was analyzed by using standard APHA(2005) method while nitrates, sulphates and phosphates was analyzed by using spectrophotometer (Adoni 1985).

Qualitative and quantitative analysis of plankton: Plankton samples (phytoplankton and zooplankton) were collected during the morning hours once in each season using circular plankton net made of bolting silk of mesh size 40 micron. The filtrate was concentrated to 20ml volume in small polyethylene preservation vials and preserved in 5% formalin. Water proof labels were fixed on the preservation vials showing the location and date of collection. Planktonic species were observed under compound light microscope at 100X magnification. The identification of planktonic groups was carried out following Adoni (1985), Belcher and Swale (1978), Edmondson and Winberg (1971) and Pennak (1978) as a standard identification key.

For quantitative analysis, the drop count method was applied and the number of plankton per litre of the concentrate was calculated by using the formula:

Organism/Litre = A x 1/L x n/V

Where,

V = Volume of 1 drop(ml), A = Number of organism per drop(ml), n = Total volume of concentrated sample(ml), L = Volume of original sample(litres)

RESULTS AND DISCUSSION

Physico-chemical parameters: In the present investigation period (January, 2019-December, 2019), a total of 17 physico-chemical parameters were analyzed season-wise. The value of various physico-chemical parameters of the studied pond showed well marked seasonal variability (Table 1).

Biotic parameters: The various physico-chemical parameters showed fluctuation with seasons and thus favoured the sustenance of plankton. Qualitative and quantitative distribution of plankton (phytoplankton and zooplankton) in Botanical garden pond was analyzed. A total of 11 phytoplankton species belonging to two classes viz. Chlorophyaceae (6 species) and Bacillariophyaceae (5 species) were recorded. The species diversity showed variability during 4 different seasons (Table 2, Fig. 3). Phytoplanktons were represented by 2 classes viz. Chlorophyaceae and Bacillariophyaceae. Among phytoplankton species, maximum contribution was from the


Fig. 1


Fig. 2

Fig. 1, 2. Sampling sites during different sampling seasons

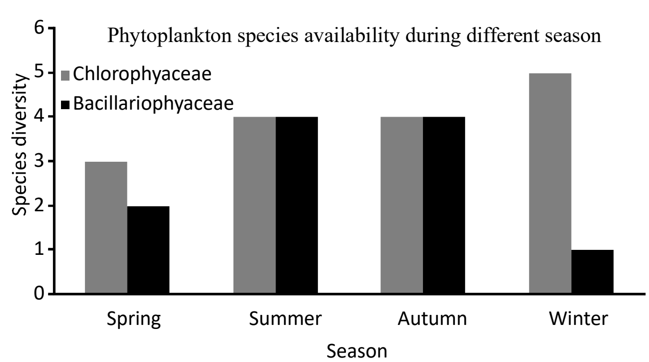

Fig. 3. Percentage contribution of Phytoplankton during different seasons

species of chlorophyaceae class in all the studied seasons. Chlorophyaceae was represented by *Closterium* sp., *Ulothrix* sp., *Mougeotia* sp., *Spirogyra* sp., *Oedogonium* sp. and *Cosmarium* sp. while Bacillariophyaceae was represented by *Acnanthes* sp., *Navicula* sp., *Nitzschia* sp., *Pinnularia* sp. and *Cymbella* sp. Among chlorophyaceae, maximum contribution was observed during the winter season that too was contributed by *Oedogonium* sp. and *Mougeotia* sp. Among Bacillariophyaceae, maxima was observed during summer in which *Acnanthes* sp. and *Navicula* sp. were the dominant species. The dominance of Chlorophyaceae during winter season in the present study was attributed to the complete transparency of the pond which enhanced photosynthesis and growth of chlorophyll bearing phytoplankton. While Bacillariophyaceae maxima was observed during summer season that was attributed to high temperature, increased nitrogen and phosphorus content and more organic load and zero transparency.

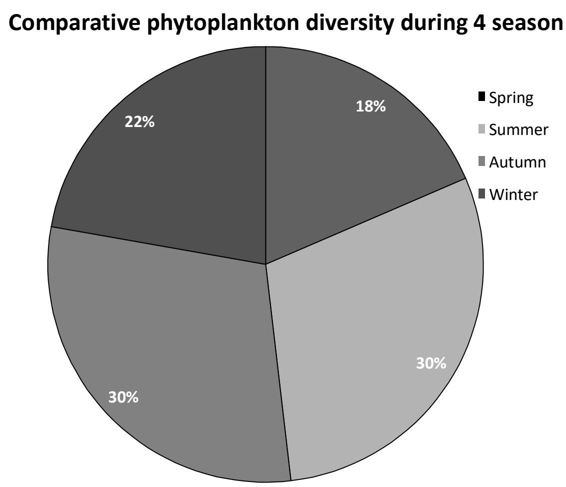

Fig. 4. Percentage contribution of phytoplankton during different season

Maximum phytoplankton species was observed during summer and autumn season while minimum phytoplankton species diversity was observed during spring season (Fig. 4).

A total of 21 zooplanktonic species were observed during the investigating period (January, 2019-December, 2019). Well marked qualitative as well as quantitative species distribution was observed (Table 3).

Presently observed zooplankton species were belonged to five groups: protozoa, rotifera, cladocera, copepoda, and ostracoda. Group protozoa was represented by seven species that belonged to three families viz. Vorticellidae, Difflugiidae, and Eulobosa. Vorticellidae was represented by *Vorticella microstoma*, Difflugiidae was represented by *Centropyxis aculeata, C. ecornis, Difflugia acuminata, D. lebes* and *D. oblonga* while Eulobosa family was represented by *Arcella megastoma*. Seasonally maximum protozoa population density was observed during the autumn season (171.932 organisms litre^{-1}), while minima was observed during winter season (19.6175 organisms litre^{-1}). Maximum

Table 1. Seasonal fluctuations in physico-chemical parameters of botanical garden pond

Season	Spring	Summer	Autumn	Winter	Average ± SD
Air temperature (˚C)	25	35	29	12.5	25.3±9.51
Water temperature (˚C)	20.5	26	25	10.5	20±6.72
pH	7.4	7.5	6.5	7.8	7.3±0.55
Depth (centimeters)	53	45	36	59	53.5±10.34
Transparency (cms.)	0	0	0	59	17±34
Dissolved oxygen (mg l^{-1})	4.8	4	0.96	5.44	3.8±1.98
Carbon dioxide(mg l^{-1})	16	12	5.28	Absent	11.09±5.41
Carbonates (mg l^{-1})	Absent	Absent	Absent	240	60±120
Bicarbonates (mg l^{-1})	173	190.5	158.36	143.72	166.39±20.02
Chlorides (mg l^{-1})	16.017	18.0198	8.509	11.012	13.38±4.38
Calcium (mg l^{-1})	31.11	56.35	42.89	21.026	37.84±15.23
Magnesium (mg l^{-1})	8.14	9.06	18.71	6.87	10.69±5.41
Sulphates (mg l^{-1})	0.046	0.3509	0.003097	0.00192	0.100±0.168
Nitrates (mg l^{-1})	0.5616	0.734	0.06403	0.2811	0.410±0.296
Phosphates (mg l^{-1})	0.609	0.923	0.5788	0.5781	0.672±0.167
Total hardness (mg l^{-1})	106	178	184	86	138.5±49.80
BOD (mg l^{-1})	2.8	2.52	0.96	1.86	2.28±1.114

Protozoa population density during autumn was attributed to the low Dissolved Oxygen, High Biological Oxygen Demand that indicates high microbial activity while in winter high Dissolved Oxygen, less Biological Oxygen Demand, and clear water attributed to least protozoan population density. Rotifera group was represented by seven species that belonged to six families viz. Brachionidae, Euchlanidae, Lecanidae, Mytilinidae, Testodinellidae, Philodinidae. They were represented by *Brachionus calyciflorus, B. bidentata, Euchlanis dilatata, Lecane luna, Mytilina ventralis, Testudinella patina,* and *Philodina* species. Maximum Rotifera species population density was observed during winter season (55.67 organisms litre^{-1}) while minima was observed during summer season (0.686 organisms litre^{-1}). Summer minima was due to more CO_2 value, high organism load and high temperature while winter maximum was due to

Table 2. Quantitative distribution (organisms litre^{-1}) of phytoplankton in Botanical garden pond during the period January, 2019 to December, 2019

Phytoplankton	Spring	Summer	Autumn	Winter
Class-Chlorophyaceae				
Family-Desmidiaceae				
Closterium sp.	-	5.054	4.136	0.0453
Cosmarium sp.	1.092	14.942	1.724	-
Family-Zygnemataceae				
Mougeotia sp.	1.638	-	-	28.9971
Spirogyra sp.	2.184	15.402	1.378	11.135
Family-Ulotrichaceae				
Ulothrix sp.	-	-	-	2.121
Family-Oedogoniaceae				
Oedognium sp.	-	3.448	1.034	24.923
Total	4.914	38.846	8.272	67.2214
Class-Bacillariophyceae				
Family-Cymbellaceae				
Cymbella sp.	-	-	0.688	-
Family-Naviculaceae				
Navicula sp.	0.546	3.906	1.032	-
Family-Nitzchiaceae				
Nitzschia sp.	-	0.688	0.344	-
Family-Achnanthaceae				
Achnanthes sp.	0.546	4.136	4.482	-
Family-Pinnulariaceae				
Pinnularia sp.	-	1.378	-	0.0151
Total	1.092	10.108	6.546	0.0151
Total phytoplankton count	6.006	48.954	14.818	67.236

Table 3. Quantitative distribution (organisms litre^{-1}) of zooplankton in botanical garden pond (January to December 2019)

Zooplankton	Spring	Summer	Autumn	Winter
Protozoa				
Class : Ciliata				
Order : Peritrichida				
Family : Vorticellidae				
Vorticella microstoma	-	-	-	2.6495
Class : Rhizopoda				
Order : Testacea				
Family : Difflugiidae				
Centropyxis aculeata	110.684	57.46	157.8	14.847
Centropyxis ecornis	8.492	1.148	8.62	-
Difflugia acuminata	23.286	6.206	0.688	-
Difflugia lebes	1.642	0.688	1.034	-
Difflugia oblonga	2.19	3.678	3.102	2.121
Class : Lobosa				
Order : Testacealobosa				
Family : Eulobosa				
Arcella megastoma	1.368	-	0.688	-
Total	147.662	62.974	171.932	19.6175
Rotifera				
Class : Monogonata				
Order : Plioma				
Family : Brachionidae				
Brachionus calyciflorus	-	0.458	-	-
Brachionus bidentata	-	-	-	0.5302
Family : Euchlanidae				
Euchlanis dilatata	-	-	-	12.726
Family : Lecanidae				
Lecane luna	3.830	-	-	-
Family : Mytilinidae				
Mytilina ventralis	-	0.228	-	-
Order : Floscularìacea				
Family : Testudinellidae				
Testudinella patina	-	-	1.378	26.5125
Order : Bdelloidea				
Family : Philodinidae				
Philodina sp.	13.698	-	15.862	15.9075
Total	17.528	0.686	17.240	55.6762
Cladocera				
Family : Chydoridae				
Chydorus sphaericus	87.66	0.228	-	47.18
Chydorus ovalis	23.834	-	-	-
Pleuroxus sp.	0.546	-	-	-
Family : Daphnidae				
Simocephalus sp.	-	-	-	3.1815
Total	112.04	0.228	-	50.3615
Ostracoda				
Order : Podocopa				
Family : cyprididae				
Stenocypris sp.	-	11.954	16.896	-
Total	-	11.954	16.896	-
Copepoda				
Order : Cyclopoida				
Family : Cyclopoidae				
Mesocyclops leuckarti	-	-	0.688	10.073
Microcyclops varican	13.424	0.688	1.034	15.2545
Copepodid stage	38.356	12.412	3.792	143.32
Nauplii stage	11.506	7.586	9.31	10.604
Total	63.286	20.686	14.824	179.252

high dissolved oxygen, decreased biological oxygen demand (less concentration of Nitrogen, Phosphorus, and Sulphur).

Cladocera was also reported during the investigating period. It was represented by four species viz. *Chydorus sphaericus, C.ovalis, Pleuroxus* species and *Simocephalus* species belonged to family Chydoridae (three species) and family Daphnidae (one species), respectively. Maximum Cladocera population was observed during the spring season (112.04 organisms/litre) while complete absence was recorded during autumn season and it was due to fluctuation in the physico-chemical parameters during autumn season such as high BOD value, low dissolved oxygen concentration and slight acidic condition. Ostracoda group was represented by single species i.e., *Stenocypris* species belonging to family Cyprididae. Ostracoda species was observed only during summer and autumn season and it may be due to sufficient availability and food, their better adaptability towards the changing environment like increased temperature, increased organisms load, and increased nitrogen and phosphorus concentration. Copepoda was represented by two species viz. *M. leuckarti* and *M. varican* belonging to family Cyclopoidae. Maximum population density was observed during winter season that may be due to their ability to adapt the extreme environment while their availability during all seasons showed their adaptability to different range of environment variables.Seasonally maximum zooplankton species diversity was observed during spring season(28%) while minimum was observed during summer season(21%) (Fig. 5). The distribution pattern of various zooplankton species diversity during 4 different seasons was also recorded (Fig. 6). Protozoa species diversity was highest in spring, summer and autumn season represented by 5 species whereas rotifera species diversity was highest during the winter season that was represented by 4 species.

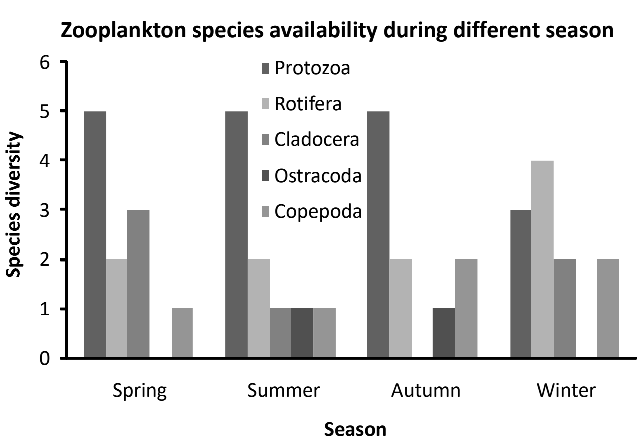

Fig. 6. Percentage contribution of zooplankton during different season

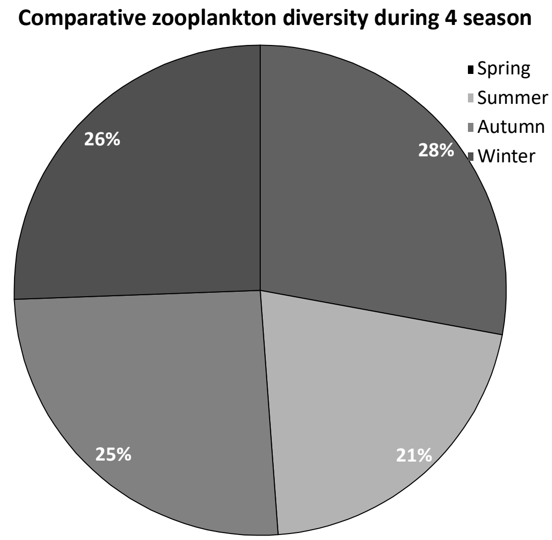

Fig. 5. Percentage contribution of Zooplankton during different season

CONCLUSION

The physico-chemical parameters of the pond and the distribution of planktonic species in water has great impact on the stability of an aquatic ecosystem. Greater the species diversity, greater will be the aquatic food web stability. During present study, it was concluded that seasonal variation in the physico-chemical factors has greater impact on the seasonality and distribution of different phytoplankton and zooplankton species. By studying the physico-chemical parameters, it was concluded that they showed seasonal variability during the investigation period while by studying the biotic parameters it was concluded that during earlier three seasons (spring, summer and autumn season), there was insurgence of total protozoan species that strongly indicated decomposition activity of the organic load of pond. Furthermore, low count of pollution indicator species such as *Brachionus* sp. and appearance of chlorophyaceae members during winter season indicate that the botanical garden pond was self sufficient to remodel its trophic status. Now, it can re-utilized for the purpose of research and propagation of macrophytes and other aquatic plant species.

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Nesting Behavior of Red Vented Bulbul (*Pycnonotus cafer,* Linnaeus 1766) in Udaipur District, Rajasthan, India

Nadim Chishty, Narayan Lal Choudhary, Puneet Sharma, Rehana Parveen, Pritesh Patel and Pushkar Kumawat

Wildlife, Limnology and Toxicology Research Laboratory,
Government Meera Girls' College, MLSU, Udaipur-313 001, India
E-mail: nadimchishty@gmail.com

Abstract: Red vented bulbul (*Pycnonotus cafer,* Linnaeus 1766) constructs cup shape nest by using fine twig and midribs of dead leaves and with the help of grass hairs. Generally bulbul construct nests on shrubs, hedges, stunted date palms, on slender branches of trees, at the butt of pollarded trees or sometime inside the building. It has been observed that height of nests ranges from 1 to 9 meter while mostly constructing their nests at height less than 3 meter but exceptionally up to 12 meters. More than 38 nests were observed which were used by bulbul to understand structural analysis and construction dynamics of their nests. The cotton fibres were used commonly in nest preparation due to its easy availability and also it provides strength to the nest. It was also observed that in some cases spiders has woven web on the nest at its external surface, while internal surface was cleaned by bulbul from tine to tine. Structural analysis of 38 nests was done after the breeding period was over and it was observed that, externally nests were composed of the withered stems of the little *Asteraceous* plant, interwoven with a few jhow-shoots or tamarisk (*Tamarix dioica*) and a little tow-like fibre of the Deccan jute (*Hibiscus cannabinus*), while a good deal of cobweb was applied externally here and there by spider itself. The interior of the nests were lined with excessively fine stems of some herbaceous exogenous plant. THe bulbul also utilized the twigs (aerial roots) of Giloy or Heart Leaved Moonseed (*Tinospora cordifolia*) with fine knitting of cotton fibres interwoven with grass fibres.

Keywords: Red vented bulbul, Midribs, Presumption, Cobweb, Spider web

Nest construction is very important part for life survival and reproductive success in animals. Nest site selection, breeding success and development are directly influence by various types of factors-availability of food and nesting material, vegetation structure and risk of predation and presence of nest ecto-parasite (Biddle et al 2017). These factors largely influenced ecology of nest and birds. Selection of nesting material depends upon the thermal properties of material and size of birds (Mainwaring et al 2014, Deeming and Mainwaring 2015). Each species have unique shape and peculiar site selection according to need. Shape of nest is responsible selection for matting partner in some bird groups. Birds nesting site and breeding success are reduced due to expansion of urbanization and habitat modification which resulted in decline of bird's population and biodiversity. Development of urban area and anthropogenic activities leads to habitat destruction, habitat modification, and introduction of exotic species are responsible for decline native birds species (Chace and Walsh 2006). In urban area due to lack of availability of plant material, birds are utilizing materials of anthropogenic origin like plastic, paper, cloth and other house hold waste materials in nest construction. Use of waste material might be limiting factors for bird's survival (Wang et al 2009, Votier et al 2011, Townsend and Barker 2014).The present study has focused on nesting ecology of Red Vented Bulbul in the study area of Udaipur, India.

MATERIAL AND METHODS

Nesting behavior of Red vented bulbul (*Pycnonotus cafer*, L.) was observed by using Olympus 8 x 40 DPS-I Binoculars. Simultaneously, video recording was done by using Sony Handycam. For photography and video recording, SLR camera of Canon 550 D with 18-135 mm lenses and SLR camera 60 D Canon with 150-500 mm lenses were used. With the help of the high precision camera and lenses, we observed the behaviour and display of breeding birds without disturbing them.

RESULTS AND DISCUSSION

Nest, as a cup of rootlets, fine twigs and midribs of dead leaves neatly woven were observed outside the cobweb and lined with grass and hair (Mainwaring et al 2014, Biddle et al 2015). The bulbuls preferred assimilatory roots of giloy or Heart Leaved Moonseed (*Tinospora cordifolia)*, kassod or Siamese cassia (*Senna siamea)* and Satawari or buttermilk root or climbing asparagus (*Asparagus racemosus)*. Figure 1 shows various nesting sites of Red Vented Bulbul utilized for the present studies in and around district of Udaipur. The nests were either placed in shrubs, hedges, stunted date palms, on slender branches of trees, at the butt of pollarded tree or sometimes inside the buildings normally at a height between 1-9 meters, most often less than 3 m and exceptionally up to 12 m. In the present study 38 deserted nests were observed out of which in one nest instead of small twigs and midribs of leaves and the hard shrubs or grass, nest was prepared by using only two hard branches. Few of these nests are shown in Figure 2. This nest was found at a height of 176 cm above the ground on the boundary wall in a flower pot. After examining the nest, it was observed that the small twigs were the aerial roots of giloy or Heart Leaved

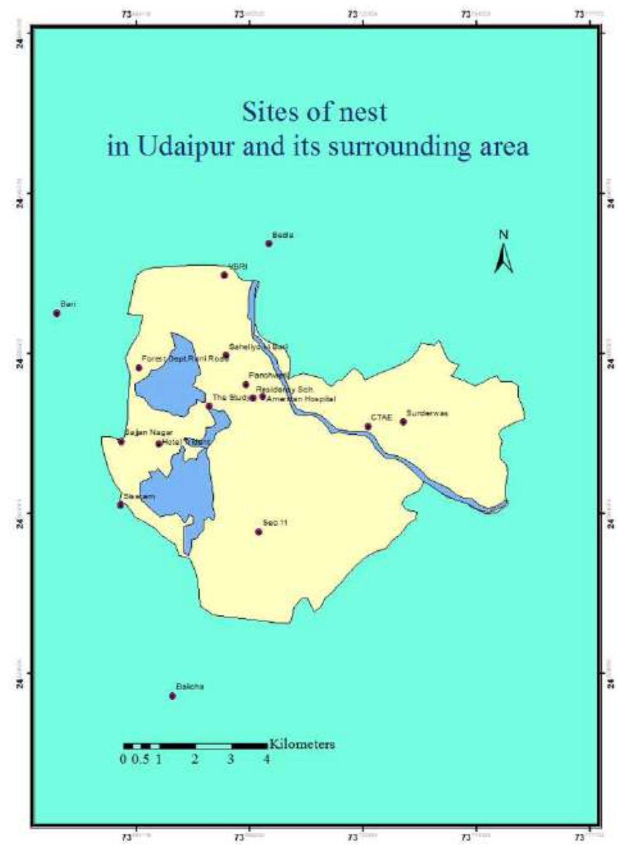

Fig. 1. Nesting sites of red vented bulbul in and around Udaipur district

Fig. 2. Different nests of red vented bulbul at different localities

Moonseed (*Tinospora cordifolia*). These types of hard twigs are very difficult to be carried by a single bird to the nest site and form the outer covering of nest as it is a tough job for the bird to manage such bigger threads by beak. It was also observed that the inner side of the nest contained 78 thin coconut coir fibers, broomstick and other material.

In the Ambavgarh area, one nest made up of stems of *Lappa* or Needle Grass or Sixweeks threeawn (*Aristida adsceniosis),* Indian Dropseed *(Sporobolus indicus* var. *diander)*, and Coral Reef Araucaria (*Araucaria columnaris*) was observed along with the rope pieces of Moonjh or Pin red

Table 1. Nesting behaviour of red vented bulbul (*Pycnonotus cafer*)

Nesting sites	Nesting material utilized by red vented bulbul's
*Murraya koenigii*or Meetha Neem	Twigs of *Tinospora cordifolia, Cassia* and Asparagus
*Delonix regia*or Gulmohar Tree	Wires and cotton
*Lawsonia inermis*or Mehandi Bushes	Stems of *Aristida adsceniosis, Sporobolus diander*and *Araucaria sp.*
*Araucaria*sp.	Rope pieces and twigs of *Tinospora cordifolia*, cotton and grass
Iron Tree Guards	Twigs of different trees
Cemented Electric Pole	Twigs of *Tinospora cordifolia*
Boundary Wall	Only two twigs of *Tinospora cordifolia*
Potted Plant 1	Twigs of *Tinospora cordifolia*
Potted Plant 2	Cotton and Twigs of *Tinospora cordifolia*

Table 2. Structural analysis of nests of *Pycnonotus cafer* at different nest sites

Height (cm)	Depth (cm)	Diameter (cm)	Weight (gm)	No. of long fibres*	No. of short fibres**	Total no. of twigs used for fabrication
6.8	2.8	6.1	6.4	10	128	138
5.7	4.2	6.8	3.9	0	102	103
6.4	2.5	8.5	4.1	1	0	1
6.5	2.8	6.6	6.8	20	97	117
6.1	3.5	9.3	4.1	8	93	101
6.3	2.5	9.6	6.1	9	84	93
5	3.4	9.2	4.9	0	137	137
7.1	3.6	8.5	8.8	16	127	143
5.5	2.9	7.5	5.9	13	137	150
4.3	2.6	8.2	4.2	0	158	158
6.3	3.3	7.5	30.8	1	0	1
6.2	4.2	8	10.2	0	241	241
5.5	3.2	7.2	8.12	0	362	362
6.8	3.8	7.3	9.6	0	188	188
5.1	2.5	7.4	12.3	0	267	267
6.3	2.8	6.6	8.1	0	267	267
6.2	3.1	7.3	5.6	0	154	154

* and ** On the basis of comparing length of fibres found in Bulbuls' nest with fibres found in nests of other birds

grass (*Saccharum munja*). Similar nest built was also observed in a potted plant in a house located in Badi area. Red-vented bulbul prefers to build nest on penultimate cluster of branches of Christmas tree (*Araucaria sp.*). Since branches of apical zone are arranged at close distance and they do not allow free entry of avian predator and also it was located at a height of at152 cm to 243 cm on Christmas trees are some of the preferable reasons for nesting on the same. Some birds were observed perching on the electric wire during the rainy season making up and down movements of the tail and constantly jerking their wings to get rid of the accumulated water for about 30 minutes. Soon after this activity, the bulbuls flew into dense foliage of bamboo clumps. During present study no excreta of any kind was observed on any nest. All the nests were very neat and tidy. Although review of literatures show use of cobwebs as nesting material in nest building by bulbuls but in present investigation complete absence of cobwebs was observed. Once they catch a cobweb in a beak or limb, it becomes a conglomerate and therefore it gets very difficult for the bird to install or wove it at another place without destroying it. During present study it was observed that cobweb adheres to beak and claws of bulbul and can't be placed on twigs of outer side of the nests. The *Tinospora cordifolia* was the main and preferable tree utilized by Red Vented Bulbul's in the construction of their nests in the present study sites may be due to its easy availability in the surrounding vicinity and also may be due to its various medicinal properties keeping nests free from any future infections or contaminations. On the basis of structural analysis of Red Vented Bulbul nests, average values of various nest parameters are height (6.01 cm), depth (3.16 cm), diameter (7.74 cm) and (weight 8.23 gm) (Table 2).

CONCLUSION

The red vented bulbul's select nest construction sites and materials primarily on the basis of its availability and important key role in the nest construction which require further studies in greater details especially in relation to physico-chemical properties of the nest constructing materials and selection of nest sites in reference to the local ecosystems.

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Impact of Anthropogenic Activities on Length-weight Relationship and Condition Factor of *Schizothorax* Species in River Jhelum (Jammu & Kashmir)

Musharaf Gul, O.P. Gusain and R.A. Magray[1]

Freshwater Biology Unit, Department of Zoology and Biotechnology, HNB Garhwal University, Srinagar-246 174, India
[1]Department of Higher Education, Govt. of J&K, GDC (Women) Kupwara- 193 222, India
E-mail: musharafgul@gmail.com

Abstract: In the present study water samples collected from different sites in the upper, middle and lower stretch of River Jhelum were assessed for selected physico-chemical parameters. The results showed considerable amount of pollutants adding to the river degrading its water quality especially in the areas with higher anthropogenic activities. The K value for *Schizothorax curvifrons* at S2 and S3 from this study suggest that *Schizothorax curvifrons* from these sites was in a poor condition owing to the relatively degraded water quality as a result of the increased human interference. Therefore, there is a dire need for collaboration between the policy makers and other stake holders to strike a balance between sustainable exploitation and conservation of the *Schizothorax* species.

Keywords: Anthropogenic activities, Length-weight relationship, Condition factor, *Schizothorax*, Jhelum

The valley of Kashmir is known for its fresh water bodies, having an enormous potential for the development of cold water fisheries. The Icthyofaunal diversity of river Jhelum is known to science for a long time. Carl Alexander Anselm von Hügel made the first fish collection after a long voyage through Eurasia over the period 1831-1836, and deposited it in the Naturehistorisches Museum in Vienna, Austria. Amongst the 16 species of fish put forth by Heckel (1838) from Kashmir valley, ten belong to the group of cyprinid fishes now commonly referred to as schizothoracines, mountain barbels, oreinins, snow trouts or snow barbels. Kullander et al (1999) did a standardized fishing in Jhelum River and the associated lakes and reported fourteen native and four exotic fish species over a period of eight years, including five species of *Schizothorax*, four of which are specialized lotic forms and one of which (*Schizothorax niger*) is mostly found in lakes. However, over the past several decades the fish diversity of river Jhelum and the associated lakes and tributaries is steadily assumed to be declining, largely as a consequence of environmental degradation. A number of scientists have opined that one of the aspect of environmental degradation is the altered ecology and destruction of both the feeding and spawning habitat as a result of encroachment, water pollution, introduction of predatory exotic species, multipurpose river valley projects and even the natural events like floods and earthquakes (Jang et al 2003). Establishing a relationship between length and weight is important for calculating the production and biomass of a fish population), allowing also for morphological comparisons among related species or among populations of the same species from different habitats and/or regions (Moutopoulos and Stergiou 2002). The effect of changes in abiotic components on fish species can be studied via the score of fish condition factor (Gomiero and Braga 2005). The fresh water bodies of Kashmir valley especially river Jhelum has been subjected to almost all the above mentioned stress conditions in the recent past. The massive land system changes (Romshoo and Rashid 2014), forest degradation, tourism related activities, reckless use of fertilizers and pesticides (Romshoo et al 2011) and unplanned urbanization (Sajjad and Iqbal 2012), have turned out to be devastating for both physico-chemical properties and biodiversity of once pristine Jhelum waters. Therefore the present study was conducted to take an account of the impact of human activities on water quality and the native *Schizothorax* species occurring in river Jhelum.

MATERIAL AND METHODS

Jammu and Kashmir surrounded by six mountain ranges , covers an area of 2,22,236 sq. km. and is located between 32° 17' and 36° 58' North latitude, and between 72° 26' and 80° 30' East longitude. The river Jhelum originates from Verinag spring situated at the foot of the Pir-Panjal in the south eastern part of the valley of Kashmir and traverses a distance of 203 km up to Khandanyar, the place where it leaves the main valley. Besides being an important tributary of Indus river system The GPS coordinates and land use pattern of the sampling sites are given in Table 1.

Water analysis: After a pilot survey sampling sites were selected keeping in view the fishing effort success rate and accordingly water samples were collected from three sites designated as S1, S2 and S3, respectively in the upper, middle and lower stretch of river Jhelumfrom May 2016 to April 2018 (Fig. 1). Selected physico-chemical parameters namely water temperature, mean depth, mean width, mean velocity, discharge, turbidity, pH, dissolved oxygen, free CO_2, conductivity and TDS were assessed using the methods given in APHA (2005) (Table 2).

Length-weight relationship and condition factor: Fish specimens were captured on monthly basis from the selected sites with the help of local fishermen. Freshly caught specimens were used for the measurement of various morphometric parameters and body weight. Identification of the fish was done following Day (1887) and Kullander et al (1999).Two species of Sub-Family Schizothorcinae namely *Schizothorax plagiostomus* Heckel and *Schizothorax curvifrons* Heckel were studied for growth patterns including Length-weight relationship (LWR) and Ponderal index or condition factor (K). LWR was estimated by using the exponential equation:

$W = aL^b$ (LeCren 1951 and Froese 2006)

Where W is the total weight (g), L the total length (mm), a the intercept (initial growth coefficient) and b the slope (growth coefficient, i.e. fish relative growth rate). Parameters a and b of LWR were estimated by linear regression analysis (least-squares method) on log transformed data, and the associated-degree between variables (W and L) was calculated by the determination coefficient (R^2). The slope of log a vs b can be used to estimate for a given LWR the value that coefficient a would have if exponent b were 3. This value ($a_{3.0}$) is called as a form factor and for these species it was calculated according to Froese (2006)

$$a_{3.0} = 10^{\log a - s\,(b-3)}$$

Where a and b are the coefficient of LWRs and s is the regression slope of log a vs b.

The condition factor (K) was estimated to assess the 'well-being' of the fish assuming that growth in ideal conditions maintains equilibrium in length and body weight Hile (1936). The fish condition factor (K) was determined by the formula:

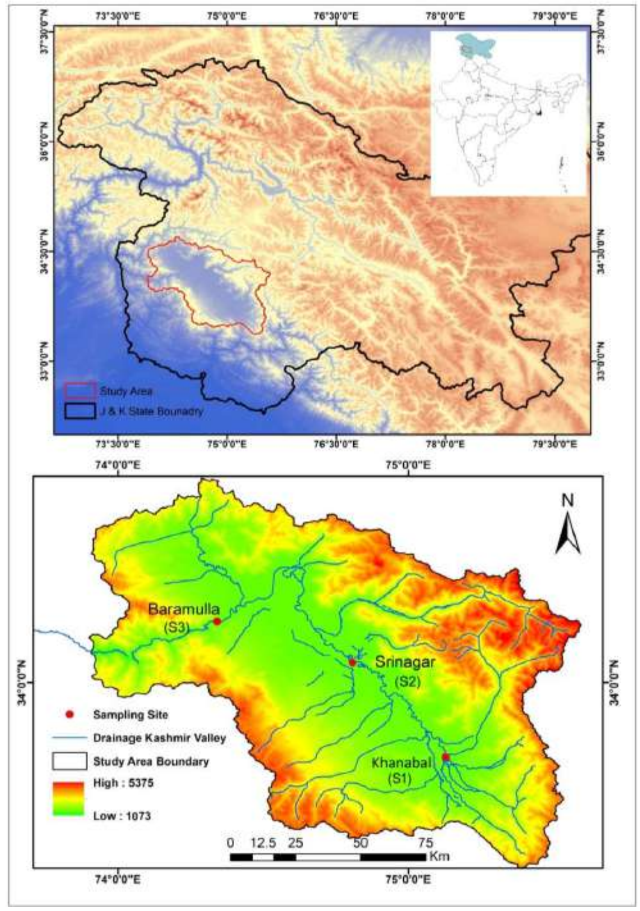

Fig. 1. Map showing the study area and different sampling sites on river Jhelum, Kashmir valley

Table 2. Standard analytical methods adopted for water quality parameters

Water temperature	Digital thermometer	(°C)
Mean depth	Secchi disk	(m)
Mean velocity	Float (drift) method	(ms^{-1})
Turbidity	Nephelometer	(NTU)
pH	Digital Electrode method	-
Dissolved oxygen	Modified Winker's method	(mg l^{-1})
Free carbon dioxide	Titrimetric method	(mg l^{-1})
Electrical conductivity (EC)	Conductivity meter	(µS cm^{-1}).
Total dissolved solids (TDS)	Digital TDS meter	(mg l^{-1})

Table 1. Location, altitude, GPS coordinates and land-use pattern of the samplings sites from river Jhelum

Stations	Distance from the origin (km)	Altitude (masl)	Latitude (°N)	Longitude (°E)	Land-use pattern
Khanabal (S1)	35	1600	33° 44'	75° 07'	Rural area, buffer zone, agriculture activities, Forest, sand extraction
Srinagar (S2)	97	1591	34° 04'	74° 48'	Urban, human interruptions, hospital effluents, domestic sewage, Large scale dredging
Baramullah (S3)	167	1582	34°10'	74°23'	Semi-urban, agriculture, domestic sewage

$K=W*100/L^3$ (Froese 2006)

Where, W= Weight of fish in grams and L= Total length of fish in millimeters.

RESULTS AND DISCUSSION

Water quality parameters: The physico-chemical characteristics of River Jhelum were recorded for two years, from May 2016 to April 2018 and the data reveals that the water quality has declined (Tables 3-5). The water quality assessment data was temporally classified into four seasons namely spring, summer, autumn and winter with each season comprising of 3 months. The water temperature varied from 5.72°C in winter at S1 to 22.03°C in summer at S3.There was a significant change in temperature and it increased steadily from ending spring to late summer and the decreased to reach the lowest in winter at all the sites. The highest mean depth 6.93 m was recorded at S2 in spring while the lowest mean depth of 2.87 m was recorded at S1 in autumn. The mean current velocity ranged from (0.10) ms^{-1} in autumn, at S1 to 0.98 m/s at S3 in spring. There was a significant seasonal change in water velocity and it increased steadily from ending winter to early summer and then decreased reaching the minimum in autumn. The mean width remained highest at S2 and lowest at S1 throughout the study period while at S3 the river width was relatively less in comparison to S2.Seasonal changes were also very prominent. The highest mean width of 113.2 m was observed at S2 in spring while the lowest mean width 41.50 m was at S1 in autumn. Both spatial and temporal variations were recorded in the river discharge, calculated as the product of cross-sectional area (m^2) and velocity (ms^{-1}). The highest discharge 637 $m^3s^{-1}$was recorded in spring at S3 while as the lowest recorded discharge was 11 m^3s^{-1} at S1 in autumn. Turbidity varied significantly although no specific trend for variation could be formulated. The

Table 3. Seasonal analysis of physico-chemical characteristics of water at S1 in river Jhelum during May 2016 to April 2018

Parameters SI	Min-Max (Mean±SD)			
	Summer	Autumn	Winter	Spring
Water temperature (°C)	14.50-17.24 (15.79±1.19)	9.55-12.42 (11.27±1.29)	5.72-8.54 (6.68±1.22)	8.34-12.74 (10.40±2.05)
Mean depth (m)	3.44-4.15 (3.81±0.29)	2.65-3.31 (2.96±0.28)	3.19-3.78 (3.54±0.31)	3.36-4.99 (4.05±0.61)
Mean width (m)	54.56-55.15 (54.81±0.21)	41.50-53.93 (51.03±4.7)	52.90-54.35 (53.56±0.85)	54.96-56.54 (55.67±0.61)
Mean velocity (ms^{-1})	0.35-0.61 (0.46±0.10)	0.10-0.28 (0.21±0.06)	0.21-0.43 (0.33±0.07)	0.64-0.83 (0.73±0.09)
Discharge ($m^3 s^{-1}$)	67-133 (97.6±27.4)	11-45 (31.8±11.3)	55-89 (62.2±16.3)	119-229 (165.9±39.2)
Turbidity (NTU)	3-7 (5.01±1.31)	2-12 (5.10±3.52)	8-26 (11.03±7.93)	7-46 (20.75±13.29)
pH	7.98-8.26 (8.12±0.11)	7.50-7.84 (7.68±0.12)	7.40-7.55 (7.48±0.06)	7.40-7.76 (7.53±0.13)
Dissolved oxygen (mg l^{-1})	7.50-8.13 (7.77±0.24)	8.33-9.17 (8.38±0.35)	8.54-10.15 (9.13±0.57)	8.05-8.96 (8.38±0.35)
Free CO_2 (mg l^{-1})	0.40-2.52 (1.07±0.94)	1.15-3.30 (2.22±0.74)	3.07-4.22 (3.55±0.43)	1.95-2.87 (2.40±0.34)
Conductivity (µS cm^{-1})	202-216 (205.00±9.1)	213-235 (220.67±10.1)	197-216 (208.50±9.0)	181-207 (197.33±9.1)
Total dissolved solids (mg l^{-1})	121-152 (137.67±8.2)	144-168 (153.50±8.5)	112-133 (135.67±8.6)	112-133 (123.33±8.2)

Table 4. Seasonal analysis of physico-chemical characteristics of water at S2 in river Jhelum during May 2016 to April 2018

Parameters	Min-Max (Mean±SD)			
	Summer	Autumn	Winter	Spring
Water temperature (°C)	16.80-19.50 (18.48±1.13)	10.68-15.38 (13.79±2.02)	5.65-9.04 (6.93±1.41)	8.80-16.74 (12.27±3.75)
Mean depth (m)	5.45-5.98 (5.84±0.50)	4.31-5.17 (4.78±0.35)	5.12-5.68 (5.39±0.25)	5.70-6.93 (6.28±0.50)
Mean width (m)	97.6-109.6 (105.42±5.3)	86.5-107.4 (95.58±7.0)	96.2-102.8 (99.21±2.5)	102.9-113.2 (108.47±4.5)
Mean velocity (ms^{-1})	0.32-0.47 (0.40±0.06)	0.18-0.36 (0.27±0.06)	0.25-0.56 (0.40±0.11)	0.56-0.82 (0.72±0.10)
Discharge (m^3s^{-1})	174-296 (245.9±44.5)	67-173 (124.8±42.4)	123-292 (215.3±67.1)	344-616 (490.3±95.2)
Turbidity (NTU)	6-11 (7.61±1.62)	3-7 (5.58±1.47)	9-15 (12.40±2.74)	7-24 (16.46±6.78)
pH	7.44-7.78 (7.59±0.12)	7.13-7.50 (7.26±0.18)	6.95-7.10 (7.02±0.05)	7.17-7.44 (7.34±0.10)
Dissolved oxygen (mg l^{-1})	5.68-6.05 (5.89±0.12)	6.32-6.93 (6.68±0.23)	6.85-8.98 (7.59±0.87)	6.38-7.18 (6.72±0.29)
Free CO_2 (mg l^{-1})	2.82-5.29 (3.78±1.04)	3.28-4.14 (3.78±0.31)	4..31-6.34 (5.61±0.74)	4.53-5.55 (5.08±0.40)
Conductivity (µS cm^{-1})	207-231 (219.67±8.1)	231-318 (273.67±37.7)	217-256 (226.00±15.4)	197-212 (204.33±7.6)
Total dissolved solids (mg l^{-1})	140-162 (148.23±9.2)	165-236 (189.67±33.3)	134-194 (157.67±21.7)	115-146 (132. 00±12.8)

highest recorded turbidity was at S1 (46 NTU) in spring and the lowest (2 NTU) again at S1 in autumn.

The parameters including depth, width, current velocity, discharge and turbidity have a direct relationship with the precipitation and melting of snow which is reflected by a steady increase in all these variables in spring (characterized by heavy downpour). The water level of the river showed a peak in spring which was reflected by an increased average depth, width and discharge. Due to higher current velocity there occurs an erosion of the soil and sediment in the upper stretch of the river and a large amount of mineral particles, sand, silt and organic matter is added from the surrounding environment resulting in increased turbidity during spring. On the other hand, minimum turbidity was observed in autumn characterized by a lower precipitation and hence a lesser amount of eroded soil. Besides the large scale dredging operations undertaken by the government after the September 2014 floods and the sand extraction by local populations in the middle, the lower stretches result in a further addition of silt to the water making it more turbid downstream to Sangham. pH values recorded in the present study are indicative of a alkaline nature of the river water. The highest pH (8.26) was at S1 in summer while the lowest pH was 6.95 at S2 in winter while intermediate pH values were observed at S3 with slight temporal fluctuations. The small changes, in pH suggest that a strong buffering mechanism is operative in the river. Significant changes in pH in running waters reflect industrial pollution (Jena et al 2013). Variation in pH was not significant because there is not much industrial development in the catchment of the river and the sources of pollution are limited to agricultural runoff and sewage from the nearby human settlements. Majority of the aquatic organisms including fish prefer the pH ranging between 7 and 8.5; value below 5.0 or above 9.0 is detrimental or even lethal (Bhatnagar and Devi 2013). Dissolved oxygen concentration showed a continuous decrease from S1 to S3, the maximum concentration being (10.15) at S1 in winter and the minimum (4.88) at S3in summer. Free carbon dioxide was highest (7.04) at S3 in winter and lowest (0.40) at S1 in summer. This increased concentration of both DO and CO_2 during winter months is attributed to the low temperatures resulting in increased amount of dissolved gases in water which is in agreement with Henry's law (International Union for Pure and Applied Chemistry IUPAC 1997). The low free carbon dioxide concentration in summer could also be attributed to the higher pH because at high pH more carbon dioxide is present as bi-carbonate ion and at low pH value it is present in free condition (Kumar et al 2004). Dissolved oxygen concentration of 5 to 10 mgl^{-1} in a water body is optimum for fish health. Oxygen content ranging from 1.0 to 5.0 mg l^{-1} may be lethal to many species if sustained for a long period and have some adverse effects on growth, feed conversion and tolerance to disease. Total dissolved solids (TDS) and electrical conductivity (EC) increased from S1 to S3 during the study period which could be due to mixing of salts through agricultural runoff and other sources downstream. TDS was highest at (250 mg l^{-1}) at S3 in autumn and lowest (112 mg l^{-1}) at S1 during spring. Electrical conductivity followed the same pattern and was highest (342 μS cm^{-1}) at S3 in autumn and lowest (181μS cm^{-1}) at S1 during spring. Annual mean value of conductivity was highest at S2 which could be attributed to the influx of ions through municipal waste discharging directly into the river. The relatively decreased electrical conductivity and TDS in spring could be explained by the dilution as a result of the increased precipitation and hence added discharge by direct runoff and input of waters from the

Table 5. Seasonal analysis of physico-chemical characteristics of water at S3 in river Jhelum during May 2016 to April 2018

Parameters	Min-Max (Mean±SD)			
	Summer	Autumn	Winter	Spring
Water temperature (°C)	18.05-22.03 (20.50±1.43)	11.60-15.70 (14.37±2.16)	5.80-9.23 (7.07±1.65)	8.90-17.93 (12.96±3.78)
Mean depth (m)	3.44-4.15 (5.82±0.11)	4.32-5.17 (4.58±0.32)	5.26-5.65 (5.52±0.17)	5.81-6.90 (6.33±0.45)
Mean width (m)	93.9-100.8 (96.59±3.0)	80.6-96.5 (87.41±5.8)	89.6-99.8 (93.55±4.2)	99.8-109.5 (101.56±4.0)
Mean velocity (ms^{-1})	0.39-0.59 (0.45±0.09)	0.16-0.45 (0.27±0.10)	0.24-0.65 (0.41±0.14)	0.62-0.98 (0.82±0.13)
Discharge (m^{3}s^{-1})	181-354 (255.2±61.5)	56-225 (112.7±59.0)	116-365 (212.6±85.6)	418-637 (524.4±91.2)
Turbidity (NTU)	5-15 (8.86±3.77)	3-8 (5.58±1.76)	9-17 (13.06±3.01)	10-26 (16.40±5.99)
pH	7.40-7.75 (7.81±0.12)	7.30-7.48 (7.40±0.07)	7.22-7.35 (7.28±0.05)	7.20-7.57 (7.37±0.13)
Dissolved oxygen (mg l^{-1})	4.88-5.89 (5.50±0.44)	6.55-7.34 (6.88±0.29)	6.43-8.55 (7.54±0.71)	5.83-7.68 (6.81±0.75)
Free CO_2 (mg l^{-1})	2.90-4.65 (3.70±0.28)	3.60-4.35 (3.92±0.30)	4..50-7.04 (5.89±1.05)	4.80-5.63 (5.10±0.28)
Conductivity (μS cm^{-1})	215-234 (224.83±7.7)	228-342 (283.50±45.9)	219-273 (233.50±20.1)	204-243 (218.00±13.7)
Total Dissolved Solids (mg l^{-1})	136-164 (145.81±9.8)	142-250 (202.3±39.2)	158-184 (165.67±17.5)	128-165 (148.67±15.7)

tributaries which in turn carry lesser solute. The inflow of water during the rainy season initially may be increasing the EC by bringing the ions along with the effluents however the conductivity is reduced beyond a threshold due to increased volume of water. Mehmood et al (2017) concluded that excess of dissolved solids may create an imbalance, a sudden change in the osmotic regulation or cause suffocation of fish.

Length-weight relationship and condition factor (K): The logarithmic regression plots generated by plotting total length against body weight showed that the highest value of regression coefficient '*b*' was obtained for *Schizothorax plagiostomus* at S2 (*b*=2.83) followed by *S. curvifrons* at S1 (2.82) while the lowest *b* value (2.72) was also obtained for *Schizothorax plagiostomus* at S1 (Fig. 2). These *b*-values are indicative of an allometric negative growth pattern ($b<3$) which further suggest that the smaller specimens were in a better nutritional condition at the time of sampling or the larger specimens had a body shape that became more elongated. These findings were also supported by the Student's t-test as the calculated 't' values were significant at 5% level. An estimated 95% confidence limit for *b*-values suggest the overall tendency for the populations to increase in thickness as theyhave grown by an over-proportional increase in length relative to weight, apparently favouring swift swimming (Table 6). Yousuf et al (2001) reported value of *b* for *S. niger* in Manasbal lake, Anchar lake and Dal lake as 3.014, 2.974 and 2.977, respectively.

The plot of log *a* vs *b* for LWR (Fig. 3) did not show much expansion of the points around the trend line, with the correlation coefficient being R^2= 0.890.The value of form factor ($a_{3.0}$) ranged between (0.0045) in *S. curvifrons* to (0.0048) in *S. plagiostomus* at S2 and S1 respectively, which are interpreted to be in conformity with the more elongated body shape in *S. plagiostomus* than *S. curvifrons* indicating allometric growth for both the species (Table 6). A high coefficient of determination in the range of 0.91 to 0.98 resulted from simple linear model with *ln* (length) as the only predictor variable for *ln* (weight) in both the species (Fig. 2). Similar findings have been reported from the comparative work on LWR for a number of fish species in wild habitat all over the world ((Leonardo et al 2008, Hossain et al 2009, Mir et al 2012, Sarkar et al 2013). For *S. plagiostomus*, the value of K ranged from 0.59 to 1.72 at S1 with an average condition of (1.19±0.19) suggesting that the fish was in a relatively better condition at this site. On the other hand, for *S. curvifrons*, the K value ranged between 0.69 and 1.42 and the lowest average value of K was (0.97±0.11) at S2. The K is influenced by age of fish, fullness of gut, type of food consumed sex and stage of maturation. In some fish species the ovary may weigh up to 15% or more of total body weight and hence in females of these species the K value decreases

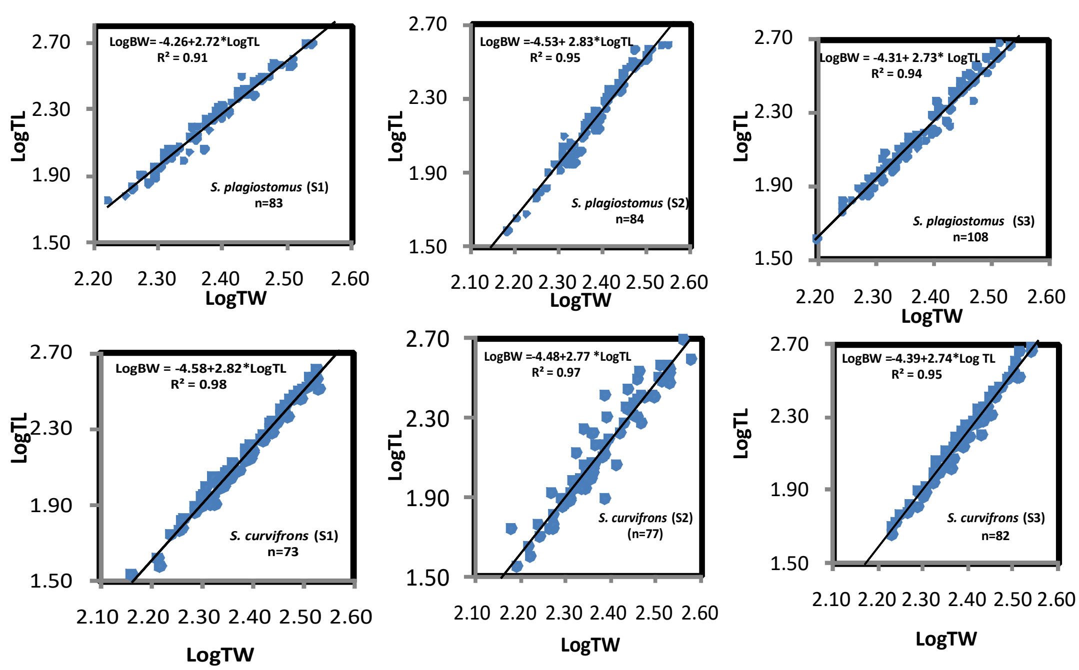

Fig. 2. Length-weight relationships of *S. plagiostomus* and *S. curvifrons* collected from three sites (S1, S2 and S3) of Jhelum river from May 2016 to April 2018

Table 6. Descriptive statistics and estimated parameters of length-weight relationships for *Schizothorax plagiostomus* and *Schizothorax curvifrons* from the selected three sites of river Jhelum

Sites	Species	N	Total length (mm)	Total weight (g)	Regression parameters				K		
			Min.-Max. (Mean±SD)	Min.-Max. (Mean±SD)	a	*b*	95% CL of *b*	R^2	Min.-Max. (Mean±SD)	t_{value}	$a_{3.0}$
S1	*Sp*	83	166-440 (262±51)	55-540 (228±118)	-4.26	2.72	(2.53-2.91)	0.91	0.59-1.72 (1.19±0.19)	6.37	0.004875
	Sc	73	128-394 (252±52)	20-665 (186±115)	4.58	2.82	(2.67-3.00)	0.98	0.71-1.42 (1.06±0.15)	9.13	0.004681
S2	*Sp*	84	153-390 (249±49)	38-600 (197±112)	-4.53	2.83	(2.69-2.97)	0.95	0.82-1.56 (1.17±0.15)	8.92	0.004855
	Sc	77	139-376 (240±54)	25-409 (147±91)	-4.48	2.77	(2.66-2.89)	0.97	0.71-1.19 (0.97±0.11)	13.76	0.004516
S3	*Sp*	108	114-477 (263±61)	19-1226 (228±173)	-4.31	2.73	(2.60-2.86)	0.94	0.63-1.54 (1.12±0.18)	7.96	0.004775
	Sc	82	146-415 (245±51)	31-734 (163±103)	-4.39	2.74	(2.60-2.89)	0.95	0.69-1.32 (1.01±0.13)	12.70	0.004575

Sp: Schizothorax plagiostomus, Sc: Schizothorax curvifrons

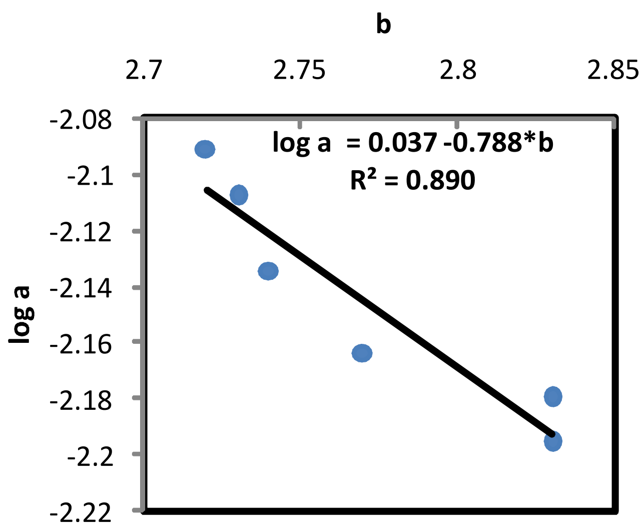

Fig. 3. Plot of log a over *b* for length-weight relationship of *Schizothorax* species from Jhelum river for the estimation of form factor

rapidly after spawning. Therefore K value is significantly influenced by the stage of development of the reproductive organs. The differences in condition factor (K) for these species in different stretches of the river could be attributed to low feeding intensity and degeneration of ovaries after breeding and high feeding intensity and full development of ovaries at the maturity periods. The condition factor of any fish species inhabiting a water body is also indicative of its water quality and other habitat characteristics. Thus, in this study the differences in condition factor for the studied species in different stretches of the river could also be attributed to the declined water quality at S2 and S3, which is reflected by the decreased K value of *S. curvifrons* at these sites.

CONCLUSION

The intrabasin variations in growth and other life history parameters of *Schizothorax* species from River Jhelum had not been investigated previously in detail. The steady decline in water quality as a result of an increased anthropogenic pressure is taking a toll on the fish diversity of the river. The present study urges for remedial measure to be undertaken to review the water quality and prevent any further deterioration of river Jhelum and its icthyofaunal diversity. Moreover, for the *Schizothorax* species of river Jhelum this study would assist in providing insights into growth strategies of the fish populations in the different stretches within the main river. The findings of this study are in line with the earlier reports with respect to the impact on the Ichthyofaunal diversity of the river. Therefore the continuous dwindling of the endemic *Schizothorax* species over the past few decades can genuinely be attributed to the increased human activities, encroachment and agricultural runoff resulting in water quality degradation and habitat destruction of the very delicate fish species, having a narrow tolerance range.

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What Sustains Nepalese Agroforestry Practices?

Amatya Swoyambhu Man, Nuberg Ian[1] and Cedamon Edwin[1]

Agriculture and Forestry University, Chitwan, Nepal,
[1]University of Adelaide, South Australia
E-mail: swoyambhu_amatya@yahoo.com

Abstract: Farmers in the hills of Nepal have practiced agroforestry for centuries. For much of this time, farmers grew trees to meet subsistence farming needs, but the nature and extent of these practices depended on the size of their land and the accessibility of fuelwood and fodder from community forests. Throughout this period, the role of agroforestry in Nepalese farming system has remained important, but the need for improved agroforestry systems and better knowledge of the various agroforestry options and market possibilities have increased. Over the last decade, much has changed in the rural areas of the Middle Hills. Household livelihood expectations have changed, many families have individuals working in cities or outside Nepal, which has increased household income and reduced labour availability. A survey was carried out to examine the current agroforestry systems and practices in Nepal, and factors responsible to sustain a given practice. The survey showed that number of practices has increased since the 1999 when agroforestry as science was just new in Nepal. Agroforestry practices would further scale up if the selection of tree species vis-à-vis their silvicultural characteristics and local suitability is known and practiced accordingly. Proper choice of shrubs and herbs of economic value for commercial and general purposes, such as, medicine, essential oil, fiber, floss, and food could be encouraging for agroforestry practitioners. Capacity building should focus on skill development, market and its linkages and optimal use of available resources, optimal use of spacing, livelihood development and their enhancement. The role of Local and International Non-Governmental Organizations are very effective in capturing new innovations in agroforestry practices.

Keywords: Agroforestry, Sustainability, Types, Acts and regulations, Agroforestry policy

Agroforestry is a land use system where agriculture and forestry discipline are combined to provide multiple products (food, timber, fodder, fuel wood, leaf litter, medicine) related with agriculture and forestry in a given space and time. Agroforestry has an important role in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risk in addition to providing livelihood security. Agroforestry has the potential to provide most or all the ecosystem services.

Scientists have defined Agroforestry in various forms. The World Agroforestry Centre (WAC) then International Centre for Research on Agroforestry (ICRAF) has defined Agroforestry system as "a land use system that integrates trees with agricultural crops and / or animals, simultaneously or sequentially, to get higher productivity, more economic returns, and better social and ecological benefits on a sustained yield basis, than are obtainable from monoculture on the same unit of land, especially under conditions of low levels of technological inputs and on marginal sites" (ICRAF, 1982). These definitions of agroforestry have gradually been refined in terms of the services it provides and combination pattern of both agriculture and forestry products. Declaration of 1st World Congress of Agroforestry held on Orlando, Florida, USA during 27 June to 02 July, 2004 mentions "Agroforestry as a science without borders, can tackle problems of biodiversity, rural poverty, deforestation, land degradation, genetic erosion, soil fertility decline, climate change, environment, food and nutritional security".

Therefore, the concepts and definitions of agroforestry mentioned above illustrate both complementary perspectives and diversity of agroforestry practices being taken care around the world.

Agroforestry in Nepal

Agroforestry is an age-old practice in Nepal and farmers have been practicing various combinations of tree and agriculture crops since time immemorial. Recorded history of planting trees goes back to as old as Padma Purana, a Hindu religious literature. It says "those people, who plant trees near road side, would feel happy in heaven as much the number of years as the tree has fruits and leaves on it. Agroforestry in the Nepalese context can be defined as a land use system where trees and agriculture crops are grown together, incorporating livestock, medicinal and aromatic plants, in a given space and time, to raise the productivity of each component without compromising the yield of others.

In order to examine the current agroforestry systems and practices in Nepal, and what factors are responsible to sustain a given practice, a survey was carried out in Eastern, Central and Far-western districts of Nepal in the year 2017. The survey showed that number of practices has increased from 14 in 1995 to 35 under the following seven agroforestry systems Table 1.

Table 1. Agroforestry practices in Nepal

Agroforestry Systems	Number of practices
Agrisilviculture (crops and trees including shrubs)	9
Agro-silvo-pastoral (crops/ pasture/ animals)	11
Silvopastoral (pasture/ animals and trees)	8
Home gardens	3
Silvo-fishery (tree with fish on ponds)	2
Woodlots	1
Shifting cultivation	1
Total 7	35

Source: Amatya et al (2018)

Farmers' recognizes agroforestry has important role in their farming system in the form of re-cycling nutrients besides other forms of production and ecological functions. Farmers particularly in the hills of Nepal have practiced agroforestry for centuries. For much of this time, farmers grew trees to meet subsistence farming needs. But the nature and extent of these practices depended on the size of their land and the accessibility of fuelwood and fodder from other types of forests. Over the last decade, much has changed in the rural areas of the Middle Hills. For example, household livelihood expectations have changed, many families have individuals working in cities or outside Nepal, which has increased household income and reduced labour availability. But the need for improved agroforestry systems and better knowledge of the various agroforestry options and market possibilities has increased.

The survey also showed that agroforestry practices would further scale up if the selection of tree species from among some three dozen indigenous and one-dozen successful exotics vis-à-vis their silvicultural characteristics and local suitability is known and practiced accordingly. Proper choice of shrubs and herbs of economic value for commercial and general purposes, such as, medicine, essential oil, fiber, floss, and food could be encouraging for agroforestry practitioners. The role of Local and International Non-Governmental Organizations such as International Union of Forest Research Organizations are very effective in capturing new innovations in agroforestry practices.

Agroforestry Acts and Regulations

Although not directly related with agroforestry, the Forest Act 1993 and Forest Regulations 1994 of Nepal have placed provisions of private forests. Revised Forestry Sector Policy 2000 has promoted private forestry by encouraging plantation on farms and other private land. Herbs and NTFP Development Policy 2004 Government of Nepal has prioritized 30 medicinal and aromatic plants for research and cultivation for Nepal. The development of NTFP's is one of the priority programs of the Ministry of Forests and Environment. It has recently introduced a special program of promoting NWFP's in 25 hill districts of the country so as to alleviate the rural poverty.

Agriculture policy 2004 has also made agroforestry provision for the purpose of upgrading forests and other lands to reduce poverty in the country.

The Constitution of Nepal (2015), through its directive principles pursues a policy to promote and protect rights of individuals, their property and recognized the role of private sector. Forest Policy (2015) and Forestry Sector Strategy (2016) have acknowledged the role of private forests and emphasized the private, public and community partnership in developing forest entrepreneurship of which private forestry is an integral part.

Recently Agroforestry Policy of Nepal (2019) has come into force. Recent amendment on the Forest Regulations 1994 has made the process more-simple and private forest friendly. The regulation provides opportunities to farmers to plant and harvest 23 tree species, mostly grown, in their private land.

Limited scientific knowledge is one of the critical constraints for developing forest. Hence, Government set forth a Private Forest Development Directives (2011), which provides a list of 26 tree species that are suitable to plant in the hills and in low land (200 m) along with technical inputs from the state for private tree growers.

Similarly, Government has brought the Climate Change Policy 2019 to develop agroforestry programs specifically aimed at conserving soil and water needed for reducing the impacts of climate change.

Government is trying to resolve the issue of quality tree seeds/ seedlings through promoting nursery techniques in private farms.

Role of NGOs/ INGOs in Developing Agroforestry in Nepal

The Asia Pacific Agroforestry Network (APAN) funded by Food and Agriculture Organization of the United Nations was also instrumental in sharing agroforestry related information within and outside the country through knowledge documentation. Farmers' exchange visits at national level were instrumental in understanding and identifying the important fodder trees and their lopping cycle. International Union of Forest Research Organizations (IUFRO) in collaboration with other Nepalese partner (Nepal Foresters' Association) acknowledged the contributions of women in agroforestry and identified the emerging issues especially possibility of shading effect to agriculture crops from trees, lopping techniques of fodder trees, below ground interactions between planted crops that could be taken up in the future.

Since 2013, the Government of Nepal and Australian Centre for International Agricultural Research (ACIAR) has implemented a five-year action research project titled "Enhancing livelihood and food security from agroforestry and community forestry systems in Nepal" at two districts (Kavre and Lamgung) of middle mountain physiographic zones of Nepal through national and international partners.

Provide technical knowledge: Amatya et al (2018) has identified some of the major constraints in sustaining agroforestry practices in the country. One of them is limited land availability followed by appropriate knowledge of tree-crop combinations. Most farmers have very limited private land of their own. This has restricted commercialization and marketing of agroforestry products. Farmers need some refresher training on the tending operations such as thinning and pollarding, production of healthy seedlings in nurseries.

Some of the important agroforestry species have dioecious nature (having the male and female reproductive organs in separate individuals). This makes very difficult to select female plant for desired output. This calls for research on tree breeding and development of morphological markers for early sex determination. This is complex and costly affairs.

CONCLUSION

Agroforestry is one of the sustainable land use options in Nepal. Farmers are practicing agroforestry since long time ago. Traditionally they have been retaining trees or are planting various types of trees that would yield timber, fuel wood, fodder, bark, nuts, and having medicinal and aromatic properties on terrace risers, marginal lands and underutilized land. The scale of agroforestry is minimal because of the lack of land and marketing of agroforestry products and its scale. Nonetheless, the practice is increasingly becoming important as it provides all most all sort of products that a family need. There are some constraints in the development of agroforestry in commercial scale but it has been experienced that conducive policy, acts and regulations, imparting some refresher training to individuals, providing some technical input and favorable roles of both National and International Non-Government Organizations have helped in sustaining agroforestry practices in Nepal. Marketing of agroforestry products and scale of economy are also very important in sustaining it and much emphasis is required on selection of species, quality of planting stock, their optimum management and marketing.

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Mainstreaming Biofuels in India: Analysing Weaknesses and Opportunities for the Sustainability of Biofuel and its Future Policy Making

Dhanraj A. Patil

Department of Sociology, Gondwana University, Gadchiroli-440 013, India
E-mail: dr.dhanraj9@gmail.com

Abstract: The analogies between biofuels and its sustainability are complex thus cannot be examined in isolation. Therefore, this paper proposes a holistic paradigm towards mainstreaming and sustainability of biofuels analysed through the most promising methods of futures studies, PESTEL and Delphi. Futures methods and policymaking are entwined. It takes complete account of the drivers and intricate nature of biofuels. The PESTEL and Delphi expert's consultations from trans-disciplinary domain endow with plausible weaknesses and opportunities on biofuels. This paper finally draws destructive and prospective scenarios which contextualise India's distinctive policy priorities for the mainstreaming and sustainability of biofuels.

Keywords: Biofuels, Weaknesses, Opportunities, Sustainability, Future policy

The growth of Indian economy is at rising pace. The status of fastest growing economy tethered with burgeoning urbanization, mobility and population boost formed various demands and responsibilities. One of the prime demands is to satisfy energy and fuel prerequisite. The mounting fuel demand put forth India as the world's fourth largest consumer of crude oil and petroleum products. This has two foremost repercussions i) highest import of oil creates stern impact on economy; for 2017-18 the imports are 219.15 million tonnes MT; USD 87.725 billion represents ₹.5.65 lakh crores, and ii) since majority of oil is consumed by transport sector it produces huge amount of harmful emission which alone contributes almost 30% of greenhouse gas (Petroleum Planning and Analysis Cell 2019, Pandey 2017). This has turned India as the fourth largest CO_2 emitter globally (Global Carbon Project 2018). These disastrous circumstances united with some local and international canons, including Paris treaty; energy security and justice paved way to explore alternative clean energy resources for government of India (Joshi and Rawat 2017). Amongst various clean resources biofuels have been touted as one of the promising options to decarbonize environment, energy security, west to wealth and agro-rural development. It is in this context, Government of India's Ministry of Petroleum and Natural Gasinitially introduced blending of 5% ethanol at selected states in 2002. Within a short span Indian government introduced National Policy on Biofules (NPB) in 2009 and revised in 2018. The NPB policy proposed a target of 20% blend for both biodiesel and ethanol towards mainstreaming by 2030. The Government of India is promoting ethanol blending program (EBP), ethanol derived from sugar molasses/juice for blending with petrol and biodiesel derived from non-edible oils and oil wastes for blending with diesel. Biofules are primarily classified as i) Bio-ethanol: generated from sugarcane, sugar beet, sweet sorghum, corn, and algae, and ii) Bio-diesel: produced from vegetable oils, edible and non-edibles.

In order to accomplish dual goal towards security of energy and its sustainability, India has been keen to utilize the unprecedented potential of biofuels. Nonetheless, from futures perspective sustainability of biofuelsand the reckless hustle to promote its policy framework in India may lug future problems (Saravanan and Perumal 2018, Das and Joerg 2011). In a country like India where complex socio-economic and geo-political diversities survive fangled policies like biofuel indubitably coexists with major disquiets for its mainstreaming and sustainable policy making. Thus, this paper relies on the focal question: What are the crucial drivers of plausible weaknesses-opportunities for mainstreaming and sustainable biofuel policy making in India?

MATERIAL AND METHODS

A triangulation method has been adopted connecting futures studies prime techniques: Horizon scanning, PESTEL, Delphi and Scoring method. Horizon scanning analyses review of select policy documents to examine broad range policy interfaces. PESTEL a strategic tool stands for: political (P), economic (E), social (S), technological (T), environmental (E) and legal (L) applied to explore intricate causality involved in the problem under investigation. To make PESTEL analysis operational Delphi method is also employed. The present research adopted face-to-face meetings with panellists (bureaucrats, policy makers and researchers) called as mini-Delphi (Linstone and Murray 2011). Altogether 20 experts were gathered to discuss on the intended research question and to bring their own argued future views into the discussion during September-October, 2018. Finally, scoring method is applied to identify most desirable Delphi experts' responses to draw specific drivers for the foreseeable future of biofuel in India.

RESULTS AND DISCUSSION

The analysis in this section centred on PESTEL's taxonomy reflected in Table 1 and 2 reciprocally. It explores crucial drivers which help to search plausible weaknesses and opportunities for mainstreaming and sustainable biofuel policy making in India (Table 1). It also identify most desirable drivers relied on scoring analysis (Table 2).

Political sphere*:* Political factors tend to have an important impact on biofuel policies and assist to identify macro-micro level comprehensive drivers for strategic future planning. Biofuel policies have resultant impacts on socio-democratic dividend through conglomerating popular vote-bank politics in India. Therefore, deserves careful attention. The highest probable (HP-9) driver in political sphere is founded on centralised colonial legacy, idealistic political ambitions and relatively lack of collective political consciousness on biofuels. It has emerged as prime future driver for biofuel sector in India. All-party political consciousness is yet to be evolved. These political uncertainties and wasted interest groups also appear as principal weaknesses. Hence, the preferable scenario towards its sustainability is to create conducive, strategic bounding and accountability across political parties and federal governments. Social support from community organisations and common citizens on biofuel may employ as tactical pressure group. The buoyant political relations at international level can be a good opportunity to patronage and amplify biofuel sector at domestic and international context. Finally, although present political milieu for biofuels proffer fairly stable and optimistic scenario however, from futures perspective the pace of collective amount of political will should be maintained judiciously, there will be a strategic rationality between political ambitions and local-global realities.

Economic sphere*:* The causality between political and economic factor is quite susceptible. Economic factors of biofuels have two distinctive aspects i) by developing biofuels India could decrease import cost up-to almost 40 billion (USD 61.5 billion) by 2021-22ii) the economics of producing biofuels on larger scale capitalizes its benefits and will become too expensive from socio-economic and environmental standpoint. The high probability drivers(HP-8) in economic sphere are i)severe demand-supply gap in biofuel produces higher production cost and economic setbacks ii) lack of commercial viability of jatropha (*Jatropha curcas*) and karanj (*Pongamia pinnata*) has been emerging as serious threat and iii) Biofuel alliances find difficulty to adopt new technology due to economic reasons, mainly sugar industry, which is under stern debt constrain it seeks almost 7.34 billion debt restructuring (Energy Next Agency 2019). The case of National Biodiesel Mission (NBM), launched in 2009 is self-illustrative of its economic un-sustainability. Over five years jatropha and pongamia were cultivated under (NBM) on 500,000 ha with capital investment of ₹.1, 500 crore (15 billion). Three prominent oil corporations- Bharat Petroleum; Indian Oil and Hindustan Petroleum signed memorandum of understanding (MoU's) with states to institute jatropha on wastelands based on contract farming. Nevertheless, due to low yield and lack of commercial viability all three corporations have hushed from joint MoU's (Down to Earth, 2019). This scenario opens up opportunity for i) low cost long term 2 and 3 generationnano-technological innovations, ii) creation of green national fund involving public-private actors and iii)strengthen supply chain mechanism instituting integrated low cost value chains like biofuel villages-banks and self-help groups. Ultimately, future of biofuels economic sustainability in India desires to be treated with a few cautions due to its diverse socio-economic and environmental feasibilities and operational costs. Thrust can be focused on future management and establishment of special by-product zones (SBZ's) it has enormous potential to reduce biofuels production cost and enhance sustainable production-supply linkages.

Social sphere*:* Social aspects are always coeval with ongoing policy changes. Any potholed changes in social sphere can create serious long-term effects. Expansion of biofuel feedstock (e.g., sugarcane, soybean and jatropha) is generally embraced by governments to achieve energy security, sustainability and rural development, however from futures perspective the higher probabilities are it will effect on local land ownership and control and deprives poor masses from their land it also further evokes food security at household and national level (HP-9). It moreover exceeds migration, poverty and hunger in near future. To cope up with this depressing scenario strategic inclusive policy based on pro-poor social innovations at grassroots are essential such as: development of biofuel notified areas; legislation on cultivation, manufacturing and protecting rights of vulnerable masses and gradual take over from first generation (1G) to

Table 1. PESTEL analysis of weaknesses and opportunities for biofuels in India

Driver (s)	Weaknesses	Opportunities
Political	i) Fragile international political relations and dramatic changes in energy/fuel aligned countries. ii)Uncertainties to execute biofuel policies in true spirit from opposition and politically wasted interest groups at local, state and central government iii) Centralised control and idealistic political ambitions/ dividends; and lack of collective political consciousness on biofuels.	i) Being a growing economic power and Paris Treaty Indian political relations may obtain strong policy patronage and space for negotiations. ii) Opportunity to reinvent linkages with incentives, trust and accountability amongst the allied political actors.Develop citizens/CBO's support groups on biofuel's iii) Decentralisation and rational political linkages on biofuel policies, political will to create conducive ecology and active involvement of private/cooperative sector on biofuels. Develop rational linkages towards political ambitions and sensible realities on biofuels.
Economical	i) Severe demand-supply gap in biofuel, mainly 1G ethanol creates economic setback, stakeholders like Sugar factories lack affordability to adopt new technology. Lack of commercial viability mainly (jatropha and karanj). ii)Confining ethanol manufacturing only from sugar molasses is either not sustainable or economically feasible. iii) Segmented and unorganised biofuel markets lack of sustainable distribution.	i) Scope for 2-3 generation nano-technological innovations. Creation of national fund involving public-private actors includes green fund. Strengthening 2-3G biofuel supply chain/feedstock and by-product management. ii)Indianised version of Brazilian model of '*Proalcool'* can be a viable option. iii) A pool of biofuel marketers, production and distribution (primary to end stage) can be developed with an active involvement of grassroots level utilities (SHG's, Cooperatives, local federations, extension etc) an enhanced social capital can certainly be benefited.
Social	i)May cause future food security, in order to make higher profit producers may turn towards fertile land lending to food inflation, migration and malnutrition. Lacks ethical credentials of biofuels. ii) Practically, poor peasants are based on wastelands. Mass-scale Bio-fuel production on wasteland may harm these groups. iii) Big farmers and private companies may grab undue advantages creates uneven allocation of profits.	i) Development of notified areas for BF production, cluster based approach also helps to reduce food security, scope for sustainable biofuel livelihood schemes and community farming; biofuel villages and SHG's. Adopt ethical credentials for biofuel policies. ii) Small and marginal peasant's biofuel producer's cooperatives or integrating with employment generation program with appropriate legal terms can be great choice. iii) An appropriate legislation on cultivation and manufacturing is developed considering the natural profit rights of small-marginal cultivators.
Technological	i) Transport/automobiles technologies are not yet modified for ideal use of biofuels. 2-3 G biofuels technology adoption an transfer is at nascent stage ii) Lacks severe technological investment in R & D and transfer of technology. iii) Distribution and service infrastructure for advanced Bio fuel technology is also wanting.	i) A massive policy shift is needed particularly based on Brazil's flex-fuel vehicles (FFV's) with tax and legal incentives and promotion of Hybrid policy. ii) India can utilize its cordial international relations with G-20 nations, BRICS and EU countries for R & D and transfer of technology under 'Make in India' and 'SAHYOG' project. iii) Scope for utilizing public, private and cooperative infrastructure and human resource under 'Skill India Project' and IIT/IIM's.
Environmental	i) Growing biofuels could create water crises, higher water footprints; land and biodiversity degradation. ii) The unexplored area is the whole-impact of Bio-fuels right from production, transportation and refining may perhaps exceeds the emissions level than conventional fuels. iii) Sustainable biofuel production	i) Rising eco-sensitivity of end-users of bioffuel producers and national-local level public-civil society's active role in ecological awareness; policies like waste land development; sustainable rural livelihoods and land-water use acts must be strengthened. ii)Potential to conduct scientific studies on notified areas; clustering; advance technology transfer and second generation Bio-fuel promotion can be an opportunity iii) Positive Agro-climatic fusion to produce diverse type of biofuels. Well developing market/infrastructure with planned forward and backward linkages per-post production may have good prospect.
Legal	i) Lack of integrated legal national framework and coordination (State-Centre & line departments and ministries) on biofuel. ii) Uncertain classification of land tenure/ownership/ classification for Bio-fuel cultivation iii) The present law controls direct move of sugar to ethanol.	i) Finetuning of existing legal framework: National policy on energy, Electricity Act, National Action Plan on Climate Change; National Biofuel Policy,2018.Local governance like *Panchayat* and Municipalities can also act for legal enforcement. ii) Formulate special land laws for Biofuel cultivation in consultation with Agriculture, Forest and Environment: Policies like Social forestry; granting ownership rights to landless; cooperative/community farming; large scale leasing or contract with corporations can be assisted. iii) Through conducive and pro-active governance the present government will have opportunity to pursue Brazilian model'*RenovaBio'*(2018) and *Proalcool'* (1975).

Source: Based on Delphi experts interview

(2-3G) biofuels; together with producing social capital through cooperative-community biofuel farming and collection centres.

Technological sphere*:* Technology is the major driving force for development. Nevertheless, policy choices determine its future and success. Since biofuel sector in India is concerned technological issues are on forefront. The high probability driver in technology sector closely linked with India's transport/automobiles sector. Although government inclined to introduce flex-fuel vehicles (FFV's) but the Indian automobile sector is not yet compatible with such new modifications having dedicated engine for both ethanol and gasoline. Modifications are necessary for (FFV's) even beyond 10 % for petrol and 5% for diesel engines (Saravanan and Perumal 2018, Das and Joerg 2011). Lack of dedicated engine is one of the prime weaknesses towards mass utilisation and mainstreaming of biofuels. Likewise, the technology to develop 2-3G biofule in India is still at nascent phase and may face challenge headed for constant feedstock availability and supply chain (HP-10). The technological mapping shows obscurity to achieve intended target of 20% blending only through 1G biofuel with existing technology. India can achieve its target more efficiently using advanced biofuel. For instance, lignocellulosic agricultural residues can produce 38 and 51 billion litres of lignocellulosic ethanol/BTL in 2020 and 2030, respectively, which would be sufficient to meet the NPB's 20 percent blending by 2030 (Purohit and Dhar 2018). Yet, the present status of outlay and pace of expansion in technological research is perhaps sparse. Nevertheless, India has an optimistic future to conquer these challenges. Healthy international political relations with advanced nations (G-20, BRICS,OECD) and Paris treaty can pave way for next generation cutting edge bio-technology transfer and adoption under 'Make in India', 'Skill India' and 'SAHYOG' project coupled with indigenous acclaimed research institutes and strong scientific and political determination (Lali 2016).

Environmental sphere*:* Delphi experts forecast that the un-prophetic expansion of biofuels could create higher water footprints; land and biodiversity degradation in India where water and food security issues are already on high alert (HP-10). As per 2016 Global Hunger Index (GHI) India ranks 97 out of 118 nations[12]. Paradoxically, in-spite of world's fastest growing economy India's diminution in food security has been fallen from 80th to 97th since 2000 (Grebmer 2016). Likewise, mounting cultivation of biofuel crops largely sugarcane can also construct destructive scenario for water footprint. By now India's water footprint is 980 cubic meters per capita which ranks below global average of 1,243 cubic meters (Lal 2015). In order to achieve government's 20 % EBP mandate in 2030 would require additional 10.26 M ha of huge land (Lal 2015).From environmental sustainability perspective Delphi experts already cautioned that biofuel policies assured a lot of economic-environmental benefits, however field realities are more impairment than beneficial (Debnath and Babu 2018). Despite of that, Indian policy makers prime thrust is on bio-ethanol primarily for its environmental benefit of reducing carbon emission. Nevertheless, studies show that ethanol is not a fine substitute for regular gasoline due to its less energy quality it has only two-third energy content of regular gasoline (Fuel Economy 2018). Similarly, FAO found that 'corn ethanol produced on no-cropland released at least 17 times more emissions than the amount of reduced carbon dioxide by the use of biofuels' (Food and Agriculture Organization 2018). Consequently, International Energy Agency (IEA), observed that output of conventional transport biofuel sugar and starch based ethanol grew just 4 % (2017-18) in contrast, demand for hydro-treated vegetable oil (HVO) and hydro-processed esters and fatty acids (HEFA) is likely to be expanded because of its advantages, they can be used unblended without modifications to engines and relatively maintenance free and fuel efficient than the conventional biofuels (International Energy Agency 2019). The Delphi findings explores following shortcomings in ethanol sector, i) almost 822 million litres (27% of total estimated capacity) annual scarcity of ethanol is recorded, ii) out of total 29 states and 7 Indian territories EBP is functional in only 13 Indian states, iii)

Table 2. Key drivers for main streaming and sustainable biofuel policy making in India

Drivers	W.I	W.II	W.III	O.I	O.II	O.III
Political	LP (3)	MP (6)	HP (9)	LP (3)	MP (6)	HP (9)
Economical	HP (8)	MP (5)	LP (2)	HP (8)	MP (5)	LP (2)
Social	HP (9)	MP (6)	LP (3)	HP (9)	MP (6)	LP (3)
Technological	HP (10)	MP (7)	LP (4)	HP (10)	MP (7)	LP (4)
Environmental	HP (10)	LP (4)	MP (7)	HP (10)	LP (4)	MP (7)
Legal	HP (9)	MP (6)	LP (3)	HP (9)	MP (6)	LP (3)

W-weakness; O-opportunities
Score: LP (low probability)-(1-4); MP (marginal probability)-(4-7); HP (high probability)-(7-10).

India has hardly managed to achieve 5% of EBP by 2017 which is far below than 20% projected target originally set for 2017 later on extended for 2030, iv) there is stiff competition for ethanol from allied sectors like potable liquor (45%); chemical industry (40%) while the rest (15%) is used for EBP (Indian Council for Research on International Economic Relations 2019). It clearly indicates that it will be arduous to fulfil 20% EBP at 2030. The EBP has been hamstrung by policy and market hurdles that obstruct ease of doing business in biofuel sector. This scenario raises fundamental question that, to what extent ethanol is feasible and sustainable from environmental and socio-economic standpoint? Thus, future of sustainable biofuel production in India presents multiple challenges nevertheless; there is scope for hope to reanimate biofuel policies from the foreseeable holistic futures framework while incorporating strategic, comprehensive tailor made policies based on energy democracy and ethical considerations of biofuels.

Legal sphere*:* Legal aspects comprise present and future legislation that may affect the biofuel sector as a whole. The HP (9) driver in legal sphere is somewhat euphemistic and lacks integrated national legal framework (INLF) and coordination (centre-state; line departments and ministries). Biofuel laws are relatively fragile and find operational gaps in particularly biofuel cultivation at wasteland. Fundamentally, government affirmed term wasteland itself is rather hazy and an example of politically constructed reality which however not entitled as waste or fallow. Wastelands have historically been governed and managed by majority of rural landless, nomadic, tribal and marginal folks for their primary sustenance (Gadgil and Guha 2013). Any policy profligacy in this direction may deprive these vulnerable groups from their fundamental natural rights results already appeared in southern parts of India (Baka 2013). Therefore, inclusive sustainable livelihood biofuel cultivation policy (SLBCP) amid laws for ecological incentives in the light of opportunities constructed herein results effectively. Some of the associated key legal barriers are: lack of unified permit system for interstate movement of biofuel; lack of amendments for hybrid and (FFV's); legal control to direct move of sugar to ethanol; uneven tax policy for blending; lack of uniformity in taxes and duties imposed by different states; state wide uneven laws for pricing and export of biofuel; and condition of and hindrance for obtaining No Objection Certificates. These barriers are at forefront for slugging the pace and sustainability of biofuel's. Opportunities, therefore, indispensably requires reassimilation of flexible (INLF) and coordination involving inter-sectoral, intra-sectoral and cross-sectoral efforts with strong political and stakeholders commitment. Thus, the aforesaid analysis provides a deeper understanding to identify key drivers of change from systems perspective which facilitate to alter future threats and make aware of opportunities for strategic sustainable biofuel policy planning.

Way forward: Notwithstanding anything, analysing the present state of affair it is fair that at early stage policy makers' focus on: tailored designed policies (TDP's); small-scale non-export oriented production; demand based backward-forward linkages of supply chain feeding for both conventional and advanced biofuels; ensure ethical credentials; integrated persistent mechanism to review market feasibility value; flexible liberal national legal framework; radically enhanced monitoring and enforcement mechanism; for long term sustainability democratisation of biofuels coupled with 'energy security' philosophy as a primary goal can result in (PBS). Towards the way forward the paper argues that, biofuel policies that are strategically designed in view of 'energy for supply' as a prime driver rather than 'energy for security' philosophy cannot be sustainable. Since 'security' perspective proffer 'justice' however 'supply' intends 'profit' and eventually 'exploitation' of natural resources hence, unsustainable. Therefore, although the promotion of biofuel is highly judicious in conclusion, it is imperative to design strategies visualising ethical credentials and its comprehensive future impact as analysed in PESTEL will determine the future for mainstreaming and sustainable biofuel policy making in India.

CONCLUSION

This paper envisages that there are more precincts than scope for the highly quixotic expansion of biofuel's in India, considering the aforesaid viability gaps in PESTEL and sapid vying in coming future in allied clean energy counterparts' due to path breaking innovations and flexibility in the areas like solar energy, electric vehicles (EV's); bio-CNG; hydrogen fuel; hybrid vehicles (HV's); and a plug-in hybrid electric vehicles (PHEV's).In a nutshell, the study put forward two plausible scenarios: i) destructive biofuel scenario (DBS) and ii) prospective biofuel scenario (PBS). The DBS recognises shortcomings of biofuels in India from multidisciplinary perspective. Biofuel policies predicted a lot of benefits however, from its operational pragmatic and lifecycle deportment it exemplifies more convolutions than good. As a result, future political tide may turn against biofuels. As the biofuels success stories from Brazil and USA does not seem viable to replicate in India ideally considering drastic variations like conducive geography, adequate surface and ground water footprint, agricultural modernisation and policy reforms, technological advancement and defined market linkages in Brazil and USA. Therefore, it is an appropriate time for policy makers to review lopsided policies and align strategic goals recognising biofuels feasibility and sustainability gap to enable to achieve set objectives for its mainstreaming in India. Conversely (PBS) based on realistic and holistic policy approaches the future of biofuels can have a prospective scenario in India.

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Short term Effects of Low Intensity Prescribed Biomass Combustion on Soil Physicochemical Properties in Degraded Paleudult in Enugu Area Southeastern Nigeria

M.A.N. Anikwe, J.C. Eze and E.E. Ikengannyia

Department of Agronomy and Ecological Management
Enugu State University of Science and Technology, Enugu, Nigeria
E-mail: anikwema@yahoo.co.uk

Abstract: The short-term impacts of prescribed combustion of wood shavings biomass (WSB) on soil properties were examined. The experimental five treatments comprising dried wood shavings biomass were spread uniformly on the experimental plots at the rate of 0, 12.5, 25, 37.5, and 50 tons ha^{-1}. The WSB was burned *in situ* to produce different fire intensities. The soil temperature in plots amended with prescribed wood shavings biomass of 50 kg ha^{-1} was higher than that in other plots by 18-26%, respectively, at both soil depths. The highest bulk density (1.59 and 1.62 Mg m^{-3}) were in plots amended with 50 t ha^{-1} wood shavings biomass, and was higher than other. Soil saturated hydraulic conductivity in the plots amended with 37.5 and 50 t ha^{-1} wood shavings biomass was lower) than that of the other plots by 33% in both soil depths. The volumetric water content and soil water droplet penetration time decreased with burn severity. In contrast, soil pH, soil organic carbon, total nitrogen, exchangeable potassium, calcium, and magnesium and available phosphorus increased with burn severity by between 5-66%, respectively, after biomass burning at the rates applied. During low intensity prescribed fires, volatile constituents of soil organic carbon are not entirely incinerated at soil temperatures <50°C, and the quantity of SOC at the surface in the short run determines the percent SOC and other nutrients available in the topsoil.

***Keywords*:** Prescribed fire, Biomass burning, Soil properties, Degraded Ultisols, Southeastern Nigeria

Fire occurs naturally and causes a disturbance in the ecology of many landscapes. Humans have also deliberately used fires to modify the ecosystem globally. In southeastern Nigeria and some parts of Asia and South America, it is a common practice for farmers to use slash and burn agriculture for land clearing for different purposes. During this process, high and low-intensity fires are generated from biomass burning. Several physical, chemical, mineralogical, and biological soil properties can be affected by biomass burning as a method of land clearing for crop production as practiced for centuries in Southeastern Nigeria and other parts of the world. As noted by Neff et al (2005) and Edem et al (2012), the invention of deliberate fire ignition and its control by man started the anthropogenic modification of the zone of life on earth. DeBano et al (1998) placed prescribed fire conditions as generally low fire severity situations that are depicted on the lower portion of the fire severity and resource response curve. These situations are usually characterized by higher soil moisture burning conditions, where biomass loading is low, and fuel moisture can be elevated with higher relative humidity and lower air temperature. These conditions produce lower fire intensities that lead to lower fire severity and reduced possibility for the destruction of soil and water resources.

Climate, vegetation, and relief of the burnt area control the flexibility of the soil system; some fire-induced changes can even be perpetual. Low to moderate severity fires, as those prescribed in forest management; promote the renovation of the dominant vegetation through the elimination of undesired species and transient elevation of pH and available nutrients. No permanent ecosystem modification occurs, but the enhancement of water repellency reduces the ability of the soil to absorb water and make them prone to erosion. However, if plants succeed in promptly recolonizing the burnt area, the pre-fire level of most characteristics can be recovered and even enhanced. Sometimes, fires cause permanent and irreversible changes in the soil. Intense fires, including controlled fires, leave more negative effects on different soil characteristics (Rab 1996). Biomass burning can as well lead to loss of ecosystem functions in the soil (Anikwe and Ubochi 2007), and these impacts can have damaging effects on the water and air environments as well as soil productivity concerning crop yield (Anikwe 2006). However, its impacts on soil quality are not accurately surveyed or routinely monitored, and hence, effects on short term sustainability are generally not well understood. The short-term effects of concentrated biomass burning on soils need to be better understood, and the excellent understanding of the impact of fire on soil physicochemical properties is required for terrestrial fire management, especially in fire-dependent systems. This research will drive the development of a model to help farm planners, managers, and decision-makers understand the spectrum of watershed responses to fire severity primarily as it affects soil physicochemical quality in a low intensity prescribed fire situation on a short run. The primary objective of this work is to examine the short-term effect of prescribed biomass burning on soil physicochemical properties in a Typic paleudult in the Enugu area southeastern Nigeria. The study specifically aims to explore the effects of prescribed biomass burning on some soil physical properties viz. soil temperature, bulk density, soil volumetric water content, soil hydrophobicity and saturated hydraulic conductivity of a Typic paleudult; investigate the effect prescribed biomass burning on some soil chemical properties viz. soil organic carbon content, total nitrogen, soil pH, Ca, Mg, P, K, cation exchange capacity; and determine the relationship between soil temperature and some physical and chemical parameters as influenced by prescribed biomass burning.

MATERIAL AND METHODS

Soil characterization: This research was carried out for two consecutive seasons (2016 and 2017) at Enugu State University of Science and Technology, Nigeria. The area lies between latitude 06^0 52' N and 07^0 15' E; mean elevation 450 m above sea level. It has an annual rainfall of 1700-2010 mm. The area has a bimodal rainfall pattern spanning between April and October, while the dry season is between November and March. The experimental site has been left fallow for three years. The site was overgrown by *Mimosa pudica* and *Calopogonium mucuniodes* with other species like *Imperata cylindrica, Ageratum conyzoides*, and few others. The soil is of sandy loam textural class. It has an isohyperthermic soil temperature regime and is classified as Typic Paleudult (Anikwe and Ubochi 2007).

Field methods*:* The site was ploughed and harrowed using a tractor. The total land area of 25 m × 23.5 m (587.5 m^2) divided into 20 experimental units of 4 m × 3 m (12 m^2) with 2.5 m alley was marked out using a randomized complete block design having 5 treatments and replicated 4 times. The experimental beds (raised sunken beds, 30 cm high) were prepared manually with traditional hoes before the application of the treatments. The treatments [dried wood shavings] collected from the Enugu timber processing market were dried, weighed, and applied uniformly on the respective experimental plots at the rate of 0, 12.5, 25, 37.5 and 50 tons ha^{-1} and burnt to produce different fire intensities.

Determination of soil parameters*:* Soil temperature measurements were taken simultaneously from 2 points in each plot at 0-15 and 15-30 cm soil depth using a soil thermometer at 0 hours (immediately after complete combustion). The determination of hydrophobicity was performed by determining the presence of water repellency in the field using a water droplet penetration time (WDPT) test (Dekker et al 2009). Two undisturbed core samples and two auger samples were collected from each plot 48 hours after combustion for laboratory analysis. The soil core samples, collected using 100 cm^3 cores, were analyzed separately and mean results used, whereas the auger samples were mixed, and a composite subsample was taken for analysis. The samples were analyzed in Department of Soil Science, the University of Nigeria Nsukka for bulk density, total porosity, hydraulic conductivity, particle size distribution, volumetric water content, soil organic carbon content, pH in water, total nitrogen, available P, cation exchange capacity, available P, exchangeable K, Mg, Ca and base saturation. Total N was analyzed using the macro Kjeldahl method (Bremner and Mulvaney 1982). Available P was analyzed using the Bray II method (Olsen and Sommers 1982), and soil organic carbon (SOC) was analyzed by the Walkley/Black procedure (Nelson and Sommers 1982). Soil pH in water was measured by the glass electrode pH meter (McLean 1982). The exchangeable cations plus cation exchange capacity (CEC) were analyzed by the method described by Thomas (1982). Particle size distribution was analyzed by the hydrometer method of Gee and Orr, 2002. The soil dry bulk density was estimated by the core method (Grossman and Reinsch 2002). Total porosity was determined from bulk density data. Saturated hydraulic conductivity (Ksat) was derived using the technique of Klute and Dirksen (1986).

RESULTS AND DISCUSSION

Initial soil properties*:* The textural class of the study site is loamy sand with isohyperthermic soil temperature regime. Soil temperature measured at 12.0 hours was 29.25-30°C for both years (Table 1). The initial soil dry bulk density was 1.35 and 1.40 Mg m^{-3} and is within the dry bulk density range classified as ideal bulk density in the general relationship between soil bulk density and root growth based on soil texture (Arshad et al 1996). The soil total porosity and saturated hydraulic conductivity (Ksat) ranged between 47-49% and 38-39 cm hr^{-1}, respectively. The Ksat is classed as very high. The volumetric water content and soil water droplet penetration time (a measure of soil hydrophobicity) were 27-29 cm^3 and 0.28-0.30 mins, respectively. The soil pH in water was 5.52 in both years, indicating 'strongly acidic'. The exchangeable cations content of the soil in 2016 were (Mg^{2+} 1.305, K^+ 0.043, Ca^{+2} 2.2, Na^+ 0.17 and CEC 6.075 cmol kg^{-1}) whereas the values obtained in 2017 were (Mg^{2+} 1.270, K+ 0.055, Ca^{+2} 2.4, Na^+ 0.17 and CEC 5.560 cmol kg^{-1}).

Percentage organic carbon (1.12-1.16 %) is moderate, indicating values within critical levels for the study area, whereas nitrogen content of the soil is also low (0.056 %).

Effects of prescribed biomass burning on soil temperature: The prescribed combustion of the wood shavings significantly influenced the soil temperature in the amended plots relative to the control (unamended plots) (Table 2). The highest soil temperature (39.75 and 34.5°C) was found in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 and 15-30 cm soil depth, respectively, in the first year of the experiment. The soil temperature in these plots was higher (p=0.05) than the soil temperature of the control plots (unburnt plots), plots with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by 19-26, 18-20, 15-19 and 1.0%, respectively in the 0-15 and 15-30 cm soil depth in the first year. In the second year of study, the results followed the same trend. The highest soil temperature (43.25 and 36.0°C) was recorded in plots amended with 50 kg ha^{-1} wood shavings biomass at 0-15 and 15-30 cm soil depth, respectively. The soil temperature in was higher (p=0.05) than the soil temperature of the control plots (unburnt plots), plots with prescribed combustion at 12.5, 25.0 and 37.5 kgha^{-1} wood shavings biomass by 18-31, 17-24 %, 13-19 and 7-16%, respectively in the 0-15 and 15-30 cm soil depth.

Table 1. Initial soil properties of the study sites collected at 0-30 cm depth

Soil parameter	2016	2017
Soil temperature (°C)	29.25 ± 0.13	30.00 ± 0.42
Bulk density (g cm^{-3})	1.35 ± 0.04	1.40 ± 0.02
Total porosity (%)	49.44 ± 0.66	47.46 ± 0.03
Hydraulic conductivity (kcm^{3} hr^{-1})	39.90 ± 0.26	38.13 ± 0.63
Moisture content (cm^{2} cm^{-3})	27.04 ± 0.11	29.04 ± 0.91
Soil water penetration time (mins)	0.30 ± 0.02	0.28 ± 0.04
Soil pH	5.525 ± 0.31	5.525 ± 0.21
SOC (%)	1.245 ± 0.28	1.160 ± 0.45
TN (%)	0.056 ± 0.002	0.056 ± 0.03
Ave. P (Cmol kg^{-1})	7.580 ± 0.26	7.630 ± 0.41
Exch. K (Cmol kg^{-1})	0.043 ± 0.004	0.055 ± 0.003
Exch. Ca (Cmol kg^{-1})	2.220 ± 0.34	2.430 ± 0.51
Mg (Cmol kg^{-1})	1.305 ± 0.51	1.270 ± 0.31

The prescribed fire under the condition of this experiment behaved like a typical grass fire. They are fast-moving and wind-driven, may be substantial, and have a narrow flame front. The amount of biomass available for burning in grasslands is usually much less than that found in brush lands and forests. Because of this, soil heating is substantially less reduced during exterior or smoldering fires (DeBano et al 2005).

The significant concomitant changes in soil temperature at different rates of wood shavings application depict that biomass combustion at the prescribed rates increased the heat energy released during flaming combustion (fire intensity) and resulted in the recorded varying degrees of soil temperature achieved. This implied that fire severity, a measure of a fire's impact on the ecosystem (during prescribed or uncontrolled wildfires depends on the quantity and quality of the biomass, and other factors within the ecosystem. Keeley (2009) postulated that a well-established requirement by resource managers has been how to use different patterns of fire intensity as an antecedent for pre-empting post-fire effects. As the intensity of fires is often not known for most wildfires, fire and burn severity measures are typically used for such predictions. The highest soil temperature increase of between 34-43°C was achieved at the highest rate of wood shavings application (50 t ha^{-1}) in both years. Ghuman and Lal (1989) collected dried biomass in four windrows 10 m wide and 50 m long in a 1-ha plot. Each windrow contained 494 kg m^{-2} of fuel that formed a 30-50 mm thick layer of ash on the surface after burning. During burning, the maximum soil temperatures rose to 218, 150, 104, and 70°C at 1, 5, 10, and 20-cm depths, respectively. These results allude to the fact that the quantity and quality of

Table 2. Effects of prescribed biomass burning on soil temperature and soil bulk density

Soil property	Soil temperature (°C)				Bulk density (g cm^{-3})			
	Year 1		Year 2		Year 1		Year 2	
Biomass (t ha^{-1})	0-15 cm	16-30 cm	0-15 cm	16-30 cm	0-15 cm	16-30 cm	0-15 cm	16-30 cm
0	29.25	28.00	30.00	29.50	1.3450	1.4150	1.3975	1.5650
12.5	31.75	28.25	33.00	29.75	1.5050	1.5500	1.5325	1.5725
25.0	32.00	29.50	35.00	31.00	1.5275	1.5850	1.5725	1.6450
37.5	36.00	31.00	36.25	33.50	1.5325	1.6000	1.5750	1.6450
50.0	39.75	34.50	43.25	36.00	1.5900	1.6200	1.6300	1.6650
CD (p=0.05)	1.234	1.242	2.033	1.420	0.022	0.024	0.035	0.06

the biomass in a particular ecosystem greatly influence the intensity and severity of the impact of prescribed fire on soil temperature. DeBano et al (2005) observed that some of the critical physical attributes of soil that are influenced by soil heating are texture, clay content, soil structure, bulk density, and pore size distribution. Physical qualities such as wettability and structure are altered at relatively low temperatures, while quartz sand content that contributes to texture is influenced only at very high soil temperatures.

Effects of prescribed biomass burning on soil bulk density*:* The prescribed combustion of the wood shavings significantly influenced the soil bulk density in the amended plots relative to the control (Table 2). The highest soil dry bulk density (1.59 and 1.62 Mg m^{-3}) were in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 and 16-30 cm soil depth, respectively, in the first year of the experiment. The recorded soil dry bulk density in the plots amended with 50 t ha^{-1} wood shavings biomass were higher (p=0.05) than soil dry bulk density of the control plots, plots with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by 12.9, 4.3-5.6, 1.2-4.4 and 1.2-5.6%, respectively in the 0-15 and 16-30 cm soil depth in the first year. In the second year of study, the results followed the same trend. The highest soil dry bulk density (1.63 and 1.66 Mg m^{-3}) were in plots amended with 50 tha^{-1}wood shavings biomass at 0-15 and 16-30 cm soil depth, respectively. The soil dry bulk density in the plots amended with 50 tha^{-1}wood shavings biomass was higher (p=0.05) than soil dry bulk density of the control plots (unburnt plots), plots with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by 6.02-14.7, 5.42-6.13, 1.20-3.62 and 1.20-3.68, respectively in the 0-15 and 16-30 cm soil depth. The results of this study depict that bulk density (BD) increased with burn severity in the experimental plots. Minimal changes in bulk density occurred at low-intensity burn severity, but bulk density increased as fire severity increased to high and medium levels. This might be because of the breakdown of voids and the destruction of organic matter with increased fire severity. Badia and Marti (2003) and DeBano et al 2005) asserted that the relative increment in soil bulk density after a fire is attributable to the destruction of the structures and pores within the soil profile. Seymour and Tecle (2004) found that high-severity fire in Ponderosa pine (*Pinus ponderosa*) forests resulted in the destruction of soil aggregate structure and an increase in the bulk density in the surface horizons. Certini (2005) reported that bulk density increased because of the destruction of aggregates and clogging of pores by the ash and deflocculated clay minerals; as a consequence, soil porosity and permeability diminished. Soil densification increases with ash depth (Cerdà and Doerr 2008). Boerner et al (2009) showed that the bulk density of forest soils increased significantly as a result of the forest fire. This, however, is in agreement with the finding of this research. The increase in soil dry bulk density may lead to constriction of voids, restriction of air, water, and by extension, nutrient movement in the soil, among other detrimental effects.

Effects of prescribed biomass burning on soil total porosity: There was an inverse relationship with bulk density and showed a significant variation in the total porosity of burned and unburned plots (Table 3). Lowest soil total porosity was recorded in plots with prescribed biomass burning of 50 t ha^{-1} wood shavings (40.23 and 38.72%). This was followed by plots with prescribed biomass burning of 37.5 t ha^{-1} wood shavings. The total porosity of plots with prescribed biomass burning of 25 t ha^{-1} wood shavings was relatively higher than the previous by 0.18 and 0.09%, which, however, was lower than the pore spaces of plots with prescribed biomass burning of 12.5 tha^{-1}wood shavings by 0.85 and 1.51%. Control plots recorded the highest porosity (49.44 and 47.46%) in both years. This is following the findings of Eden et al (2013), which stated that there was a 10% decrease in total porosity after burning. This observation affirmed the report of reduction in larger pores and total porosity following burning and ascribed it to the ash deposits in the larger pores. The decrease in total porosity can also be attributed to the increase in bulk density.

Table 3. Effects of prescribed biomass burning on soil total porosity and saturated hydraulic conductivity

Biomass (t ha^{-1})	Soil total porosity (%)				Ksat ($cmhr^{-1}$)			
	Year 1		Year 2		Year 1		Year 2	
	0-15 cm	16-30 cm	0-15 cm	16-30 cm	0-15 cm	16-30 cm	0-15 cm	16-30 cm
0	49.44	46.81	47.46	41.17	39.90	38.91	38.13	37.63
12.5	43.42	41.78	42.39	40.89	35.60	35.98	35.74	34.10
25.0	42.57	40.41	40.88	39.10	35.45	32.94	33.98	29.55
37.5	42.39	39.85	40.79	38.16	31.05	26.62	30.56	27.23
50.0	40.23	39.10	38.72	37.41	32.24	29.06	29.83	25.69
CD (p=0.05)	0.823	0.888	1.311	0.936	2.524	4.100	1.796	0.820

Ayotamuno et al (2006) and Certini (2005) observed that biomass burning causes significant removal of organic matter, deterioration of both structure and porosity, considerable loss of nutrients through volatilization, entrapment of ash in smoke columns, erosion and leaching. It also causes a marked obliteration of both quantity and species composition of microbial and soil-dwelling invertebrate communities. This, however, validates the alteration in the soil porosity of the burned plots in this study. These changes in organic matter reduce the total porosity and pore sizes. Destruction of macropores in the upper layers of the soil decreases infiltration rates and leads to surficial erosion. Distortion of soil organic matter content can also result in a water repellent soil condition, which leads to a reduction in infiltration rates. The collapse in soil structure diminishes soil porosity (mainly macropores), and the soil surface is compacted further by raindrops impact energy when surface soil particles and ash are displaced, leading to surface sealing. Finally, the impervious soil surface reduces infiltration rates into the soil and produces rapid runoff and hill slope erosion.

Effects of prescribed biomass burning on soil saturated hydraulic conductivity (Ksat): The combustion of the wood shavings significantly influenced the soil saturated hydraulic conductivity (Ksat) in the amended plots relative to the control (Table 3). The lowest soil Ksat (26.62-32.24 cm hr^{-1}) were in plots amended with 37.5 and 50 t ha^{-1} wood shavings biomass at 0-15 and 16-30 cm soil depth, respectively in the first year of the experiment. The soil Ksat in the plots amended with 37.5 and 50 tha^{-1} wood shavings biomass was lower than soil Ksat of the control plots; plots with prescribed combustion at 12.5, and 25.0 kg ha^{-1} wood shavings biomass by 17.4% in the 0-15 and 16-30 cm soil depth in the first year. In the second year, the results followed the same trend. Neary et al (2005) demonstrated that fire exerts a tremendous influence on the hydrologic conditions of watersheds in many ecosystems in the world, depending on a fire's severity, duration, geomorphic conditions, and frequency. Ksat reductions are often implicated as a significant factor affecting base flow and storm flow responses of burned watersheds. Results from this work show that fire severity plays a vital role in some of these reductions. Neary (2011) concluded that related severity reductions in Ksat were measured in coniferous forests, and the results showed Ksat reductions of 20 to 48%. In contrast, Blake et al (2009) also noted Ksat reductions of 88 to 92% with high severity wildfire. Loss of surface organic horizons during fire causes significant Ksat reductions. Besides, high severity fires transmit large amounts of heat into the soil that often produce breakdowns in soil structure, leading to macropore size decreases and concomitant Ksat rate declines.

Effects of prescribed biomass burning on soil volumetric water content: The recorded soil volumetric water content in the plots amended with 50 t ha^{-1} wood shavings biomass (27.04 and 20.86 cm^3 cm^{-3}) was lower (p=0.05) than in the control plots, plots with prescribed combustion at 25.0 and 37.5 kg t ha^{-1} wood shavings biomass by 5.7 -14.24 cm^3cm^{-3} and 12.00-26.55 cm^3cm^{-3} respectively in the 0-15 and 16-30 cm soil depth in the first year (Table 4). In the second year of study, the results followed the same trend. The results of this study depict that volumetric water content decreased with burn severity in the experimental plots. Verma and Jayakumar (2012) stated that the significant effect of fire on soil physical attributes is to remove the soil water storage capacity in the horizons of organic matter accumulation near the surface.

Effects of prescribed biomass burning on soil water droplet penetration time (minutes): The prescribed combustion of the wood shavings significantly influenced the soil water droplet penetration time (mins) in the amended plots relative to the control (Table 4). The highest soil water droplet penetration time (0.53 mins) were in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 cm soil depth in the first year. The soil water droplet penetration time in these plots was higher than the soil water droplet penetration time

Table 4. Effects of prescribed biomass burning on soil volumetric water content and water droplet penetration

Soil property	Soil volumetric water content (cm^3)				Water droplet penetration time (mints)			
	Year 1		Year 2		Year 1		Year 2	
Biomass (t ha^{-1})	0-15 cm	16-30 cm	0-15 cm	16-30 cm	0-15 cm	16-30 cm	0-15 cm	16-30 cm
0	27.04	20.86	29.04	19.98	0.30	0.10	0.28	0.10
12.5	26.68	21.07	28.16	18.87	0.35	0.10	0.58	0.10
25.0	25.50	18.32	27.51	16.10	0.43	0.10	1.30	0.10
37.5	24.96	17.52	26.10	15.01	0.45	0.10	0.43	0.10
50.0	23.19	15.32	25.31	13.56	0.53	0.10	0.70	0.10
CD (p=0.05)	1.337	1.127	3.000	0.530	0.02	-	0.03	-

of the control plots, with prescribed combustion at 12.5, 25.0 and, 37.5 kg ha^{-1} wood shavings biomass by 43.4, 34, 19% and 15% respectively in the 0-15 cm soil depth in the first year. In the second year of study, the results followed the same trend. The highest soil water droplet penetration time (0.28 mins) was in plots amended with 50 kg ha^{-1} wood shavings biomass at 0-15 cm soil depth, respectively. The recorded soil water droplet penetration time in these plots was higher than the soil water droplet penetration time of the control plots (plots with prescribed combustion at 12.5-25.0 and 37.5 kg ha^{-1} wood shavings biomass) by 86, 57 and 55%, respectively in the 0-15 cm soil depth. No significant treatment differences in soil water penetration time were found at the 16-30 cm soil layer in both years. The results of the study imply a water repellency index category of slightly water repellent for all the treatments and the control.

In practice, water droplet penetration times are not evaluated beyond 10 minutes. A repellency index value > 10 indicates an extremely water repellent soil; 1 to 10 is moderately water repellent; 0.1 to 1, is slightly water repellent; and less than 0.1 is wettable (Dekker et al. 2009). This means that prescribed combustion of the wood shavings at the rates applied generated insufficient soil temperature to induce water repellency in the study soil. High surface temperatures 'burn' off organic components and produce vapours that move down the soil in response to a temperature gradient. The vapour then condenses on soil particles and cause them to become water repellent (Letey 2001). There were no differences in soil water droplet penetration time at the 16-30 cm soil layer. This may be because induced water repellency decreases with depth. It is most active at the soil surface in areas combusted at high and moderate severity and reduces in strength with a decrease in burn severity and an increase in depth (MacDonald and Huffman 2004). Huffman et al (2000) observed that the depth of the water-repellent front is usually due to heating and the characteristics of the soil, such as moisture and particle-size distribution. Portions of water-repellent soil repeatedly occur with portions of permeable soil, usually due to irregular patterns of the severity of fires (Martin and Moody 2001).

Effects of prescribed biomass burning on soil pH in water: The results show that the prescribed combustion of the wood shavings significantly influenced the soil pH in water in the amended plots relative to the control (Table 5). The highest soil pH in water (7.17) were recorded in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 and 16-30 cm soil depth respectively in the first and second years of the experiment. The recorded soil pH in water in the plots amended with 50 t ha^{-1} wood shavings biomass was higher than soil pH in water of the control plots, plots with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by 21 and 18, 7 and 2, 5 and 2 and 2 and 1%, respectively in the 0-15 and 16-30 cm soil depth in the first and second years. The soil acidity reduced progressively with increase in the burn severity. The reduced acidity can be ascribed to the liming effect of ash from the burned biomass. Wood ash is known to have a liming effect on soil hence increases the pH of the soil. Knoepp et al (2005) concluded

Table 5. Effects of prescribed biomass burning on soil chemical properties

Treatment	Prescribed biomass (ton ha^{-1})					CD (p=0.05)
	0	12.5	25	37.5	50	
Soil pH	5.525	6.650	6.825	6.975	7.175	0.0954
	*5.525	6.550	6.550	6.650	6.750	0.1553
SOC (%)	1.245	1.333	1.587	2.280	3.680	0.1061
	*1.160	1.257	1.527	2.190	2.900	0.3170
TN (%)	0.056	0.063	0.086	0.115	0.160	0.0254
	*0.056	0.069	0.078	0.090	0.141	0.0198
Av. P (Cmol kg^{-1})	7.580	8.190	8.690	9.660	11.270	0.7270
	*7.630	7.730	8.650	9.960	11.130	1.0680
Exch. K (Cmol kg^{-1})	0.043	0.051	0.051	0.053	0.053	0.0166
	*0.055	0.050	0.053	0.058	0.058	0.0131
Exch. Ca (Cmol kg^{-1})	2.220	2.940	3.530	5.090	5.370	0.5553
	*2.430	2.250	3.260	3.680	5.070	0.9050
Mg (Cmol kg^{-1})	1.305	1.400	1.640	1.673	1.820	0.1488
	*1.270	1.320	1.393	1.435	1.600	0.1261

First year = 0000; Second year = *0000; TN = Total Nitrogen; CEC = Cation Exchange Capacity; SOC = Soil Organic Carbon; Ave P = Available Phosphorus; Exch. K = Exchangeable Potassium that the combustion of organic matter during a fire leads to the release of soluble cations, which results in slight increases in soil pH. The soil heating inexorably increases soil pH as a result of organic acid denaturation. However, the result did not entirely agree with the findings of Arocena and Opio (2003) who stated that significant increases occur only at high temperatures (>450-500°C), rather significant increase at a temperature lower than this, as a result of a coincidence of the complete combustion of fuel and the consequent release of bases that also leads to an enhancement of base saturation.

Effects of prescribed biomass burning on soil organic carbon content: The prescribed combustion of the wood shavings significantly influenced the soil organic carbon content in the amended plots relative to the control (Table 5). The highest soil organic carbon content (3.68 and 2.90%) was recorded in plots amended with 50 t ha^{-1} wood. The recorded soil organic carbon content in the plots amended with 50 t ha^{-1} wood shavings biomass was higher than soil organic carbon content of the control plots (with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by 21 and 18%, 7 and 2%, 5 and 2% and 2 and 1%, respectively in the 0-15 and 16-30 cm soil depth in the first and second years. These results imply that soil organic matter content increased with burn severity relative to quantity available during low energy prescribed fires. According to Knoepp et al (2005), fire affects the organic matter by directly altering its chemical composition and indirectly by reducing the organic matter decomposition rates. However, the magnitude of the effect depends on burn severity, i.e., whether the severity is low, moderate, or high. They reported that changes in organic matter during heating showed that losses of organic matter could occur at temperatures below 100°C. In contrast, volatile constituents in organic matter are lost at temperatures up to 200°C). Destructive distillation of organic matter constituents (about 85 percent of the soil organic matter) occurs at temperatures between 200 and 300°C. The result suggests that during low intensity prescribed fires, most volatile constituents of organic matter are not entirely burned at lower temperatures (< 100°C), and the quantity of organic carbon at the surface will determine the percent organic carbon available in the topsoil. Alam (2016) concluded that after a moderate wildfire, an increase of C in the soil is usually observed, suggesting substantial incorporation of forest necromass. Similarly, the effects of (low combustible biomass) fire are more effective in killing and drying than charring, i.e., resulting in soil inputs of biodegradable C-forms.

Effects of prescribed biomass burning on soil total nitrogen content: The prescribed combustion of the wood shavings significantly influenced the soil's total nitrogen content in the amended plots relative to the control (Table 5). The highest soil total nitrogen content (0.160 and 0.141 %) were recorded in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 and 16-30 cm soil depth respectively in the first and second seasons of the experiment. The soil total nitrogen content in the plots amended with 50 t ha^{-1} wood shavings biomass were higher than soil total nitrogen content of the control plots (unburnt plots). It can be deduced from this work that percent total nitrogen increased significantly with an increase in the quantity of prescribed biomass and, consequently, burn severity. The increased N availability boosts post-fire plant growth and gives the impression that total N is present after a fire. The increase in soil fertility, as a result of this phenomenon, is usually temporal and misleading and can be short-lived. Any temporary increase in available N following a fire is often quickly utilized by plants within the first few days after burning.

Effects of prescribed biomass burning on soil available phosphorus content: The prescribed combustion of the wood shavings significantly influenced the soil available phosphorus content in the amended plots relative to the control) (Table 5). The highest soil available phosphorus content was recorded in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 and 16-30 cm soil depth respectively in the first and second years of the experiment. The soil available phosphorus content in the plots amended with 50 t ha^{-1} wood shavings biomass were significantly higher than soil available phosphorus content of the control plots, plots with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by 33 and 31, 27 and 31, 23 and 22 and 14 and 11%, respectively in the 0-15 and 16-30 cm soil depth in the first and second years. Soil available phosphorus increased from about 11-33% up to the highest rate of prescribed wood shavings biomass combustion. This showed that low severity fires burn out organic matter and release phosphorus to the soil. Knoepp et al (2005) observed that the combustion of organic materials leaves a large amount of available P in the surface ash on the soil surface soon after a fire. This vastly available P is usually quickly immobilized if calcareous materials are primarily present in the ash, making it unavailable for plant use. Cade-Menum et al (2000) concluded that the combustion of organic materials changes the organic pool of available soil phosphorus to orthophosphate, the sole form of P available to biota. Sharply (2000), observed the peak of P bioavailability around pH 6.5, and any fire-induced change in soil pH toward neutrality has a productive effect.

Effects of prescribed biomass burning on soil exchangeable Ca^{2+}, Mg^{2+}, and K^{+} content: The prescribed combustion of the wood shavings significantly influenced the soil exchangeable Ca^{2+}, K^{+}, and Mg^{2+} in the amended plots relative to the control (Table 5). The highest soil exchangeable Ca^{2+} content (5.370 and 5.070 cmol kg^{-1}) were recorded in plots amended with 50 t ha^{-1} wood shavings biomass at 0-15 and 16-30 cm soil depth, respectively in the first and second years of the experiment. The recorded soil exchangeable Mg^{2+} content, 1.600-1.820 cmol kg^{-1} in the plots amended with 50 t ha^{-1} wood shavings biomass was significantly higher than that in the control plots (with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by between 8-28 % in the 0-15 and 16-30 cm soil depth) in the first and second years. The recorded soil exchangeable K^{+} content in the plots amended with 50 t ha^{-1} wood shavings biomass were higher than that in the control plots, plots with prescribed combustion at 12.5, 25.0 and 37.5 kg ha^{-1} wood shavings biomass by between 0 – 19 % in the 0-15 and 16-30 cm soil depth in the first and second years. It can be deduced that soil exchangeable Ca^{2+} and Mg^{2+} content increased significantly in varying degrees with an increase in the quantity of prescribed biomass and, consequently, burn severity except for exchangeable K^{+}. Cations are not volatilized and usually remain on the site in a highly available form after low severity fires. A propensity of cations can be in the thick ash layers (or ash-bed) remaining on the soil surface depending on the severity of the fire (Knoepp et al 2005). Calcium and magnesium are the most abundant mineralogical components of ash. This justifies the art of using ash by local farmers to ameliorate either soil acidity or to improve the soil structure. Both elements are known to flocculate soil particles for enhanced porosity, aeration, and a better soil quality optimum for plant growth. Edem et al (2012) reported a similar trend where burned ash on soil surface gave rise to a higher concentration of non-combustible elements such as Ca and Mg when compared with unburned soil.

Relationship between soil temperature and some physical and chemical parameters as influenced by prescribed biomass burning: The highly significant relationship ($r = 0.7980^{**}$) between changes in soil temperature as a result of prescribed wood shavings biomass combustion rates and soil dry bulk density was observed (Table 6). This affirmed that the densification of surface soils increases with an increase in burn intensity. The unburnt soils had between 1.2-14 % less bulk density in their first and second years in both 0-15 and 16 -30 cm soil layers, although the effect was higher in the 0-15 cm soil layer. Soil total porosity measurements correlate negatively ($r = -0.799$) with soil temperature as a result of prescribed wood shavings biomass combustion rates. There was a highly significant negative relationship between changes soil temperature as a result of prescribed wood shavings biomass combustion rates and changes in soil saturated hydraulic conductivity ($r = 0.827^{**}$) and volumetric water content ($r = -0.673^{*}$) of soil. Soil organic carbon measurements correlate positively ($r = -0.799$) with soil temperature as a result of prescribed wood shavings biomass combustion rates. The significant positive relationship between changes in soil temperature as a result of prescribed wood shavings biomass combustion rates and changes in soil available phosphorus ($r = 0.927^{**}$), Mg^{+2} ($r = 0.562^{*}$, soil pH in water ($r = 0.496$) and, exchangeable calcium ($r = 0.981^{**}$) was observed. The relationship between changes in other soil properties including water droplet penetration time ($1- r^2 = 0.963$), total nitrogen ($1- r^2 = 0.961$) and exchangeable K ($1- r^2 = 0.816$) showed a high coefficient of alienation (degree of unrelatedness) with changes in soil temperature as a result of prescribed wood shavings biomass combustion rates. Heat absorption and transfers from fires in the soil increase soil temperature that affects the soil physicochemical properties. The quantum of heat produced varies significantly and can cause different effects on soil physicochemical characteristics.

Table 6. Relationship between soil temperature and some physical and chemical parameters as influenced by prescribed biomass burning

Soil parameter	r	r^2	$1-r^2$
Bulk density	0.798**	0.637	0.363
Total Porosity	-0.799**	0.638	0.362
Ksat	-0.827**	0.684	0.316
VMC	-0.673*	0.453	0.547
WDPT	-0.193	0.037	0.963
SOC	0.837**	0.701	0.299
Base Sat.	0.429	0.184	0.816
CEC	0.790**	0.624	0.376
Total Nitrogen	0.198	0.039	0.961
Available P	0.927**	0.859	0.141
Exch. K	0.429	0.184	0.816
pH	0.496	0.246	0.754
Exch. Ca	0.981**	0.962	0.038
Mg	0.562	0.316	0.684

CONCLUSIONS

The heat energy generated during the combustion of biomass provides the driving force that causes a modification of soil properties during a fire. Short-term changes in soil properties after combustion viz. soil temperature, bulk density (BD), volumetric water content (VWC), soil water penetration time (WDPT), saturated hydraulic conductivity

(Ksat), organic carbon content (SOC), total nitrogen (TN), soil pH, Ca, Mg, P, and K were observed at 0-15 and 16-30 cm soil depth was observed. The significant concomitant changes in soil temperature at different rates of wood shavings application depict that biomass combustion at the prescribed rates increased the heat energy released during flaming combustion (fire intensity) and resulted in the recorded varying degrees of soil temperature achieved. This implied that fire severity, a measure of a fire's impact on the ecosystem during prescribed fires, depending on the quantity and quality of the biomass, and other factors within the ecosystem. The prescribed fires depending on severity destroys soil structure and increases soil densification because of the destruction of soil organic matter, which stores nutrients and binds the soil together. However, during low intensity prescribed fires, most volatile constituents of organic matter are not entirely incinerated at lower temperatures (< 100°C), and the quantity and quality of organic carbon at the surface on the short run will determine the percent organic carbon and other nutrients available in the topsoil. The heat energy generated during the combustion of biomass and vagaries of soil condition controls the dynamics of soil physicochemical changes during a fire.

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Influence of Chemical Fruit Thinning on Thinning Level, Fruit Yield and Quality in Nectarine cv. May Fire

Rimpika and N. Sharma

Department of Fruit Science, Dr Y S Parmar University of Horticulture and Forestry, Nauni-173 230, India
E-mail: rimpikathakur1989@gmail.com

Abstract: The present investigations were carried out on 12-year old trees of nectarine cultivar May Fire raised on wild peach seedling rootstocks during 2014 and 2015. Experimental trees were subjected to nine different treatments NAA at 40 and 60 ppm; Ethrel at 200 and 300 ppm applied one and two week after petal fall at 40 ppm when applied two weeks after petal fall resulted insignificantly higher thinning, decreased yield and increased fruit size and weight over the control. Fruit TSS, and total sugar contents were higher and fruit acidity and firmness were lower in the fruits from trees treated with NAA at 60 ppm when applied two weeks after petal fall. Fruit surface colouration was higher in fruits from trees treated with Ethrelat300 ppm, two weeks after petal fall Fruit thinning percentage, yield, fruit size, fruit weight, fruit colouration, fruit TSS and total sugar contents were significantly lower and fruit firmness higher in control as compared to all the chemical thinning treatments.

***Keywords*:** Thinning, NAA, Ethrel, quality, Yield, May fire

Nectarines [*Prunus persica* (L.) Batsch var. *nucipersica*] belong to the Rosaceae family and are thought to have originated in China. It was probably carried from China to Persia, Greece and Rome. These are fuzzless peaches due to a character attained upon genetic mutation in a tree that would otherwise produce what we call peach having fuzzy skin. May Fire is one of the most important among the different cultivars of nectarine grown in the state and its fruit is an early maturing, attractive coloured, medium sized; having smooth skin of green to white with deep red over colour. Area under this cultivar is increasing rapidly due to higher price in the market. Some quality parameters are very important for profitable nectarine production and foremost being the large sized fruit which has strong market demand. Nectarines however, invariably bear excessively, resulting in the production of small sized fruits, which are relatively less remunerative. Fruit thinning is an important cultural practice to remove excessive fruitlets from trees and is one of the most effective measures to improve fruit size, and next season's flower bud initiation, colour and quality at harvest. Chemical thinners, such as naphthalene acetic acid (NAA) and ethephon can effectively thin fruits when applied at a fruit diameter of 14-15 mm (Rimpika et al 2015). However, chemical thinning results are extremely variable and very difficult to predict or control because of an incomplete understanding of the modes of action of chemical thinners as well as their interactions among (concentration, environmental condition and cultivar response) which affect thinning effectiveness. Environmental conditions, particularly temperature and light intensity, may impact the efficacy of chemical thinners. Low temperature following application results in a poor fruit abscission response whereas; high temperature may lead to over-thinning or excessive leaf abscission. Therefore the present investigation on fruit thinning of nectarine was undertaken at two different locations to study the influence of climatic conditions on the efficacy of thinning agents.

MATERIAL AND METHODS

The present investigations were undertaken on bearing trees of nectarine cultivar May Fire raised on wild peach seedling rootstocks at the experimental orchard of Horticulture Research Station, Kandaghat, Solan and Farmer's orchard at Kotla, Barog, Sirmour during the 2014 and 2015. Kandaghat and Kotla, Barog are located at the altitude of 1425 m and 1245 m amsl, respectively and trees at these sites had were planted at a spacing of 3×3 meters and trained as open centres. Twenty seven trees were selected at each location on the basis of uniform vigour and kept under uniform cultural practices during the entire course of investigation. There were nine treatments in (Table 1). Observations on maximum and minimum temperatures and average relative humidity were recorded starting from one week after petal fall i.e. time of first application of different treatments (1 WAPF) for 14 days i.e. up to 7 days after second application of different treatments (2 WAPF) with the pre-installed EL-USB self-recording data loggers at both the sites. Per cent fruit thinning was calculated. The fruit retained after thinning were taken as yield. Fruit size in terms of length and breadth of ten randomly selected fruits per replication was recorded with a Digital calliper. Fruit breadth was worked out by averaging the values of cheek and suture diameter which had been recorded separately. The selected fruits taken for the fruit size data were weighed and the average fruit weight was expressed in gram per fruit (g fruit^{-1}). The fruit firmness was determined by Effegi penetrometer (Model FT-327) which recorded the pressure necessary for the plunger to penetrate the flesh of nectarine fruits.Skin colour of randomly selected fruits was determined as per 4 point scale (< 25% colour =1; 25 - 49%colour = 2; 50 – 74% colour = 3 and >75 % colour = 4). The total soluble solids content in fruits were determined by Erma hand refractometer (0-32° Brix) and .Total sugars by volumetric method (AOAC 1980).The total titratable acidity was calculated in terms of malic acid on the basis of one ml of 0.1 N NaOH equivalents to 0.0067 g of anhydrous malic acid (AOAC 1980).

RESULTS AND DISCUSSION

The NAA at 40 ppm when applied 2 weeks after petal fall induced significantly higher fruit thinning at Kandaghat in the in 2014 and at Kotla, Barog in 2015 in comparison to all other treatments (Table 1). However, statistically were at par with Ethrel at 300 ppm applied 2 weeks after petal fall at Kandaghat at during 2015 and at Kotla, Barog during 2014. Data reveal that different plant growth regulator treatments were more effective in inducing fruit abscission in 2014 as compared to 2015.Fruit thinning effect of NAA is predictable (Sharma et al 2003, Rimpika et al 2015), however, inconsistency in thinning level during study period may be attributed to weather conditions at the time of application and immediately thereafter. Environmental conditions, particularly temperature and relative humidity, may have impacted the efficacy of chemical thinners. During 2015, poor fruit abscission response under different plant growth treatments can be attributed to a sharp drop in average temperature after application (19.5 to 13.7°C at Kandaghat and 20.5 to 15°C at Kotla, Barog). Under warm weather conditions, NAA (Robinson and Lakso 2004) and ethephon (Clever 2007) seems to be successful thinning agents, however, results are not always predictable and consistent (Webster and Spencer 2000). Widmer et al (2008) observed that post bloom application of ethephon induced higher thinning when temperature ranges between 18 to 22°C. The effects of plant growth regulator on fruit abscission were more pronounced at Kandaghat where average day temperatures were lower (24.0 and 20.4°C in 2014 and 2015), and average RH higher (53.3 and 66% in 2014 and 2015, respectively) in comparison to Kotla, Barog (27.8 and 25°C day temperature in 2014 and 2015, respectively; 54.1 and 57.3% RH in 2014 & 2015, respectively). The present results demonstrate that chemical thinners seem to be more effective at optimum temperature range; too low or too high temperature lessened effectiveness. The present results are also in conformity with findings of Cline and Bijl (2002) that NAA induced greater abscission at temperature between 20-25°C and higher relative humidity.

That the different thinning treatments significantly decreased the fruit yield in comparison to control, however greatest reduction in yield was in T_5(which was statistically at par with the treatments T_4,T_6 and T_7in 2014 (Table 2). Average fruit yield was higher in the year 2015 compared to 2014 irrespective of locations. Decrease in fruit yield under different plant growth regulator treatments may be the direct result of reduction in crop load due to thinning of fruits. The results are in conformity with the earlier findings that fruit thinning with NAA lead to a decrease in average yield and

Table 1. Effect of different treatments on fruit thinning in nectarine cv. May Fire

Treatment	Fruit thinning (%)			
	Kandaghat		Kotla, Barog	
	2014	2015	2014	2015
T_1 NAA 40 ppm,1 week after PF	42.04 (40.42)	31.86 (34.34)	38.24 (38.20)	30.53 (33.49)
T_2 NAA 60 ppm, 1 week after PF	39.86 (39.14)	30.59 (33.53)	35.29 (36.43)	27.80 (31.80)
T_3 Ethrel 200 ppm,1 week after PF	37.39 (37.69)	27.68 (31.72)	30.20 (33.29)	25.63 (30.39)
T_4 Ethrel 300 ppm, 1 week after PF	40.07 (39.25)	26.55 (30.97)	35.79 (36.71)	25.63 (30.39)
T_5 NAA 40 ppm, 2 week after PF	59.33 (50.40)	42.37 (40.61)	50.95 (45.55)	40.27 (41.70)
T_6 NAA 60 ppm, 2 week after PF	52.26 (46.30)	38.18 (38.16)	43.42 (41.22)	37.42 (37.71)
T_7 Ethrel 200 ppm, 2 week after PF	50.94 (45.54)	35.88 (36.77)	41.29 (39.97)	32.79 (34.93)
T_8 Ethrel 300 ppm, 2 week after PF	54.39 (47.53)	40.59 (39.56)	46.25 (42.85)	39.03 (38.66)
T_9 Control (No thinning) Mean	15.51 (23.01)	12.49 (20.61)	16.58 (24.00)	15.20 (22.88)
CD (p=0.05)	(2.49)	(1.12)	(3.09)	(1.81)

Figures in the parentheses are arc sine transformed values increase in the production of marketable fruits in peach (Sharma et al 2003) and nectarine (Rimpika et al 2015). Average fruit size in terms of length and breadth was significantly higher in in comparison to control, in at both locations (Table 2). However, statistically at par with all other the thinning treatments, which were also invariably significantly superior to control. The fruit weight (Table 3) was significantly higher in the treatment T_5 in comparison to control, however, this treatment was statistically at par with other thinning treatments except, (T_1, T_2, T_3 and T_4) in 2015 at Kandaghat. In this study, NAA and Ethrel treatments when applied 2 weeks after petal fall were better in improving fruit size and weight probably due to their greater effectiveness in inducing fruit abscission (Table 1) compared with application 1 week after petal fall. Fruit thinning with NAA or Ethrel increased fruit size and weight in 'Redhaven' peach (Sharma et al 2003) and 'May Fire' nectarine (Rimpika et al 2014). However, the increase in fruit size and weight by auxin may not be entirely due to the reduction in crop competition, but also be due to the direct effect of auxin on sink strength of the fruit

The fruits firmness was significantly more in control in comparison to all plant growth regulator. It was however, significantly lower in T_6 in comparison to all the other treatments except, T_5 at both the locations during 2015 and T_8 at Kandaghat in-2015 and at Kotla, Barog in both the years. These results affirmed previous findings (Rimpika et al 2014) that fruit firmness had somewhat inverse correlation with fruit size (Table 3). The larger the fruit size lesser the firmness and vice versa. Sharma et al (2003) observed reduction in fruit firmness by Ethrel treatment in peach. Ethylene plays a major role in acceleration of the onset of climacteric and following certain enzymatic activities bring changes associated with ripening, which results in softening of fruit, increase in soluble pectin substances, decrease in insoluble ones and firmness, due to de polymerisation and de-esterification (Dhillon and Bhatt 2011). The fruit surface colouration was significantly influenced by all the thinning treatments, however it was observed greatly higher under the treatments T_8 and T_6 (Table 3). The fruits from Kandaghat were better in colour than those from Kotla, Barog and when chemical thinners were applied 2 weeks after petal fall rather than 1 week after petal fall. Higher colour development in Ethrel treated fruit in the present study may be due to enhancement of ripening (Taheri et al 2012) and anthocyanin pigmentation (Whale et al 2012). The improved fruit skin colour was observed with foliar treatment with Ethrel when 2 weeks after petal fall (Rimpika et al 2014).

Fruit in T_6 were with significantly higher total soluble solids and sugar contents in comparison to all other treatments except, T_5, T_7, and at KotlaBarog in 2015 and in respect of total sugar content at Kandaghat during 2014 (Table 4). At both the locations, significantly higher titratable acidity was observed in control as compared to all other treatments and it was decreased greatly with the treatments of NAA at 60 ppm and Ethrel at 300 ppm when applied two weeks after petal fall. Increased fruit TSS and sugar contents in these treatments can be attributed to the reduced fruit load (Table 1) and higher photosynthetic rate and consequently more supply of carbohydrates and metabolites to the developing fruits. It also seems that exogenous application of Ethrel and NAA increased fruit sugar contents by triggering ethylene production, which has a stimulatory role in fruit ripening process as discussed above. Present study further validate earlier findings (Rimpika et al 2014) that fruit thinning

Table 2. Effect of chemical thinning on fruit yield and fruit size of May Fire nectarine

Treatment*	Fruit yield (Kg tree^{-1})				Fruit length (cm)				Fruit breadth (cm)			
	Kandaghat		Kotla, Barog		Kandaghat		Kotla, Barog		Kandaghat		Kotla, Barog	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
T_1	9.33	13.33	13.33	15	4.91	4.37	4.65	4.34	4.98	4.3	4.54	4.37
T_2	10.33	15.66	13.66	15.3	4.89	4.32	4.6	4.31	4.91	4.3	4.4	4.22
T_3	11	17.66	14	15.97	4.82	4.21	4.5	4.3	4.8	4.22	4.19	4.21
T_4	8.66	14.33	13.67	15.66	4.87	4.25	4.54	4.32	4.91	4.24	4.56	4.37
T_5	8.33	10.33	10	12.33	5.37	4.75	5.05	4.72	5.35	4.62	4.74	4.59
T_6	8.33	11.33	11	14	5.17	4.68	4.74	4.57	5.07	4.56	4.67	4.56
T_7	8.66	13.66	12.66	14.66	5.07	4.6	4.69	4.55	5.09	4.45	4.62	4.48
T_8	9.33	11.33	11.33	12.64	5.05	4.6	4.84	4.68	5.24	4.52	4.55	4.58
T_9	18	20	19	20	3.83	3	3.2	2.9	3.4	2.95	3.18	2.8
CD (p=0.05)	0.67	0.57	0.86	0.91	0.59	0.55	0.51	0.36	0.63	0.48	0.44	0.25

*As in table 1

Table 3. Effect of chemical thinning on fruit weight, firmness and fruit colouration of nectarine

Treatment*	Fruit weight (g)				Firmness (kg cm^{-2})				Fruit colouration (4 point scale)			
	Kandaghat		Kotla, Barog		Kandaghat		Kotla, Barog		Kandaghat		Kotla, Barog	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
T_1	66.33	44.41	49.13	45.92	4.36	6.06	5.80	6.20	2.90	2.80	2.86	2.70
T_2	64.08	44.08	48.00	44.08	4.23	6.12	5.70	6.15	3.00	2.83	2.90	2.70
T_3	63.83	42.16	45.88	44.17	4.40	6.00	5.80	6.10	2.80	2.70	3.00	2.60
T_4	62.08	41.17	50.03	45.08	4.00	5.90	5.78	6.36	3.00	2.83	3.26	2.80
T_5	72.33	54.33	57.10	50.08	3.80	5.56	5.20	5.60	3.16	3.00	3.33	3.16
T_6	71.25	50.50	54.80	49.33	3.06	5.31	4.55	5.32	3.66	3.33	3.46	3.00
T_7	67.50	48.50	53.73	49.00	3.93	5.86	5.71	5.90	3.50	3.16	3.20	3.00
T_8	70.75	49.42	57.10	49.83	3.73	5.31	4.76	5.42	4.00	3.50	3.46	3.33
T_9	40.75	28.75	30.67	30.00	5.36	6.60	5.96	6..95	2.00	2.00	1.66	1.28
CD (p=0.05)	12.94	9.63	12.15	7.70	0.39	0.40	0.39	0.36	0.53	0.41	0.38	0.08

*As in table 1

Table 4. Effect of chemical thinning on total soluble solid, and titratable acidity and total sugar in nectarine fruits

Treatment*	TSS (°Brix)				Titratable acidity (%)				Total sugar (%)			
	Kandaghat		Kotla, Barog		Kandaghat		Kotla, Barog		Kandaghat		Kotla, Barog	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
T_1	8.33	7.26	7.76	7.32	0.54	0.60	0.53	0.58	6.00	5.31	5.53	5.50
T_2	8.26	7.50	8.10	7.40	0.50	0.58	0.49	0.53	6.07	5.53	5.81	5.80
T_3	8.00	7.20	7.80	7.30	0.52	0.64	0.52	0.59	6.20	5.14	5.50	5.40
T_4	8.40	7.33	7.90	7.40	0.48	0.59	0.48	0.53	6.25	5.33	5.54	5.55
T_5	8.66	7.33	8.10	7.48	0.44	0.58	0.48	0.50	6.75	5.81	6.25	6.16
T_6	9.46	8.00	8.45	8.00	0.40	0.48	0.37	0.45	7.14	6.75	7.00	6.83
T_7	8.33	7.33	8.00	7.46	0.45	0.60	0.45	0.53	6.54	5.75	6.20	6.18
T_8	8.73	7.40	8.25	7.66	0.42	0.52	0.37	0.45	6.75	6.25	6.25	6.20
T_9	7.46	7.00	7.60	7.00	0.70	0.69	0.68	0.72	5.00	5.00	4.65	4.60
CD (p=0.05)	0.37	0.38	0.10	0.57	0.04	0.05	0.05	0.11	0.62	0.46	0.39	0.25

*As in table 1

with NAA at two weeks after petal fall increased the fruit TSS and total sugar and decreased acidity in nectarine. Chandel and Singh (2015) observed that thinning with Ethrel increased total soluble solids and total sugar contents of fruit of nectarine.

CONCLUSION

The foliar spray of NAA at 40 ppm when applied two weeks after petal fall judiciously thinned nectarine fruits and improved fruit size and fruit quality. However, variability in the extent of thinning was observed among the locations, which was higher at Kandaghat compared to Kotla Barog. Chemical thinners were more effective in the year 2014 than 2015 and when applied 2 weeks after petal fall instead of 1 week after petal fall. Environmental conditions, particularly temperature and relative humidity, may have impacted the efficacy of chemical thinners. Yearly variation in the time taken to complete the disintegration of cells in these tissues can be attributed to observed differences in environmental condition among locations and years. Present results indicate that disintegration of cells was advanced at Kandaghat in the year 2014 at 20.5-24.5°C/ 13-14°C maximum and minimum temperature and 47.3- 60.3% average relative humidity after application chemical thinners. These results demonstrate that chemical thinners seem to be more effective at optimum temperature range; too low or too high temperature lessened effectiveness. NAA at 40 ppm when applied two weeks after petal fall increased the superior grade fruit yield, fruit size, fruit weight and fruit quality.

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Population Dynamics and Seasonal Occurrence of Mediterranean Fruit Fly (*Ceratitis capitata* Wiedemann, 1824) in Moulouya Perimeter North East of Morocco

Jamal Ben Yazid, Zouheir Chafik[1], Anwar Bousamid[1], Imane Bibi and Ez-Zahra Kharmach

Laboratory of Biochemistry and Biotechnologies
[1]Laboratory of Plants and Microorganisms Biology, Mohamed first University, Faculty of Sciences, Oujda, Morocco
E-mail: benyazidjamal@yahoo.fr

Abstract: In Morocco, The Mediterranean fruit fly (Medfly) *Ceratitis capitata* is largely an established pest and causes damage to a number of host plants and it is of phyto-sanitary concern (trade barriers) for Citrus exportation. The objective of this research is the monitoring of the fluctuations of Medfly population in citrus orchards and other host plants using male traps. The study was conducted from 2016 to 2018 in eight localities (Lamriss, Slimania, Zegzel, Aklim, Chouihia, Tzayesset, Urban backyards and Reggada) representing the main fruit production areas of Moulouya Perimeter. The results showed significant differences between patterns of medfly population's occurrence, in some localities during three-year period of monitoring. Captures occurred continuously from early April to late November with variability between years. Moreover, Five main periods of high fly activity were distinguished: the first period occurred in April late, the second in early June, the third in the August late, the fourth occurred in September late and early October and the last one in early November mainly in clementine orchards. Our findings suggest that the Medfly has a year around presence in fruit orchards and urban backyards. The highest captures were observed in the traps hung in argan, fig and jujube trees. The fruits showed different rates of infestation and variable numbers of larvae in fruits. The highest means of larvae per fruit were recorded in oriental persimmon, avocado, argan, bitter orange, pomegranate and clementine.

Keywords: Captures, Citrus, Integrated Pest Management, Medfly, Occurrence, Pests, Population dynamics

The Mediterranean fruit fly, *Ceratitis capitata* (diptera: Tephritidae), commonly known as Medfly, is one of the world's most destructive insect pests of fruit trees (Papadopoulos et al 2001, Szyniszewska and Tatem 2014). It is a highly polyphagous species, able to feed on over 300 wild and cultivated hosts belonging to 69 families and known to be capable of adapting to a wide range of climates (Thomas et al 2001) it displays highly seasonal population dynamics, and the environmental conditions suitable for its abundance are not constant throughout the year in most places (Szyniszewska and Tatem 2014). *Ceratitis capitata* exhibits an almost cosmopolitan geographical distribution due to its high invasive potential (De Meyer et al 2008, Diamantidis et al 2009, Papadopoulos et al 2013, Papadopoulos et al 2014). In the Mediterranean region (including Morocco), Medfly is an established insect (FAO/IAEA, 2013). In addition, the Medfly is one of the most important quarantine pests in many parts of the world and trade barriers are imposed against plant products from infested areas (CABI 2017, CDFA 2017, EPPO 2017). The main aim of this study is to report and assess data on population fluctuations of medfly and its seasonal occurrence and distribution in Moulouya Perimeter (North East of Morocco) during three years of study.

MATERIAL AND METHODS

Study area and fruit species: The field study was carried out in eight localities [Lamriss (latitude W35°0'26.6", longitude N2°11'32.3"), Slimania (latitude W34°57'56.9", longitude N2°23'29"), Zegzel (latitude W34°50'32.9", longitude N2°21' 15.2"), Aklim (latitude W34°53'10.1", longitude N2°30'53.4"), Chouihia (latitude W34°52'17.7", longitude N2°37'3.6"), Tzayesset (latitude W34°56'12.4", longitude N2°25'48.4"), urban backyards of Berkane city (latitude W34°55'3.8", longitude N2°18'44.2") and Reggada (latitude W34°56'3.9", longitude N2°13'47.3")] representing the main fruit production areas of Moulouya Perimeter, which is located close to southern Mediterranean seacoast. The monitoring was performed from 2016 to 2018 years. For each locality, the average number of captured flies on traps was counted. Several commercial host plants were monitored including clementine [*Citrus clementina*], orange [*Citrus sinensis*], apricot [*Prunus armeniaca*], Peach-nectarine [*Prunus persica*], jujube [*Ziziphus jujuba*], Argan [*Argania spinosa*], loquat [*Eriobotrya japonica*], pomegranate [*Punica granatum*], and urban backyards trees as bitter orange [*Citrus aurantium*], avocado [*Persea Americana*], oriental persimmon [*Diospyros kaki*], prickly pears [*Opuntia vulgaris Mill*], white sapote [*Casimiroa edulis*], apple [*Maluspumila*], pear [*Pyrus *communis*] and cherimoya [*Annona cherimola*].

Effect of climatic factors on population fluctuations of medfly: To study the effect of climatic factors on the population fluctuation of medfly; means of maximum and minimum temperatures; rainfall and relative humidity (RH) were obtained from the Agro meteorological Station at Proagor orchard. The daily records of each climatic factor were grouped into monthly means according to the date of traps inspection.

Population dynamics and medfly monitoring: In order to determine the seasonal fluctuations on population dynamics of the pest, 2 traps were hung in each selected orchard. Maghreb Med traps baited with Parapheromon Trimedlure and a Dichlorvos tablet as toxicant were hung about 1.5 m above ground in the sunny side (South Eastern) of the tree in the 1/2 - 1/3 part of the tree canopy or on a branch that contains fruits before the emergence of the adults.

The distance between traps in the orchard was approximately 30 m to avoid interferences. The traps were inspected weekly and the number of captured flies on each trap was counted and taken out of the traps. Trap capsules (trimedlure and dichlorvos) were replaced with new ones every 6 weeks.

Fruit infestation rate and host plants overwintering refuge: To estimate the fruit infestation rate of different host plants, ripe and ripening fruits on trees and fruits recently fallen on the ground were randomly collected (3775 fruits) from orchards with adult's presence in traps. The collected fruits were transferred weekly to the laboratory for examination. Fruits were counted and placed in medium plastic containers with in deep a layer of 4cm of dry fine sand as a pupation media for the last stage of larvae when they leave fruits. The sand was weekly sifted to count Medfly instars (larvae or pupae) found and record their number. The infestation rate was calculated by dividing the number of infested fruits (fruits with at least one larvae or pupa of medfly) by the total number of those examined. The mean number of larvae per fruit was obtained by dividing the total number of collected medfly larvae and pupae by the total of infested fruits for each species. During the coldest three months; December, January and February, Medfly captures were recorded and samples of fruits left on trees, mainly in prickly pear, pomegranate and bitter orange, were collected and conducted for examination in the laboratory.

Statistical analysis: Trap captures were expressed as the number of flies per trap per day (FTD) which is the population index used to estimate the average number of flies captured. Trap captures (FTD) and dates of inspection in different localities were statistically analyzed by analysis of variance (ANOVA test) and means were separated according to the Tukey's honestly significant difference (HSD) test ($\alpha = 0.05$). To study the effect of climatic factors (Temperature, Relative Humidity and Rainfall) on population fluctuations of *C.capitata*, a multiple regression analysis (Pearson correlation) was performed. All statistical tests were performed using IBM SPSS statistics 25.

RESULTS AND DISCUSSION

Seasonal distribution of Medfly in Moulouya perimeter: The captures decrease in winter with low temperatures and absence of host plants in Moulouya perimeter and indicate that medfly has five to six overlapping generations in Moulouya perimeter. The current results are similar to those obtained by Israely et al (2005) and Pimentel et al (2017), who reported that the Medfly adult population decreased to a zero levels during the winter months and remained at this level until spring, when early flies were again captured by the traps. Thereafter, the spatial distribution and build-up of the population during summer and autumn were closely associated with the phenology of the different fruit hosts and with their spatial distribution, insecticide applications, density of host fruits and distance between hosts (Fig. 1).

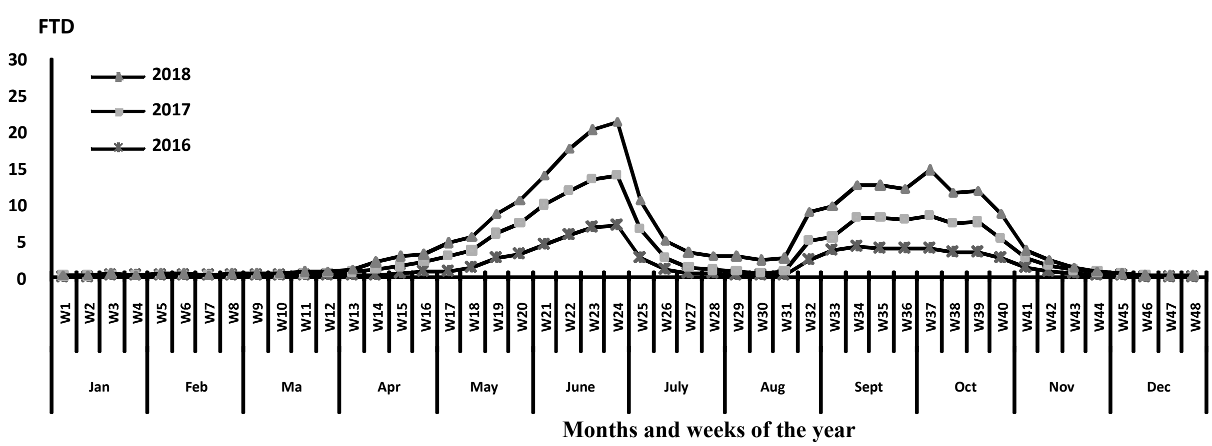

Fig. 1. Temporal population fluctuations of *Ceratitis capitata* in Moulouya Perimeter during the period of study (2016-2018).

Annual and spatial distribution of Medfly according to locations and host plant availability: The results of temporal pattern of adult captures in the eight studied localities during the years 2016, 2017 and 2018 are drawn in (Fig. 2). A significant similarity {HSD test, α= 0.05, *p* value (2016, 2017) = 0.790} between patterns of occurrence of medfly during 2016 and 2017 years, a slight similarity between 2017 and 2018 {with *p* value (2017; 2018) = 0.139} and a significant difference between 2016 and 2018 {with p value (2016; 2018)= 0,037} were noted. According to HSD test, three subassemblies of localities were distinguished, Aklim, Zegzel as a first subassembly (p value = 0.058), the second subassembly was Tzayesset, Lmariss, Slimania, urban backyards and Reggada (p value = 0.610) and the last one was constituted of Chouihia locality. Moreover, Captures occurred continuously all year around mainly in urban backyards. In Zegzel, the most Southern and coldest location among the eight locations studied, a low population size was observed during the three years of study showing a low similarity with the pattern observed in Aklim and slight in Tzayesset. While in Chouihia location, where the traps were hung in Argan trees, captures were significantly different (HSD test α = 0.05) to other areas and peaked on June during three years of investigation (Table 2) when the peak was associated with the availability of ripe argan fruits and adequate weather conditions. In Lamriss, Slimania, urban backyards and Reggada areas, we noted all year around presence of medfly adults and slightly different pattern of distribution.

This variability in population patterns was probably the result of differences in the availability of ripe and ripening fruits in these areas. Many studies showed that *C. capitata* moves from one fruit species to another according to their. Israely et al (1997) observed that flies are captured at different times following the ripening of different host fruits the same result had been confirmed by the same author in 2005.

Fruit infestation rate and host plants potentially suspected to be an overwintering refuge: From a total of 3775 host fruits collected, 6517 Medfly pupae were obtained (Table 2). Argan fruits showed the highest infestation rate (78.75 %) followed by fig fruits (73%). Therefore, the oriental persimmon was the host fruit with the highest number of larvae per fruit (29.4) followed by avocado (13.55), argan (10.30), pomegranate (8.60), bitter orange (8.58) and clementine (8.40). However, from 137 apple fruits collected and examined none was infested.

In urban Backyards, with the presence of mature fruits left on the trees and warmer microclimate, captures continue to occur in coldest months during three years of study (December, January and February). Bitter orange, pomegranate, fig, jujube and prickly pears are a reservoir for next infestations (Overwintering refuge) of other host plants mainly clementine. In addition, the adults trapped continuously all year around in urban backyards, including the coldest months, showed that medfly was overwintering in adult stage.

Effect of climatic factors on Medfly captures: The climate of study area is characterized by a warm dry summer and wet winter with low temperatures but over zeros degree (Fig. 3). Maximum monthly temperature recorded over the study period ranged from to 15-36°C. The relationship between capture levels and temperature was not uniform, but overall higher temperatures were usually associated with significantly higher trap catches (α= 0.05) (Pearson correlation test r = 0.587, p=0.000) (Table 3). These results

Table 1. Periods of ripening and sensitivity to Medfly attack for hosts in Moulouya perimeter

	January	February	March	April	May	June	July	August	September	October	November	December
Citrus (sweet Orange and clementine)	x	x	x	x	x	x			x	x	x	x
Pomegranate									x	x	x	
Bitter orange	x	x	x	x	x	x					x	x
Apple, pear and quince							x	x				
Loquat			x	x	x	x						
Apricot				x	x	x						
Argan				x	x	x						
Peach, Nectarine					x	x	x					
Fig					x	x	x	x	x	x	x	
Jujube							x	x	x			
Sapote									x	x	x	
Avocado									x	x	x	x
Prickly pear						x	x	x	x	x	x	
Cherimoya						x	x	x	x	x	x	
Oriental Persimmon						x	x	x	x	x	x	

support those obtained by Saafan et al (2006); that Medfly populations were significantly correlated with temperature degrees. The total monthly rainfall values of 72.00, 41.00 and 115.00 mm were recorded in February 2016, April 2017 and 2018, respectively. The relationship between fly capture levels and total monthly rainfall was directly proportional, with higher rainfall values resulting in significantly lower fly (Pearson correlation test with r = -0.412 and *p* = 0.013). During the study period, a negative correlation between rainfall and the number of flies captured was observed.

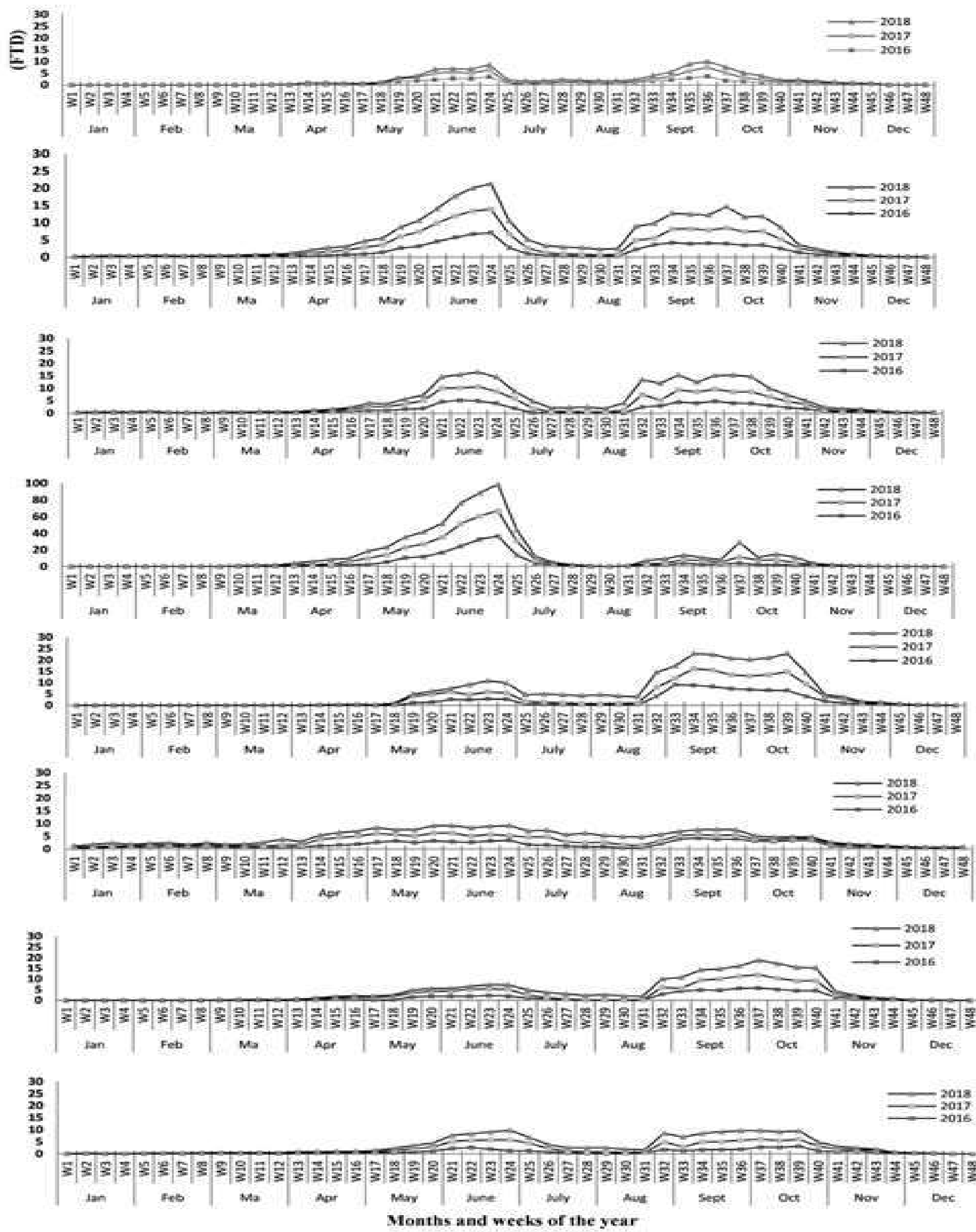

Fig. 2. Medfly captures in different localities in Moulouya perimeter (2016-2018). (A) Zegzel, (B) Tzayesset, (C)Slimania, (D) Chouihia, (E) Reggada, (F) Backyard, (G) Lamriss, (H) Aklim

Relative humidity over the months ranged from 43.00% in March 2016 to 85.00% in December 2017. Generally, as relative humidity increased, fly capture levels decreased, then, relative humidity and fly capture levels were slight negatively correlated (r= - 0.383, p= 0.021). Moustafa et al (2014) reported that Medfly is significantly affected by temperature degrees and relative humidity.

Based on multiple regression test, the strongest predictor of captures variability was the average temperature with a power regression (Fig. 4) (Pearson correlation test R^2=0.5921).

Table 3. Multiple regression analysis of the effect of some climatic factors on the population of *Ceratitis capitata*

		Captures	Relative humidity	Rainfall	Average temp
Captures	Pearson correlation	1	-0.383*	- 0.412*	0.587**
	Sig. (bilateral)		0.021	0.013	0.000
	N	36	36	36	36

*Correlation is significant at level 0.05 (bilateral).
**Correlation is significant at level 0.01 (bilateral).

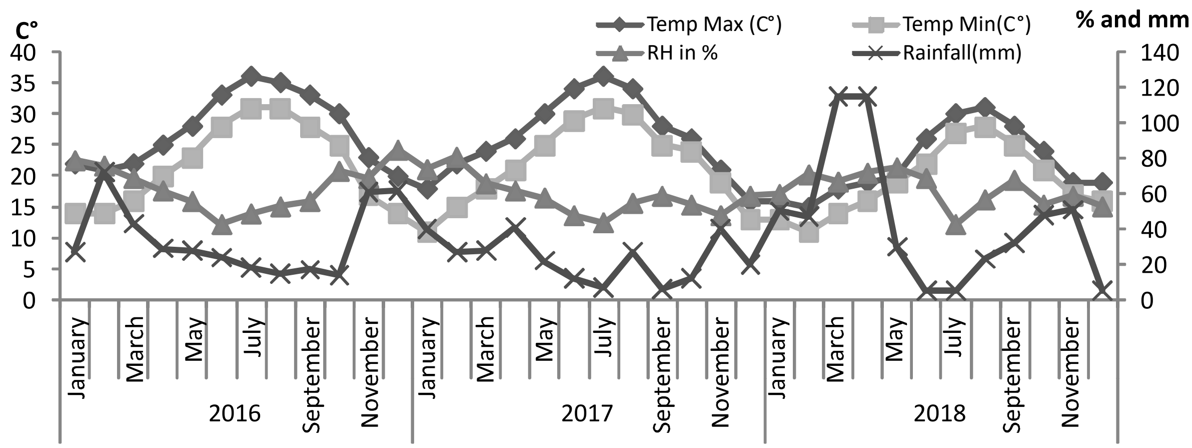

Fig. 3. Seasonal temperatures, rainfall and relative humidity in Moulouya perimeter during the study period

Table 2. Mean percentage of fruit infestation with medfly and mean number of larvae/fruit in Moulouya perimeter during three years of study period (2016-2018)

Host plant	Total no. of fruits	No. of infested fruits	Percentage of infestation	Total no. of larvae	Mean no. of larvae $fruit^{-1}$
Pear	255	11	4.31	39	3.55 ±2.33
Apple	137	0	0.00	0	0.00 ±0.00
White sapota	75	25	33.33	199	7.96 ±4.81
Prickly pear	150	11	7.33	24	2.18±1.10
Persimmon	52	10	19.23	294	29.40 ±16.23
Avocado	59	20	33.90	271	13.55 ±6.18
Bitter orange	161	13	8.07	111	8.58 ±2.12
Pomegranate	151	26	17.22	223	8.60 ±1.12
Loquat	133	4	3.01	8	2.00 ±2.00
Argan	320	252	78.75	2596	10.30 ±3.22
Fig	200	146	73.00	832	5.70 ±2.00
Orange	455	74	16.26	458	6.19 ±2.13
Clementine	316	72	22.78	605	8.40 ±2.33
Apricot	112	15	13.39	66	4.40 ±0.88
Peach	145	48	33.10	251	5.23 ±1.22
Nectarine	320	7	2.19	22	3.14 ±0.42
Jujube	300	58	19.33	252	4.340 ±0.28
Cherimoya	221	28	12.67	204	7.29 ±5.71
	213	19	8.92	62	3.26 ±2.75
Total	3775	839	22.22	6517	7.76

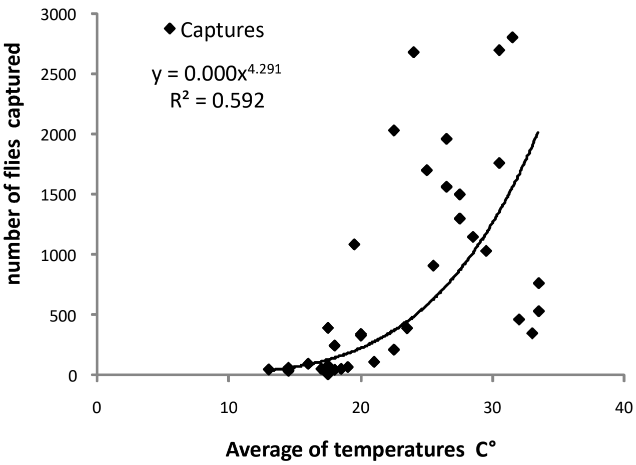

Fig. 4. Relationship between medfly captures and average of temperatures

CONCLUSION

The study is the first relevant data on *C. capitata* spread and population dynamics in Moulouya Perimeter. The Medfly had distinct seasonal patterns in population fluctuation. Population density is very low during July and early August, increases during late August and first half of September, and peaks from mid-September to end of October. Adult activity ends in December (except for urban backyards). The study may contribute to establish preliminary results on biology, spatial and seasonal distribution of the pest in the study area climatic conditions. The results will contribute to evaluate the Medfly impact on agricultural production and formulate the appropriate control measures and strategies mainly in citrus orchards where this pest represents a major phytosanitary concern. Furthermore, this knowledge on population dynamics of *C.capitata* will contribute to develop more effective area-wide pest management strategies including the use of sterile insects, natural enemies, and bait sprays and help in planning integrated pest management program for controlling the insect in Citrus Orchards.

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Rhizosphere *Streptomyces* Species from Major Crop Plants of Shifting Cultivation, Northeast India

Marcy D. Momin and Shri Kant Tripathi

Department of Forestry, Mizoram University, Mizoram-796 004, India
E-mail: mominmarcy@gmail.com

Abstract: In the present study, the main objectives were isolation of actinomycetes from the rhizosphere of crops under *jhum* cultivation and determination of physico-chemical properties of rhizopsheric soil. Rhizosphere soil was collected from the major crop plants like rice, maize, bean and yam from Lengpui and Reiek of Mizoram, Northeast India. Actinomycetes were isolated by the standard method of serial dilution and identified by following the keys of Bergey's Manual of Determinative Bacteriology and further isolates were tested for salt-tolerant activities. Physico-chemical properties of rhizospheric soil of major crop plants were analysed. Total 32 rhizospheric actinomycetes were obtained and identified them upto genus level as *Streptomyces* species. Strain SKT12, SKT33 and SKT40 isolated from maize and yam showed different ranges of salt-tolerance activity. Strain SKT34 which isolated from crop rice showed casein hydrolysis activity. The physico-chemical analysis of soil revealed variations of soil properties between the crops. Major crops of Mizoram under shifting cultivation have great potential to influence of soil properties and soil actinomycetes particularly *Streptomyces* species.

***Keywords*:** Major crops, Shifting cultivation, Rhizosphere, *Streptomyces*, Soil properties

Actinomycetes are prokaryotic organisms, gram-positive high G+C bases composition mycelium forming organism. Actinomycetes are widely distributed in soils and represent major components of rhizosphere microorganisms. Actinomycetes are useful in nutrient cycling and helps plant growth promotion. They promote plant growth and development by nitrogen-fixation, producing extracellular enzymes, enhancing production of indole-3-acetic acid (IAA), phosphate solubilization, ammonia, siderophore and inhibit the growth of plant pathogens (Sreevidya et al 2016). In natural habitats, among the microorganisms, actinomycetes are the dominant microbial species and genus *Streptomyces* spp., were the most frequently found actinomycetes. Terrestrial streptomyces were isolated and found to be potential sources of therapeutic compounds (Mamatha et al 2016, Hassan et al 2019). Actinomycetes genome have revealed that numerous 'cryptic' or 'orphan' biosynthetic gene clusters with the potential to direct the production of novel and structurally diverse natural products (Gomez-Escribano et al 2016). Northeast India is well-known for their rich in bio resources. Shifting cultivation or locally named *jhum* is a dominant agricultural farming in Northeast. Actinomycetes from ethnomedicinal plants have been studied from Mizoram, Northeast India (Passari et al 2019). However, rhizosphere actinomycetes from the major crops of shifting cultivation from this habitat has not been investigated. In the present study, our main objectives were to isolate actinomycetes from the rhizosphere of crops under *jhum* cultivation and determination of physico-chemical properties of rhizopsheric soil.

MATERIAL AND METHODS

Rhizosphere soil collection and isolation of actinomycetes: Rhizosphere soil were collected from rice, maize, bean and yam crop plants of five years old fallow shifting cultivation under two different areas i.e., Lengpui and Reiek of Mizoram, Northeast India. Plant and soil were transferred into sterile polythene and brought into the laboratory. Collected rhizospheric soil were sieved through 2 mm and heated at 60˚C for 15 min. Pre-treated soil was then dissolved in a sterile 0.9 per cent saline water (NaCl) and serially diluted until reaching 10^6. Then, 100µl aliquats were plated on prepared Starch Casein Agar (SCA), International Streptomyces Project 2 (ISP2), Cross Streak Media (CSM) and Actinomycetes Isolation Agar (AIA), supplemented with nalidixic acid (50 µg ml^{-1}) and amphothericin B (50 µg ml^{-1}) to inhibit gram-negative bacterial growth. The agar plates were incubated at 28°C for 1-4 weeks. Streaking method was used to isolate a pure strain from a single species of actinomycetes.

Morphological and microscopical observation: The spore chain morphology and surface of spore were examined by the microscope. The drops of inoculum were spread over the centre of the slide and air dried. The smear was flooded with crystal violet for one minute. Then the slides were repeatedly washed with sterile to remove the excess stain. After washing with water, the smear was then flooded with safranin, for 30 sec and washed with sterile water, dried and examined under oil immersion. The plate culture like colony nature, aerial and substrate mycelium, colony colour, days of growth, pigmentation and liquid test tubes culture characteristics were also observed (Bergey and Holt 2000).

Salt-tolerance activity: Salt-tolerance activity screening followed the method given by Cai (2009). Purified actinomycetes were inoculated on their medium in which NaCl concentrations were 0, 50, 70, 100, 150, 180, 200, 250 and 300 g l^{-1} respectively, and observed their growth conditions. The highest NaCl concentration that the strain could tolerant expressed the strain salt-tolerance.

Determination of Rhizosphere Soil Physical and Chemical Properties

Soil pH: The soil pH was determined in soil and water (1:2.5) suspension using pH meter. The pH value of the soil was measured of its acidity as the negative logarithm of hydrogen ions concentrated in water.

Soil moisture content: Soil samples were oven dried at 105˚C for 48 hrs to constant weight. The moisture content was expressed in percentage (%).

Per cent moisture content= Fresh soil weight-Dry soil weight/ Dry soil weight X 100

Estimation of soil organic carbon (SOC), total nitrogen (N), hydrogen (H): Estimation of soil organic carbon (SOC), total nitrogen (N), hydrogen (H) were determined by using CHNS elemental analyzer and exchangeable potassium (K) was extracted with 1N ammonium acetate (NH4OAC) (pH 7.0) and determined by using microwave plasma atomic emission spectrophometer (MPAES Agilent 4100).

RESULTS AND DISCUSSION

Isolation of actinomycetes: Total 32 strains were isolated from rice, maize, bean and yam crops of shifting cultivation in Mizoram, Northeast India, among which 13 isolates (40.6%) were isolated from rice, 7 isolates (21.8%) from bean and yam, and 5 isolates (15.6%) from maize (Table 1, Fig.1). Based on their morphological characteristics, the species belonged to *Streptomyces* spp. Isolated on four different medias employed in the present study, maximum actinomycetes were isolated in SCA (50%) followed by CSM (21.8%), AIA (15.6%) and ISP2 (12.5%) (Fig. 1). On plate culture, all the isolates were able to grow well within 3 to 31 days; their colony nature was maximum dry, fuzzy, filamentous and sticky-hard and their formation shapes were entire, circular or irregular. Colony sizes of the isolated actinomycetes were recorded between 0.5 to 1.5 mm in diameter. While on liquid culture, isolates showed subsurface granular, ring on surface, flaky, flocculent and translucent nature. Root exudates may be the key factor regulate the interaction between plant roots and soil microbes (Mommer et al 2016). Diversity of actinomycetes in the rhizosphere soils may depends on the plant species that root exudation secretes various organic materials. In the present study, total 32 actinomycetes were identified as particular genus *Streptomyces* sp. and maximum isolates were obtained from crop rice followed by beans and yam. The present study demonstrate that *Streptomyces* sp. can easily interact with crop rhizosphere in the shifting cultivation. Similarly, Anawar et al (2016) reported that genus *Streptomyces* sp. were isolated from crop plant rhizosphere and revealed that rhizospheric *Streptomyces* are good plant growth promoting candidates. Therefore, rice, beans and yam may have capacity to secrete various organic compounds derived from the root exudates which is most favourable for actinomycetes Whereas maize may exudate lesser compounds. Hence, major crops of shifting cultivation may have been influencing soil actinomycetes and enhance plant growth promotion as well as plant adaptation in the shifting cultivation areas.

Out of 32 isolates, 3 actinomycetes were detected producing salt-tolerance activity. Strain SKT12 can tolerate salt concentrations at 50, 100, 150, 200, 250 and 300 conc/L, followed by SKT33 has capacity to tolerate salt containing at 150, 180, 200, and 250 conc/L and SKT40 can able to grow salt containing at 100 and 150 conc L^{-1} (Table 2, Fig. 3). Among total isolates, only one strain SKT34 showed casein hydrolysis activity (Fig. 3). This finding showed that rhizosphere actinomycetes strain SKT12, SKT33 and SKT40 were the most potential which can able to tolerate high salt containing environments. *Streptomyces* sp. were able to survive in diverse range of salts containing condition that may be useful in application in high salinity agricultural land. Rhizosphere actinomycetes strain SKT34 showed casein hydrolysis activity which can be useful in industries and factories.

The physico-chemical rhizosphere soil characteristics varied among the major crop plants. The soil was acidic in all the selected crops with pH ranging between 5.5 to 6.0. The bean crop was most acidic (pH 5.5). The maximum CEC of the soil was in crop yam (0.02) followed by rice, maize and bean .Moisture content (%) was more in yam (9). Total N content was maximum in maize (0.25%) followed by rice, bean) and yam. Maximum carbon content was in crop maize (1.5) followed by rice, yam and bean. Available phosphorus content was maximum in rice (0.016%) followed by bean, maize and yam .Exchangeable-K contents were higher in the crop yam (0.94%) followed by rice, maize and bean. The soil from the four rhizosphere crops showed variation between the crops. All the selected crops were possessing higher at least one parameter among the total tested parameters. Actinomycetes were isolated maximum from rice followed by

Table 1. Morphological characteristics of 32 rhizosphere actinomycetes isolates

Isolate code	Crop	Colony nature, colour, colour of AM and SM, colony sizes and shapes	Media used
SKT15	Maize	AM-creamy, SM-light cream; punctiform, hard, smooth; 0.6mm in dia.; growth in 3 days	SCA
SKT14	Maize	AM-light cream, SM-light cream; punctiform, sticky-hard; 0.1mm in dia.; growth within 5 days	SCA
SKT13	Maize	AM-light-cream, SM-light-cream; sticky, punctiform, entire; growth in 7 days	SCA
SKT16	Maize	AM-light-cream, SM-light-cream; sticky, entire, flat; 0.3mm in dia.; growth within 5 days	AIA
SKT12	Maize	AM-off-white, SM-dark-cream; filamentous, soft, pulvinate; 1mm in dia.; growth in 7 days	AIA
SKT19	Bean	AM-black-smooth, SM-dark-coffee; filamentous, flat, sticky; 0.5mm in dia.; growth in 31 days	AIA
SKT6	Bean	AM-grey, SM-dark-brown; entire, pulvinate, sticky, pigment present; 1.5mm in dia.; growth in 7 days	SCA
SKT18	Bean	AM-pure-grey, SM-black; pigment present, entire, pulvinate, sticky; growth in 7 days	SCA
SKT20	Bean	AM-pure-grey, SM-dark-brown; pigment present, entire, pulvinate, sticky; growth in 7 days	SCA
SKT3	Bean	AM-light grey, SM-brown; pigment present, entire, pulvinate, powdery on top, hard; growth in 7 days	SCA
SKT5	Bean	AM-off-white, SM-pink; irregular, hard, convex; 0.5mm in dia.; growth in 5 days	SCA
SKT4	Bean	AM-off-white, SM-brown; irregular, hard, convex; 0.5mm in dia.; growth in 5 days	SCA
SKT7	Yam	AM-cream, SM-light-cream; sticky-hard, circular, convex; 1mm in dia.; growth in 5 days	AIA
SKT17	Yam	AM-cream, SM-light-cream; smooth, hard, circular; 0.5mm in dia.; growth in 5 days	AIA
SKT33	Yam	AM-off-white, SM-dark-cream; thick, soft, filamentous, colony with ring; colony growth in 3 days	SCA
SKT38	Yam	AM-off-white, SM- light-yellow; circular, umbonate; 0.8mm in dia.; growth within 6 days	SCA
SKT39	Yam	AM-off-white, SM-cream; irregular, umbonate, smooth; 1.5mm in dia.; growth within 6 days	SCA
SKT40	Yam	AM-grey, SM-pink pigmentation; sticky, irregular, flat; 1.5mm in dia.; growth within 6 days	SCA
SKT41	Yam	AM-off-white, SM-yellow; entire, umbonate; 1mm in dia.; colony appeared in 6 days	SCA
SKT25	Rice	AM-dark-cream and white powdery on top, SM-cream; thick, very hard, irregular; 1.5mm in dia.; growth in 14 days	CSM
SKT29	Rice	AM-light-cream and whitish on the surface, SM-light yellow; sticky hard, entire; 1mm in dia.; growth within 15 days	ISP_2
SKT57	Rice	AM-transparent and white on the surface, SM-yellow; sticky, thick; 1mm in dia.; growth in 10 days	CSM
SKT59	Rice	AM-white-grey powdery, SM-dark-yellow light orange on the surface; soft, flat, undulate; filamentous; growth in 7 days	CSM
SKT70	Rice	AM-whitish cream, SM-cream; sticky-hard, irregular, raised; 1mm in dia.; growth in 10 days	CSM
SKT74	Rice	AM-white, SM-yellow; entire, convex, hard; 1mm in dia.; growth in 15 days	ISP_2
SKT82	Rice	AM-off-white, SM-cream; soft-sticky, powdery surface, tiny colony; growth in 7 days	SCA
SKT84	Rice	AM-pure white, SM-yellow; undulate, thick; 2mm in dia.; growth in 7 days	ISP_2
SKT88	Rice	AM-pure white, SM-yellow; umbonate, entire, sticky; 1.2mm in dia.; growth in 7 days	ISP_2
SKT28	Rice	AM-off-white, SM-cream; entire, ring on the centre, umbonate, hard; 1.5mm in dia.; growth in 7 days	SCA
SKT32	Rice	AM-white with ring, SM-transparent; hard, circular; 0.8mm in dia.; growth in 10 days	CSM
SKT61	Rice	AM-off-white, SM-cream; sticky, circular, umbonate; 1mm in dia.; growth in 7 days	CSM
SKT34	Rice	AM-dark-grey with brown pigment, SM-dark-brown; entire, umbonate, sticky-hard; 2mm in dia.; growth in 3 days	CSM

Table 2. Screening of salt-tolerance activity of the isolates

Sample code	Crop	Screening of the actinomycetes at salt content (conc. g L^{-1})	Growth of actinomycetes observed at salt content (conc. g L^{-1})
SKT12	Maize	50. 100, 150, 180, 200, 250, 300 conc. g L^{-1}	50, 100, 150, 200, 250, 300 conc. L^{-1}
SKT33	Yam	50. 100, 150, 180, 200, 250, 300 conc. g L^{-1}	150, 180, 200, 250 conc. L^{-1}
SKT40	Yam	50. 100, 150, 180, 200, 250, 300 conc. g L^{-1}	100, 150 conc. L^{-1}

beans and yam in the present study. The values of phosphorus of rhizospheric rice soil were maximum. Higher phosphorus content in soils could be due to lesser availability of free oxides of Ca, Mg and Na at higher altitude which induce the fixation and subsequent precipitation of phosphorus (Annepu et al 2017). Beans recorded the most acidic compared to rice, maize and yam. Acidic of soil may be due to higher plant litter fall. Microorganisms are more confined to the surface soil layer where organic matter and nutrient availability was higher. The soil potassium of yam was higher compared to rice, maize, bean. One of the reasons may be due to the activity of the root exudation of the

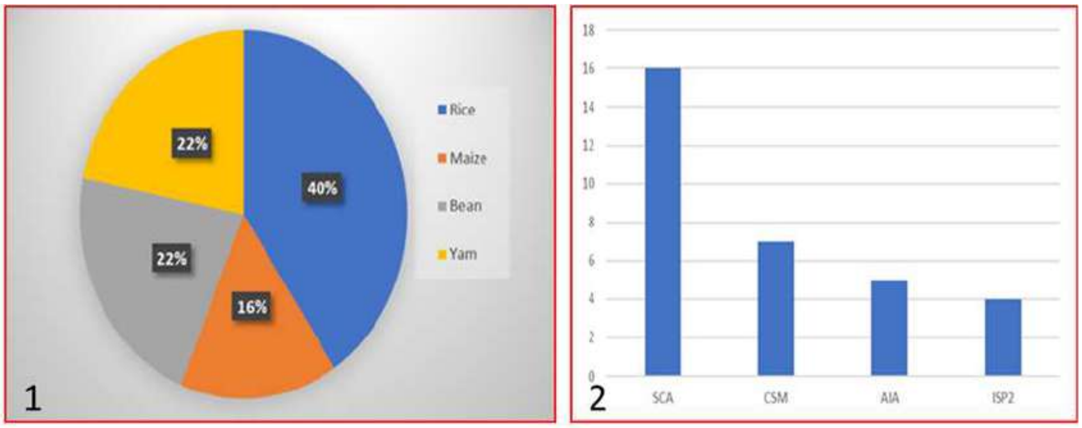

Fig. 1. 1. Representative of distribution of rhizospheric actinomycetes isolated from the selected crops, 2. Graphical representative of distribution of actinomycetes in the selected media used

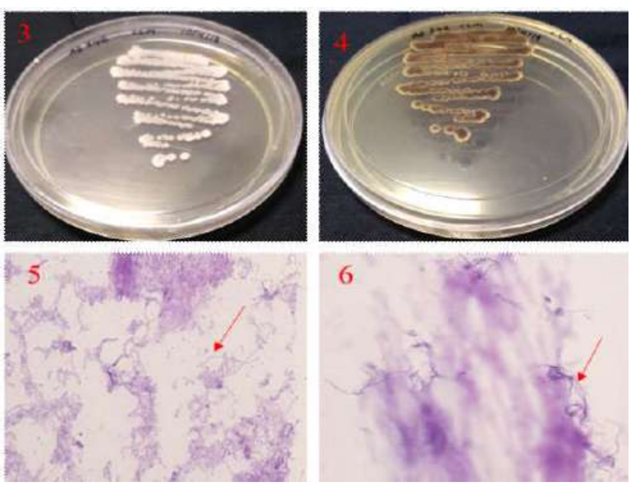

Fig. 2. 3. Aerial mycelium characteristics of the isolates, 4. Substrate mycelium characteristics of the isolates and 5 & 6. microscopical morphology of the isolates

Fig. 3. 7,8, 9, 10. Representatives of salt -tolerance activity of strain SKT33 & SKT40 and (11) & (12)- Representatives of casein hydrolysis test of strain SKT34

Table 3. Physico-chemical properties of rhizosphere soil of major crop plants

Soil types	Temperature ˚C	pH	Electrical conductivity (me per 100 g soil)	Moisture (%)	Total N (%)	SOC (%)	P_2O_5 (%)	K_2O (%)
Rice	27	5.7	0.01±0.009	0.04±0.02	0.94±0.5	0.009±0.005	1.63±0.9	0.47±0.2
Maize	27	5.9	0.01±0.007	0.04±0.02	2.05±1.1	0.01±0.007	0.81±0.4	0.47±0.2
Bean	27	5.5	0.01±0.007	0.08±0.04	0.82±0.4	0.008±0.004	1.24±0.7	0.47±0.2
Yam	27	6.0	0.02±0.01	0.09±0.05	0.47±0.2	0.009±0.005	0.81±0.4	0.94±0.5

Mean± standard deviation

selected crops. The growth of plant root systems is managed by soil physico-chemical properties that are in turn partly improved and influenced by roots themselves (Olanrewaju et al 2019).

CONCLUSION

Based on study carried, rhizospheric actinomycetes particularly *Streptomyces* sp. were explored from the crops under shifting cultivation. This study helps us to understand the crop plant-microbe interaction and their potential to tolerate various salt concentrations. Actinomycetes from anthropogenic activities like shifting cultivation area may have strong capacity to tolerate various biotic and abiotic stress environments and enhance plant growth development and health. With this soil microbial activity long-term cultivation of major crops in the shifting cultivation of Mizoram, Northeast may improve.

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Phytobiological and Morphological Diversity of a Malvaceous *Lavatera Maritima* in Rachgoune and Oulhassa Region of Tlemcen

S. Ghalem and F. Hassani

Laboratory of Ecology and Management of Natural Ecosystems,
Faculty SNV.STU-University of Tlemcen, Algeria
E-mail: sarah.ghalem@outlook.com

Abstract: The vegetation of Tlemcen presents a good example of the study of biological diversity. This study is devoted to a phytoecological analysis in the stations of Rachgoune and Oulhassa, the latter is characterized by an important floristic diversity.

Keywords: *Lavatera maritima*, Malavaceae, Rachgoune, Oulhassa, Morphology, Biology

The Mediterranean world represents a real puzzle, as much by its fragmented and heterogeneous shape to the extreme as by its geology, which is certainly one of the most complexes in the world. (Quézel et Médail). The study of vegetation concerns the description of groups of species and their stationary conditions. According to (Ozenda 1964), vegetation is defined as a set of plants gathered in the same station as a result of identical or similar ecological requirements. Biodiversity is a term formed from "biological diversity", which includes three levels of biological variability: complexity of the ecosystem, richness of species and genetic variations (Roberto et al 2000). The biogeographic analysis of the current flora present on the Mediterranean rim is likely to provide valuable information on the methods of their establishment, in particular in the light of historical paleo data. The objective of work is to study the dynamics of the vegetation of *Lavatera maritima* in the West region of Algeria

MATERIAL AND METHODS

The surveys were carried out during optimal vegetation periods from March to June during 2018. The coordinates of the stations were obtained using a GPS. Each of these statements understands the general characteristics linked to the station itself. These are place and date; altitude; slope; the exhibition; the nature of the substrate; plant cover. Currently, the survey method is based on the method of Braun-blanquet (1951) Zurich-Montpellier, which consists of determining the smallest area called minimum area (Gounot 1969).

RESULTS AND DISCUSSION

The analysis of the floristic procession indic Tindicate that the indicate tha t most represented families in Rachgoune: are Asteracea (18) followed by Poaceae (7), and Fabaceae,Chenopodiaceae (4) hereas in in-Oulhassaalso dominate famliy was Asteracea (8) followed by Poaceae (6), and Lamiaceae (4). There was heterogeneity in the distribution of genera and species between families. The high percentage of Asteraceae followed by Poaceae explains the low recovery rate of the tree layer and the invasion of the station by species belonging to the herbaceous layer. Some species have a low percentage of presence of species compared to other families but ecologically their role is very important in the study area these are the Cupréssaceae and Plantaginaceae.

The results obtained show that the distribution of the biological types of Rachgoune station was Th> He> Cam> Ge> Ph in Rechgoun station. The therophytes present the highest rate, which shows a very strong anthropic action. The pasture enriches the soil with nitrates and allows the development of ruderal plants, particularly annuals. In addition to anthropization, therophytization is said to originate in the phenomenon of aridification. The hemicryptophytes keep a particularly important place. The chamaephytes and geophytes occupy the third position. The rate of phanerophytes remains low; this explains its degraded state. In the Oulhassa station, the Therophytes were best represented with a percentage of 45%, the Chamaephytes 30%, the Hemicryptophytes 17%, the Geophytes 05% and finally the Phanerophytes 3%. In both stations, the rate of Phanerophytes always remains rare compared to the other biological types. From a morphological point of view, our study area shows that the majority of our species are annual herbs. These species with high production of "R" strategy are favored by a short biological cycle (a few weeks to a few months) which allows them to occupy the soil during the brief periods favorable to their development and this in all the bioclimatic groups and all the vegetation stages (Quezel 2000). For our Rachgoune station, the plant formations marked by their heterogeneity between woody and herbaceous plants, on the one hand, and perennials and annuals, on the other. Perennial herbs are dominant with 40.67%; next come the annual

Table 1. Number of family inventories in the two stations

Family	Rachgoune	Oulhassa
Asteraceae	18	8
Primulaceae	0	1
Lamiaceae	0	4
Liliaceae	2	1
Asphodelaceae	0	1
Poaceae	7	6
Palmaceae	1	1
Cistaceae	0	2
Fabaceae	4	2
Convolvulaceae	1	1
Cucurbitaceae	0	1
Boraginaceae	1	1
Zygophyllaceae	0	1
Apiaceae	2	1
Papaveraceae	0	1
Pinaceae	0	1
Plantaginaceae	3	1
Caryophylaceae	0	1
Hyacinthaceae	0	1
Malvaceae	2	1
Solanaceae	0	1
Rhamnaceae	0	1
Chenopodiaceae	4	0
Aristolochiaceae	1	0
Scrofulariaceae	2	0
Brassicaceae	2	0
Cesalpineae	1	0
Cupressaceae	1	0
Juncaceae	1	0
Oxalidaceae	1	0
Oleaceae	1	0
Polygonaceae	2	0
Anacardiaceae	1	0
Tamaricaceae	1	0

Table 2. Percentages of biological types in study stations (%)

Biological types	Rachgoune	Oulhassa
Ph	8, 47	3
Ch	16.94	30
Ge	16.94	5
Th	35.59	45
He	22.03	17

Table 3. Percentages of morphological types in the two study stations (%)

Morphological types	Rachgoune	Oulhassa
L.v	20.3	20
H.v	40.67	32
H.a	38.98	48

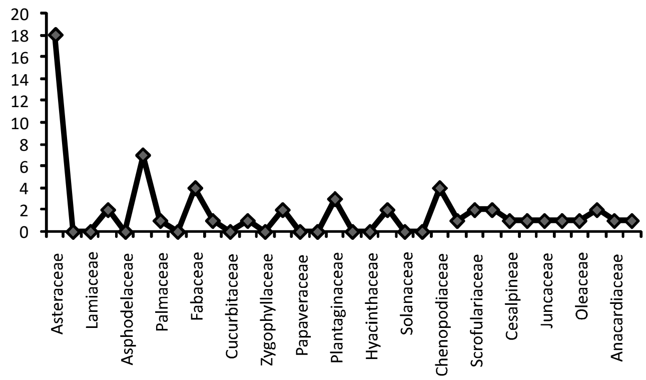


Fig. 1. Family breakdown in the Rachgoune resort

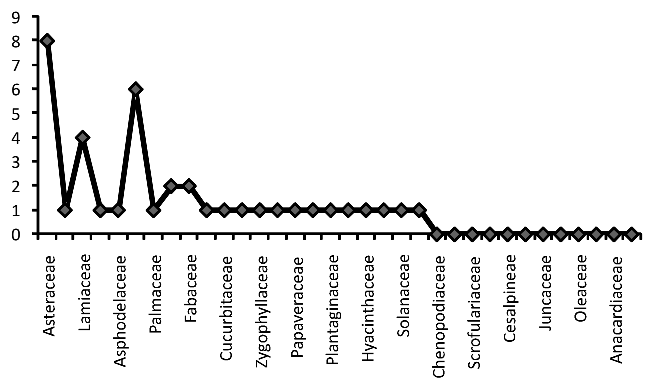


Fig. 2. Family breakdown in Oulhassa station

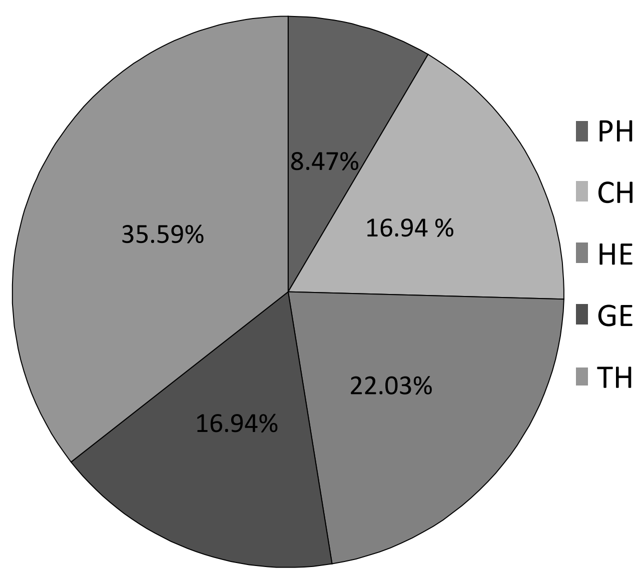
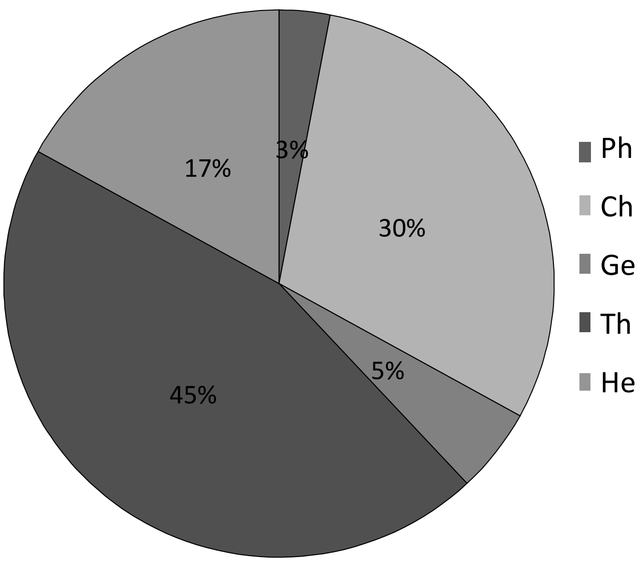


Fig. 3. Biological types of the floristic procession of the Rachgoune station

herbaceous plants with 38.98% and finally the perennial woody plants with a 20.33%. The Oulhassa station dominates annual herbaceous plants with a percentage of 48%, followed by perennial herbaceous plants (32%) and finally 20% for perennial woody plants.

Disturbance index: The strong degradation caused by human action is clearly visible (land clearing, fires, pastures and urbanization). (Barbero et al 1990) point out that the disturbances caused by man and his herds are numerous and correspond to two increasingly severe situations ranging from cropping up to desertification through steppization. The disturbance index for the Rachgoune station was 52.54% and for the Oulhassa station 74.35%. It also shows that the therophytisation of the area following steppisation which is considered to be the final stage of degradation of the different ecosystems with the dominance of sub-nitrophilic species linked to overgrazing (Barbero et al 1990).



Ph : Phanerophyte, Ch: Chamaephyte, Ge: Géophyte, Th: Therophyte, He: Hémicryptophyte

Fig. 4. Biological types of the floristic procession of the Oulhassa station

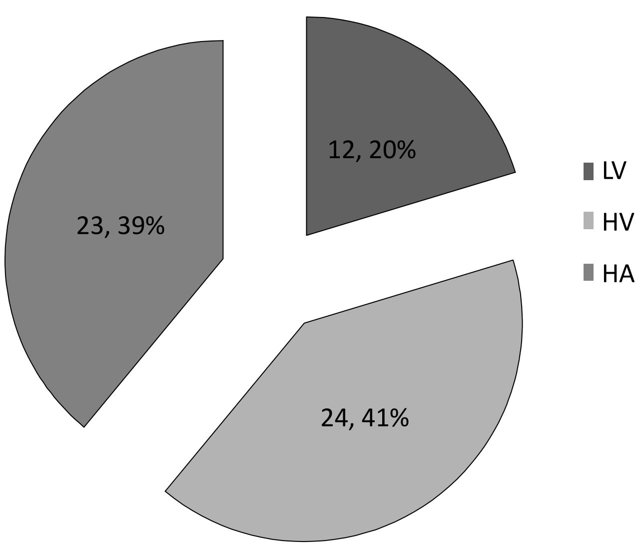
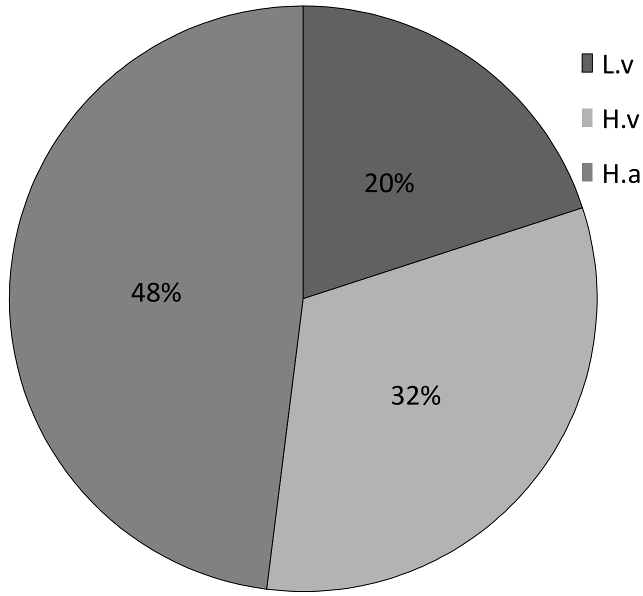


Fig. 5. Percentages of morphological types of the Rachgoune station



Ha: annual herbaceous, Hv: perennial herbaceous, L.v: perennial woody

Fig. 6. Percentages of the morphological types of the Oulhassa station

CONCLUSION

The flora of the two stations Rachgoune and Oulhassa are rich and are diversified, which reinforces the interest for the protection and the conservation of the biodiversity. The exhaustive inventory carried out at two study stations (Rachgoune and Oulhassa) allowed us to carry out biological and morphological characterizations and to bring out that Asteraceae dominâtes on the grounds annual herbaceous species largely dominates . The importance of Therophytes confirms the phenomenon of Therophytization. The dominance of the Therophytization character is linked to the invasion of annual species, disseminated by herds especially in the study area. The biological and phytogeographical diversity is conditioned by climatic factors which play an essential role for a very large part of the vegetation in order to favor the process of biological ascent.

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Seasonal Incidence and Influence of Weather Factors on Population Dynamics of Blossom Midge, *Contarinia maculipennis* Felt in Jasmine (*Jasminum sambac* L.)

I. Merlin Kamala

Department of Agricultural Entomology
Tamil Nadu Agricultural University, Coimbatore-641 003, India
E-mail: merlinento@gmail.com

Abstract: A study was conducted to assess the population dynamics of blossom midge in infesting jasmine in two different climate zones, Madurai and Coimbatore District of Tamil Nadu. The occurrence of blossom midge, *Contarinia maculipennis* was less severe during December till March, where the midge incidence varied from 10.30to 34.27 per cent in Madurai District, while the incidence was minimum from December till April in Coimbatore district with the midge incidence from 9.96 to 31.58 per cent. The midge incidence showed a steady increase during summer months in both the districts. The blossom midge incidence in jasmine had a significant positive correlation with maximum temperature; sunshine hours and wind velocity, while significant negative correlation with minimum temperature.

Keywords: Population dynamics, *Contarinia maculipennis, Jasminum sambac,* Madurai, Coimbatore, Correlation

Jasmine (*Jasminum sambac* L.) known in persian as Yasmin, is one of the oldest fragrant flowers of India. It is traditionally as well as commercially cultivated for its sweet-scented flowers. In India, jasmine occupies an area of about 8,000 ha with an annual production of flowers worth Rs. 80-100 million. Tamil Nadu is the leading producer of jasmine in the country with an annual production of 77,247 tonnes in an area of 9,360 ha (Prakash and Muniandi 2014). Jasmine flowers and unopened buds have a wide range of usage in the community in social and religious ceremonies for decoration (Thakur et al 2014). Jasmine flowers are of high demand in perfume industries for jasmine based perfumes, tea factories for flavoured 'jasmine tea' and in medicinal field adhering to its medicinal properties (Kanniamal and Divya 2016). As the demand for high grade perfumes has greatly increased in recent times, there is tremendous scope for the production of concretes and oils from jasmine flowers. There are many factors that affect jasmine production, of which pest incidence takes major lead. Among the arthropods attacking jasmine, blossom midge, *Contarinia maculipennis* is one of the prime pests which devastates the productivity of the crop. In view of this, it is of prime importance to monitor the population build-up of midges as influenced by weather factors, so that suitable management strategy could be taken up when such a favourable climatic change occurs besides forecasting the likelihood of occurrence of midge incidence. With this idea, field investigations were conducted in two different climatic zones of Tamil Nadu, Madurai and Coimbatore district.

MATERIAL AND METHODS

Field investigations were carried out in two different agro climatic regions *viz.,* Coimbatore and Madurai district to assess the seasonal fluctuation or temporal variation of blossom midge*, Contarinia maculipennis* in local variety "Ramnad Local' at Agricultural College and Research Institute, Madurai and Botanical Garden premises, Tamil Nadu Agricultural University Coimbatore. The midge incidence was recorded on five randomly selected plants per plot at fortnightly interval continuously for one year (June 2015-May 2016) by counting the number of pink discoloured and bud stalk shrivelled buds as well as total number of buds. The mean midge incidence was correlated with the weather parameters *viz.*, maximum and minimum temperature, sunshine hours, rainfall, relative humidity and wind velocity. The weather data of Madurai and Coimbatore district was collected from the Meteorological observatory of Department of Agronomy, Agricultural College and Research Institute, Madurai and Tamil Nadu Agricultural University Coimbatore-3.

RESULTS AND DISCUSSION

The occurrence of blossom midge, *Contarinia maculipennis* was less severe in winter *ie* from December till March and December-April due to the prevalence of moderate temperature and RH, along with receipt of frequent and sharp showers in both the districts (Table 1). The midge incidence varied from 10.30 (December) to 21.64 (March) in Madurai. The midge population reached its peak during

October (34.27%) followed by November (33.62%) and September (32.68%) in Madurai district. The peak population of midges started declining from November, with sharp decline in December, January and February. Again, the midge population, started to rebound in March, steadily increasing in April, May, June, July and August, attaining peak status in September followed by October. The incidence of blossom midge, *C. maculipennis* also showed a similar trend in Coimbatore district. The maximum occurrence was in October (31.58%) followed by September and November and minimum occurrence in January (9.96%). The population started increasing with the onset of summer months in April-August. However, the midge incidence reached maximum in September followed by October and November. The population again started decline with the onset of winter months. Moreover, the number of pink shrivelled buds was also maximum in October (18.10 buds plant^{-1}). Neelima (2005) reported similar trend with reference to population dynamics of *C. maculipennis* in Jasmine (Fig. 2).

The blossom midge incidence was also positively correlated for maximum temperature (r = +0.688) and (r= +0.439) and negatively for relative humidity (r=-520) and (r= -0.559) and rainfall (r= -0.504) and (r=-0.543) in Madurai and Coimbatore districts, respectively (Table 2). Vanitha (2002) observed that blossom midge, *C. maculipennis* showed a significant positive correlation with maximum temperature and negative correlation with relative humidity and rainfall. Isabel (1996) also supported that both maximum as well as the minimum temperatures were positively correlated with blossom midge incidence. Rainfall caused a wash out effect over the midge population significantly reducing their spread and intensity of damage and could observe a drastic decrease in incidence and population in rainy period (Table 3). From the multiple linear regression analysis between weather parameters and abundance of blossom midge it is evident that the maximum temperature (T_{max}) and minimum temperature (T_{min}) had significant contribution towards the abundance of midges with R^2 of 0.822 and 0.875 in Madurai and Coimbatore districts. With 1°C increase in maximum temperature (T_{min}), midge per cent increased by 3.80 and 5.19 per cent, whereas, with 1°C decrease in minimum temperature (T_{min}), midge population decreased by 1.117 and 6.131, respectively in Madurai and Coimbatore districts. Nevertheless, an increase in RH by one per cent there was a

Table 1. Influence of weather factors on population dynamics of blossom midge, *Contarinia maculipennis* in Jasmine ecosystem (June 2015 to May 2016)

Month	Madurai district		Coimbatore district	
	No. of pink discoloured buds plant^{-1}	Per cent midge incidence	No. of pink discoloured buds plant^{-1}	Per cent midge incidence
June	13.60^{c}	25.18^{c}	10.20	21.42
July	15.80^{b}	26.49^{b}	13.10	23.54
August	16.30^{b}	27.15^{c}	14.60	24.96
September	18.70	32.68^{d}	16.30	30.41
October	20.10^{a}	34.27^{a}	18.10	31.58
November	17.30^{b}	33.62^{b}	15.60	29.65
December	7.20^{cd}	13.54^{e}	5.30	11.25
January	4.30	10.30^{f}	2.40	9.96
February	8.30^{e}	19.42^{g}	7.40	14.50
March	9.70^{de}	23.64^{d}	9.60	18.36
April	12.40	23.45	10.90	19.38
May	14.30	24.15	11.80	20.47

Table 2. Correlation between weather parameters on seasonal abundance of blossom midge, *Contarinia maculipennis* in Jasmine eco-system in Madurai and Coimbatore district during 2015-2016

Weather parameters	Correlation coefficient	
	Madurai district	Coimbatore district
Maximum temperature (T_{max}) (°C)	0.688*	0.439^{NS}
Minimum temperature (T_{min}) (°C)	0.555^{NS}	0.045^{NS}
Relative humidity (%)	-0.520^{NS}	-0.559^{NS}
Rainfall (mm)	-0.504^{NS}	-0.543^{NS}
Sunshine (hrs)	0.336^{NS}	0.317^{NS}
Wind velocity (km hr^{-1})	0.080^{NS}	0.014^{NS}

Correlation coefficient is significant at 0.05 % level (one-tailed)

Table 3. Multiple linear regression analysis for the prediction of blossom midge, *Contarinia maculipennis* in Jasmine eco-system in Madurai and Coimbatore district during 2015-2016

Variables	Regression coefficient	
	Madurai district	Coimbatore district
Intercept (a)	-90.04*	49.607*
Maximum temperature (T_{max}) (°C)	3.808*	5.199*
Minimum temperature (T_{min}) (°C)	-1.117*	-6.131
Relative humidity (%)	0.451	-0.981
Rainfall (mm)	-0.947*	1.712
Sunshine (hrs)	-1.293*	-1.749
Wind velocity (km hr^{-1})	-3.06*	2.206
R^2	0.822	0.875

Regression equations

1) Y_1 = 90.04*+ 3.808*X1 -1.117*X_2+0.451X_3-0.947 X_4*-1.293X_5*-3.06* X_6

2) Y_2 = 49.607*+5.199*X_1-6.131X_2-0.981X_3 +1.712X_4- 1.749X_5 +2.206X_6

decrease in two spotted midge population by 0.451 and 0.981 numbers in both districts, respectively. The increase in sunshine hours by 1 hour increased the midge numbers by 1.293 and 1.749 in both the districts and an increase in wind velocity by 1 km hr^{-1} boosted the midge population significantly by 3.06 and 2.206 numbers.

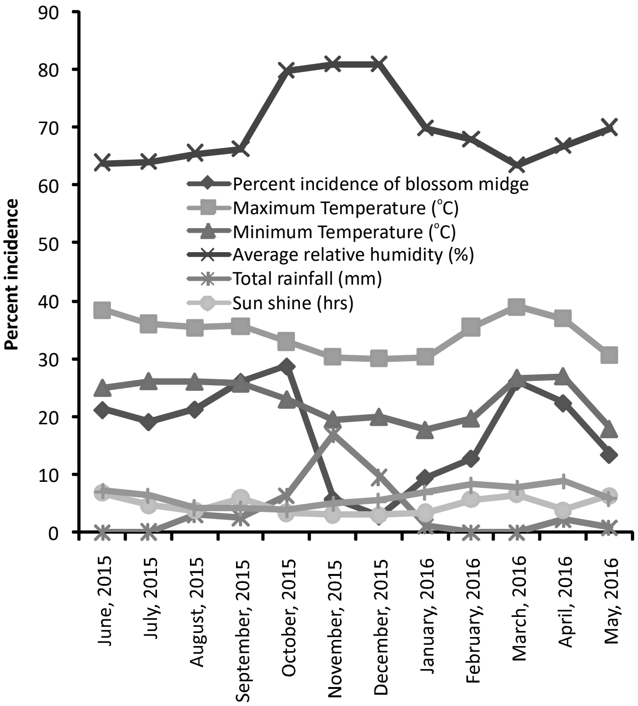

Fig. 1. Influence of weather parameters on seasonal abundance of blossom midge, *Contarinia maculipennis* in Madurai district

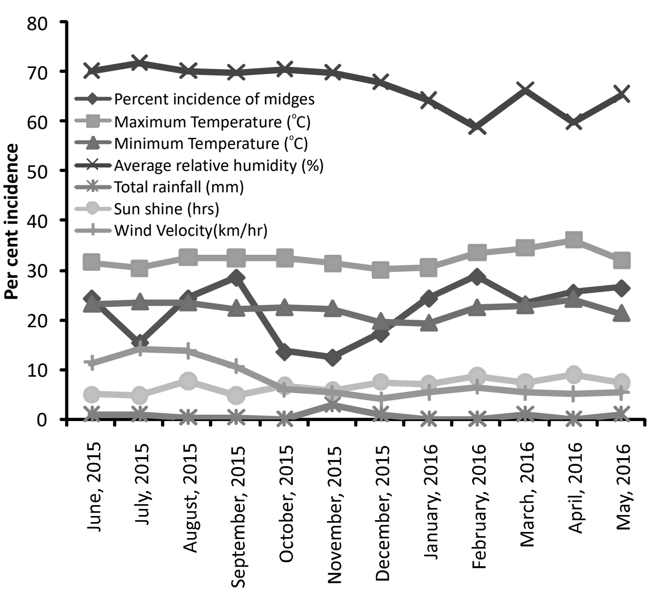

Fig. 2. Influence of weather parameters on seasonal abundance of blossom midge, *Contarinia maculipennis* in Coimbatore district

The influence of weather parameters on jasmine pest population is immensely needed for chemical interventions. There is a sudden decrement in the midge incidence in December and January. In winter months, flower production is very low due to mist damage and most gardens are pruned; therefore less access to food. Moreover, blossom midges require mild weather for their survival and hence their population is inevitable with the outset of summer months. The positive correlation with maximum temperature shows the scope of build-up of blossom midge with the increase in temperature, which demands timely intervention to check the population. The negative correlation with rainfall highlights the natural reduction of pest population.

CONCLUSION

Blossom midge, *C. maculipennis* is observed as a key pest of jasmine in different agroclimatic regions of Tami Nadu. The peak population of midge was observed in October, November and September months in both the region. A stable rise in midge population was noticed in summer months. The maximum temperature, sunshine hours and wind velocity were positively corelated and minimum temperature was negatively corelated with the midge population.

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Influence of Liquid Formulations of Beneficial Microorganisms on Biocontrol Efficiency, Seedling Vigour Index and Growth of Spinach (*Spinacia oleracea*) under Green House Condition

H. Gurumurthy, M.K. Shivaprakash and C.C. Maina

Department of Agricultural Microbiology, UAS, GKVK, Bengaluru-560 065, India
Email: gurumurthyh.8031@gmail.com

Abstract: The study was conducted at Department of Agricultural Microbiology, UAS, GKVK, Bangalore. There were eight treatments replicated thrice in CRD design. Liquid bioinoculants used in this study were *viz*., *Azotobacter chroococcum*, *Bacillus megaterium*, *Frateuria aurantia*, *Psuedomonas fluorescens*, *Bacillus subtilis* and *Trichoderma viridae* as single inoculation and also as consortia. Treatment T_8 (Pathogens+ *Bacillus subtilis* + *Pseudomonas fluorescens* + *Trichoderma viride*) recorded maximum biocontrol efficiency (82.92%) and vigour index (1997.42) followed by T_7 (58.91% and 1707.87). Growth parameter like maximum plant height (5.80 cm at 15 DAS, 15.57 cm at 21 DAS and 37.03 cm at 30 DAS) was recorded in T_5. Maximum number of leaves (5.30 at 15 DAS, 9.47 at 21 DAS and 12.97 at 30 DAS) was recorded in T5 which received consortia of *Azotobacter chroococcum, Bacillus megaterium, Frateuria aurantia, Pseudomonas fluorescens, Bacillus subtilis* and *Trichoderma viride*. Maximum root length, shoot length, plant fresh weight and plant dry weight were 10.40 cm, 37.03 cm, 9.37 g and 3.27 g, respectively, recorded in T_5 followed by single inoculation and control treatments.

***Keywords*:** Liquid bioinoculants, Biocontrol efficiency, Seedling vigour index, Spinach

Humans had tremendous knowledge on edible plants before civilization. Traditional vegetables are valuable sources of nutrition in rural areas. The health and nutrition of expanding world population is major upcoming challenges especially in developing countries. Green leafy vegetables were used since ancient periods as source of food as they contain many nutrients and minerals which are helpful in maintaining human health. Abbey et al (2006) suggested the need to consume vegetable meals to prevent colon and stomach cancers. It is advisable to include at least 50 g of green leafy vegetables daily in one's diet (Singh and Kalloo 2000). Ball (2006) reported that high vitamin, dietary fibre and mineral contents of vegetables plays a major role in maintaining alkalinity of the body. Green leafy vegetables like spinach, amaranthus, fenugreek and coriander *etc*. are rich source of calcium, magnesium, iron and bicarbonate as well as vitamin C, riboflavin and folic acid.

Biofertilizer is a substance which contains living microorganisms which, when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth promoting substances. The microorganisms in bio-fertilizers restore the soils natural nutrient cycle and build soil organic matter. Through the use of biofertliizers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Since they play several roles, a preferred scientific term for such beneficial bacteria is Plant-Growth Promoting Rhizobacteria (PGPR). Therefore, they are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through microorganism and their by-products (Vessey 2003). Liquid formulation is a budding technology in India and has very specific characteristics and uniqueness in its production methods. Liquid biofertilizers are the microbial preparations containing specific beneficial microorganisms which are capable of fixing or solubilizing or mobilizing plant nutrients by their biological activity (Mahdi et al 2010).

Spinach (*Spinacea oleracea*) is a cool season vegetable annual crop. The rosette of leaves produced during vegetative phase is used as vegetable. Indian spinach commonly known as palak or beet leaf is native of Central and Western Asian region. This study was conducted to study the efficacy of liquid bioinoculant for biocontrol, seedling vigour index and growth on spinach (*Spinacia oleracea*) under greenhouse condition.

MATERIAL AND METHODS

A seedling tray experiment was conducted to evaluate the antagonistic and growth promoting effect of the liquid consortia of biocontrol agents in substrate enriched with biocontrol agents against pathogen under greenhouse condition in the Department of Agricultural Microbiology UAS. GKVK, Bangalore with treatments (Table 1).

Preparation of substrates and seedling trays: The substrate was prepared by mixing 10 kilograms of coir pith with 2.5 kilograms each of red earth, perlite, vermicompost and pongamia cake and was autoclaved in autoclavable polybags and filled into large polythene bags and were inoculated with pathogens *viz., Fusarium* sp.*, Phytophthora* sp.*, Pythium* sp. and *Rhizoctonia* sp. and biocontrol agents @ 100 grams /kg one week prior to sowing. The trays were filled with these mixtures and sowing was taken up in replications and was watered daily. The following observations related to germination *viz*., germination percentage, percent pre-emergence and post emergence disease incidence, Seedling vigour index (SVI), shoot and root length, bio control efficiency were recorded.

Percent pre-emergence disease incidence, post-emergence disease incidence and seedling vigour index was calculated (Abdul-Baki and Anderson 1973). Biological control efficacy was also calculated (Guo et al 2004).

For assessing the growth promotion and biocontrol activities of liquid formulations on spinach in raised beds land was dug and soil was brought to fine tilth and plots having a dimension of 1m × 1m were prepared. FYM and vermicompost were applied at the rate of 12.5 t ha^{-1} 15 days prior to sowing Microbial inoculants were applied to each plot as per required treatment as soil application seven days before sowing. Sowing was taken up and the beds were regularly watered and maintained and observations were recorded at regular intervals. The treatment details are as follows. T_1: Control, T_2: *A. chroococcum* (A.c) + *B. megaterium* (B.m) + *F. aurantia* (F.a), T_3: *A. chroococcum* A.c) + *B. megaterium* (B.m) + *F. aurantia* (F.a) + *B.subtilis* (B.s), T_4: *A. chroococcum* (A.c) + *B. megaterium* (B.m) + *F. aurantia* (F.a) + *T.viride* (T.v), T_5: *A. chroococcum* (A.c) + *B. megaterium* (B.m) + *F. aurantia* (F.a) + *T.viride* (T.v) + *P. fluorescens* (P.f) + *B.subtilis* (B.s), T_6: *A. chroococcum* (A.c) + *B. megaterium* (B.m) + *F. aurantia* (F.a) + *P. fluorescens* (P.f), T_7: *A. chroococcum* (A.c) + *B. megaterium* (B.m) + *T.viride* (T.v) + *B.subtilis* (B.s) T_8: *A. chroococcum* (A.c) + *B. megaterium* (B.m) + *P. fluorescens* (P.f) + *T.viride* (T.v) (Table 3). Observations related to plant growth *viz*., plant height (cm), number of leaves, shoot length (cm), root length (cm), fresh weight and dry weight of plants (g) were recorded at regular intervals.

RESULTS AND DISCUSSION

An increase in germination percentage, and reduced pre emergence and post emergence disease incidence in Palak seedlings was observed when treated with liquid consortia of both biocontrol agents and PGPRs in different combinations (Table 1). Highest biocontrol efficiency (82.92 %) was recorded in T8 and was significantly higher than T7 (58.91 %).

Various reports have shown the biocontrol potential of *Trichoderma* sp*, Pseudomonas* sp and *Bacillus* sp against many plant pathogens *viz., Rhizoctonia* sp.*, Pythium* sp.*, Fusarium* sp. and *Phytophthora* sp. Karthikeyan et al (2003) reported the suppression of growth of *Phytophthora cinnamomi* by *Trichoderma* sp. Saikia et al (2004) observed that, *Pseudomonas aeruginosa* RS B29 inhibited the growth of *Fusarium oxysporum f.sp.ciceri, Fusarium udam, Fusarium solani, Rhizoctonia solani* and *Macrophomina phaseolina* under *in vitro* conditions by producing an antifungal metabolite.

Highest root length (6.10 cm) was in (T7) (*Pseudomonas fluorescence* and *Trichoderma viride*) followed by T8 (5.80 cm). Highest shoot length (18.17 cm) was in T8 followed by treatment T7 (17.10 cm). Maximum root dry weight (0.071 g) was in T6 and significantly higher than other treatments followed by T5 (0.67 g). Highest shoot dry weight (0.31 g) was in T8 (Pathogens + *Bacillus subtilis, Pseudomonas fluorescence* and *Trichoderma viride*) followed by T7 (0.28 g). Maximum vigour index (1997.42) was with T8 (Pathogens + *Bacillus subtilis, Pseudomonas fluorescence* and *Trichoderma viride*) followed by T7 (1707.87). Treatments receiving pathogens alone recorded least vigour index (477.79).

Afsharmanesh et al (2005) reported that an important group of biocontrol agents suppressed the fungal rot and seedling disease by production of antifungal metabolites such as 2-4 diacetyl phloroglucinol, pyoluetorin, pyrolnitrin, siderophores and HCN. Chitinases have been found to be directly involved in the mycoparasitic interaction between *Trichoderma* and its host fungus. Kavitha et al (2005) reported the effectiveness of *Bacillus subtilis* and *Pseudomonas* spp. against *Pythium aphanidermatum* causing damping off of chilli under *in vitro* conditions. The biopesticide ability of indigenous *Bacillus subtilis* as a biocontrol agent against cowpea fungal pathogens *Fusarium* sp, and *Rhizoctonia solani* isolated from diseased cowpea in the northern Guinea savanna has been reported by Killani et al (2011).

Growth and yield of palak: At 15 DAS, T5 (*Azotobacter chroococcum, Bacillus megaterium, Frateuria aurantia, Pseudomonas fluorescens, Bacillus subtilis* and *Trichoderma viride*) recorded significantly highest plant height (5.80 cm) compared to T6 (5.67 cm) and are at par with each (Table 3). At 21 DAS, T5 recorded maximum plant height (15.57 cm) followed by T6 (15.20 cm) and T7 (15.00 cm) which were on par with each other. At 30 DAS, maximum plant height (37.03 cm) was in the treatment T5 followed by T6 (32.67 cm) and T7 (32.60 cm). Treatments T6 and T7 are at par with each other.

The liquid bioinoculants also have positive influence on number of leaves and at 15 DAS, T5 recorded maximum number of leaves (5.30) followed by T6, T7 and T8, T6, T7 and T8 are significantly at par with each other. Lowest number of leaves (3.57) was observed in uninoculated control (T1). At 21 DAS, maximum number of leaves (9.47) was recorded in T5 (*Azotobacter chroococcum, Bacillus megaterium, Frateuria aurantia, Pseudomonas fluorescens, Bacillus subtilis* and *Trichoderma viride*), followed by T6 and were at par each other. Uninoculated control (T1) which received no liquid bio inoculants recorded lowest number of leaves (6.70). Observations were recorded at 30 DAS. T5 recorded significantly higher number of leaves (12.97) followed by T6 (12.73) and T5 and T6 were on par with each other. T1, which did not contain any bio-inoculant recorded lowest number of leaves (10.50).

Maximum root length was in the treatment T5 followed by T6. Lowest root length was in the uninoculated control. Maximum shoot length also followed the same trend. T6 and T7 are at par with each other. Significantly lowest shoot length was recorded in the untreated control. The maximum plant fresh weight was recorded in the treatment T5 followed by T6. Significantly lowest plant dry weight was recorded in the untreated control. Maximum plant dry weight was recorded in T5 followed by T6. Lowest plant dry weight was recorded in the untreated control.

Plant growth benefits due to the addition of PGPRs include increase in germination rates, root growth, yield shoot and root weights and delayed leaf senescence (Lucy *et al*., 2004). The efficacy of microbial consortium of *Bacillus* sp, *Azotobacter* sp and *Frauteria* sp. for its plant growth promoting efficacy in black gram (*Vigna mungo* (L.) Hepper) has been reported by Maiyappan et al (2010). Mahakavi et al (2014) worked on efficiency of biofertilizers on *Arachis hypogea* and they reported that the combined application of biofertilizers (*Rhizobium leguminosarum* and *Bacillus*

Table 1. Biocontrol efficiency of liquid formulations of beneficial microorganisms in Palak grown in seedling trays under greenhouse condition

Treatments	Percent germination	Days taken for 50 percent germination	Pre-emergence disease incidence (per cent)	Post-emergence disease incidence (per cent)	Biocontrol efficiency (per cent)
T_1	51.32^{g}	5.17^{a}	42.33^{a}	14.29^{a}	0.00^{g}
T_2	55.22^{f}	5.00^{a}	24.31^{d}	8.91^{b}	5.34^{f}
T_3	57.60^{e}	5.00^{a}	35.00^{b}	5.60^{c}	4.00^{f}
T_4	65.30^{d}	4.00^{a}	16.71^{f}	6.12^{c}	16.00^{e}
T_5	73.27^{c}	4.07^{a}	28.31^{c}	4.76^{d}	33.02^{d}
T_6	76.40^{b}	4.00^{a}	17.91^{e}	2.38^{e}	47.10^{c}
T_7	73.90^{c}	4.00^{a}	15.03^{g}	0.12^{f}	58.91^{b}
T_8	83.34^{a}	4.00^{a}	9.75^{h}	0.15^{f}	82.92^{a}

Note: Means with the same superscript do not differ significantly @ P=<0.05 as per DMRT

T_1: Control (Pathogens alone)
T_2: Pathogens + *Bacillus subtilis*
T_3: Pathogens + *Pseudomonas fluorescens*
T_4: Pathogens + *Trichoderma viride*
T_5: Pathogens + *Bacillus subtilis* + *Pseudomonas fluorescens*
T_6: Pathogens + *Bacillus subtilis* + *Trichoderma viride*
T_7: Pathogens + *Pseudomonas fluorescens* + *Trichoderma viride*
T_8: Pathogens + *Bacillus subtilis* + *Pseudomonas fluorescens* + *Trichoderma viride*

Table 2. Efficiency of liquid formulations of beneficial microorganisms in enhancing seedling vigour of Palak grown in seedling trays under greenhouse condition

Treatments	Root length (cm)	Shoot length (cm)	Root dry weight (g)	Shoot dry weight (g)	Vigour index
T_1	3.30^{c}	6.01^{g}	0.031^{e}	0.16^{a}	477.79^{f}
T_2	4.20^{bc}	10.11^{f}	0.021^{f}	0.18^{a}	790.34^{e}
T_3	4.50^{abc}	14.31^{d}	0.041^{d}	0.27^{a}	1083.47^{d}
T_4	4.70^{abc}	15.02^{d}	0.053^{bc}	0.22^{a}	1287.70^{c}
T_5	5.00^{abc}	13.21^{e}	0.067^{a}	0.13^{a}	1334.17^{c}
T_6	5.30^{ab}	16.11^{c}	0.071^{a}	0.19^{a}	1635.69^{b}
T_7	6.10^{a}	17.01^{b}	0.058^{b}	0.28^{a}	1707.87^{b}
T_8	5.80^{ab}	18.17^{a}	0.051^{c}	0.31^{a}	1997.42^{a}

See Table 1 for details

Table 3. Growth and yield of Palak as influenced by liquid formulations of beneficial microorganisms in raised beds under greenhouse condition

Treatments	Plant height (cm)			Number of leaves			Root length (cm)	Shoot length (cm)	Plant fresh weight (g)	Plant dry weight (g)
	15 DAS	21 DAS	30 DAS	15 DAS	21 DAS	30 DAS				
T_1	3.30^{d}	11.23^{e}	27.17^{f}	3.57^{c}	6.70^{d}	10.50^{e}	5.80^{g}	27.17^{f}	5.73^{e}	1.53^{e}
T_2	4.83^{c}	12.97^{d}	29.10^{e}	4.27^{b}	7.30^{c}	11.07^{d}	6.80^{f}	29.10^{e}	6.47^{d}	1.80^{de}
T_3	$4.90b^{c}$	13.03^{d}	30.37^{d}	4.30^{b}	7.60^{c}	11.10^{d}	7.50^{e}	30.37^{d}	6.71^{d}	2.07^{d}
T_4	$5.10b^{c}$	13.63^{cd}	30.70^{cd}	4.37^{b}	8.40^{b}	11.63^{c}	8.20^{d}	30.70^{cd}	7.62^{c}	2.87^{b}
T_5	5.80^{a}	15.57^{a}	37.03^{a}	5.30^{a}	9.47^{a}	12.97^{a}	10.40^{a}	37.03^{a}	9.37^{a}	3.27^{a}
T_6	5.67^{a}	15.20^{ab}	32.67^{b}	4.60^{b}	9.37^{a}	12.73^{a}	9.70^{b}	32.67^{b}	8.59^{b}	3.03^{ab}
T_7	5.23^{b}	15.00^{ab}	32.60^{b}	4.40^{b}	8.67^{b}	12.13^{b}	8.90^{c}	32.60^{b}	7.90^{c}	2.87^{b}
T_8	$5.17b^{c}$	14.53^{bc}	31.10^{c}	4.33^{b}	8.27^{b}	11.77^{bc}	7.80^{de}	31.10^{c}	7.40^{c}	2.47^{c}

See Table 1 for details

megaterium) increased root length, shoot length, number of lateral root, total leaf area, fresh weight and dry weight compared with other application and control. It has been reported that inoculation in chickpea with both *Pseudomonas fluorescens* and *Rhizobium* enhanced stem height; root length and dry weight of Chick pea (Dileep Kumar et al 2001).

CONCLUSION

A wide range of vegetables can be grown in the Indian subcontinent as it has a variety of natural habitat, climate and season. Leafy vegetables are grown throughout the year in all parts of the country and are affected by several diseases of fungal, bacterial and viral origin and results in 50-60 % crop loss. The treatment with Pathogens + *Bacillus subtilis* + *Pseudomonas fluorescens* + *Trichoderma viride* was shown highest biocontrol efficiency (82.92 per cent) and also maximum seedling vigour index of the plants (1997.42). Among all treatments, T_5 (*Azotobacter chroococcum, Bacillus megaterium, Frateuria aurantia, Pseudomonas fluorescens, Bacillus subtilis and Trichoderma viride*) recorded maximum plant height, number of leaves at different days of sowing and also root length, shoot length, plant fresh weight and dry weight at different intervals of crop growth which were grown on raised beds under green house conditions.

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Spatial and Temporal Spread of *Uromyces viciae-fabae* Causing Pea Rust

Simranjit Singh, Amarjit Singh and Sandeep Jain

Department of Plant Pathology, Punjab Agricultural University, Ludhiana-141 004, India
E-mail: simranbadhan-pp@pau.edu

Abstract: Intensity and spread of the pea rust disease were highly influenced by the wind direction. The disease started spreading from infection foci after two week of inoculation. A foci was set in the centre of the experimental plot. The intensity of disease spread was more towards the south western side. The minimum of 30 per cent disease was observed after 7 weeks in the whole plot during both the seasons. The maximum disease 70 per cent was located up to 2-3 meters from the focus in all the directions near the maturity of crop after 7th week during both the seasons. The velocity of the rust spread was observed 0.83-0.89 m week^{-1}.

***Keywords*:** Foci, *Uromyces viciae-fabae,* Spread, Directions and disease severity

Grain legumes are important crops which can decrease the marked deficit of high-protein feed stuff and contribute to a large extent to the sustainability of crop-livestock systems (Annicchiarico and Iannucci 2008). Among them, dry pea (*Pisum sativum* L.) is the second most important food legume crop in the world because of its high yield potential (Rubiales et al 2011, Smýkal et al 2012). Pea rust has become an important pathogen of dry pea since the mid-1980s and is mostly distributed in Europe, North and South America, India, China, Australia and New Zealand, particularly in regions with warm, humid weather. The pathogen usually appears during mid-spring when the crop is at flowering or podding stage. In years of epidemics, affected leaves dry up and fall off, and pods remain undeveloped, which consequently results in yield losses of higher than 30% (EPPO 2012). The importance of the ecological setting has been further stressed in recent heuristic arguments that detail a variety of ways in which life-history attributes of hosts and pathogens, interacting over space and time, may shape the spatial scale of interaction meta-populations and have significant implications for the relative effectiveness of different disease-resistance mechanisms.

MATERIAL AND METHODS

Main season susceptible variety Pb-89 was planted in 8 m x 8 m plots replicated thrice in the field at, Punjab Agricultural University, Ludhiana, during two consecutive seasons, i.e. 2016-17 and 2017-18. The crop was sown in mid-November by following recommended package of practices for vegetable crop.

Pathogen inoculation and disease epiphytotics: Ten plants of pea cultivar Pb -89 were raised in earthen pots (30 cm) and inoculated with spore suspension of *U. viciae fabae* at flowering stage. The suspension of aeciospores/ urediospores of *U. viciae fabae* was prepared by mixing the spore with light mineral oil (Soltrol 170) and adjusted to 10^5 spore ml^{-1} by using a haemocytometer. The spore suspension was applied at 5 ml plant^{-1} through atomizer. These inoculated plants were kept in the glass house under high humid conditions at 18±2°C to facilitate infection. The plants showing rust symptoms were placed exactly in the center of the plot in the end of January and left there till termination of the experiment. High moisture in the field was created by irrigating the field on the day of starting the experiment. The location of plants was taken as identity of the plants for recording the data at weekly interval. The disease dynamics was monitored by recording on incidence and severity of the disease at weekly intervals, up to period of 6 weeks after inoculation. Disease severity was recorded on 0-9 rating scale as followed by Mayee and Datar (1986) (Table 1). The data on spatial and temporal distribution were analyzed by using Sigma Plot Ver. 11 statistical software.

RESULTS AND DISCUSSION

Spatial and temporal spread of pea rust (2016-17): The intensity and spread of the disease were highly influenced by days after inoculation (DAI) and direction of the wind (Fig. 1). The disease started spreading from infection foci after two week of inoculation. A foci was set in the centre of the experimental plot. The disease showed no progress in first two weeks, because pea rust have minimum incubation period of 14 days and thereafter the disease showed rapid change in its development process. The disease severity was maximum 30 and 35 per cent concentrated to very near of the focus, 20 and 25 per cent disease spread observed approximately 0.5 and 0.3 meter away from the focus in all the directions. The disease severity decreased upon moving away from the focus. Ten per cent disease severity was in south and south-west direction up to the 2 meter distance, followed by western, northern and eastern side up to 1.25 meters from focus. The minimum progress (10 per cent) disease severity was in the south-east direction i.e. 0.5 meter only. The 5 per cent disease severity covered more area in east and west direction i.e. up to 3.2 meter followed by 3 meters in the south direction. The minimum distance 1.5 meters covered by 5 per cent disease severity in north direction after 3 weeks.

The disease progress increased with time. After 4th weeks the maximum 50 per cent of the disease was only at 0.5 meter distance from centre in all directions. Then the 40 per cent disease severity covered more distance i.e. 1 meter in the south direction and 0.75 meter in all other directions. Thirty per cent disease severity was spread more towards the south-western side up to 2-2.25 meters, 2.25 meters towards eastern side, 1.75 meter to south and minimum distance covered in the north direction i.e., 1 meter. Half of the plots were covered by 20 per cent disease severity, which was distributed upto 3.75 meter far away from the centre in the eastern side. In the south, west and south-western side the plants at the distance of 3 meter from centre showed the 20 per cent severity. Plants in the north side were showed 20 per cent severity at 2 meter. The severity crossed 4 meter distance in east and west direction with disease severity of 10 per cent. In the other two directions south and north 10 per cent just touches the 4 meter distance.

The disease spread in entire plot except the corners after 5th week. Plant in periphery of the foci i.e. 0.25 meters were showed 50-60 per cent disease severity. In south western and eastern side 30 per cent disease covered the area up to 2.50 meter in west and 2.25 meter in south. In west-north side 30 per cent disease covered 1 meter in north and 2 meter in west from the focus. The ten per cent of disease severity crossed the 4 meter mark in all direction except the north side and all four corners. The disease spread all over in the plots after 6th week. The minimum disease severity i.e. 10 and 20 per cent was recorded only in corners in very small area. The 30 per cent disease severity crossed 4 meter area in all the four direction. The 40 per cent disease severity touched 4 meter distance from focus in the west direction, just crossed 3 meter in south and east direction but restricted to 3 meter in the north side. In the western side from the focus disease severity of 50 and 60 per cent covered more distance i.e. 3 and 2 meter, 2.75 and 1.75 meter in the south western side followed by eastern side with 2 and 1.75 meter, respectively. The 40 per cent disease crossed the maximum distant point -400 on X- axis and -400 on Y-axis in the south-western and all other side except three corner of the field where the disease was showed 30 per cent severity. The 50 per cent disease severity crosses 3.5 meter in all direction but it touched 4 meter mark in western and south side. Sixty per cent disease severity covered maximum direction in south west direction up to 3.25 meter followed by 2.75 meter distance in south and 2 meter in east side. Minimum spread of 60 per cent disease was recoded only up to 1.75 meter in north side. The maximum 70 per cent disease severity was recorded in south and east side up to 1 and 1.25 meter from the centre. A where 70 per cent disease severity was also recorded at a point -50 and -100 axis in south west direction.

Spatial and temporal spread of pea rust: Disease followed the same trends in its developmental process during 2017-18 presented in Figure 2. The disease severity maximum i.e. 30 and 35 per cent concentrated to very near of the focus, in east direction 10 per cent of disease severity was found up to 2 meter distance, followed by western and south in northern side the 10 per cent disease progressed up to 1.25 meters from focus.

After 4th weeks the maximum 50 per cent of the disease was recorded which covered only 0.5 meter distance from centre in all directions, followed by 0.25 m from centre. The spread more towards the south side up to 1.25 meters, 1.00 meters towards south-eastern side and to a point -200 on X-axis and -50 on Y-axis. In the east and south side 20 per cent disease severity covered more area up to 3 meter, followed

Table 1. Disease severity scale for rust in pea (Mayee and Datar 1986)

Rating	Description	Reaction
0	No symptoms on leaf	Highly resistant
1	Rust pustules small, scattering covering 1% or less of leaf area	Resistant
3	Rust pustules more in number covering 1-10% of leaf area	Moderately resistant
5	Typical rust pustules covering 11-25% of leaf area	Moderately susceptible
7	Typical rust pustules covering 26-50% of leaf area. Leaf shedding	Susceptible
9	Typical rust pustules covering 51% or more of leaf area. Defoliation severe	Highly susceptible

by west side Almost 50 per cent plot covered, by 10 per cent disease severity distributed up to 3.75 meter far away from the centre in the eastern and west side. In the south-west and south side the plants at the distance of 3.00 meter from centre showed the 10 per cent severity. The disease covered more than 80 per cent area after 5th week. The minimum disease severity i.e., 10 per cent was in corners. The 20 per cent disease severity crossed 4 meter area in all the four direction. In the west side 30 per cent disease severity covered maximum distance of 3 meter from centre, just crossed 2.25 meter in south and east direction but restricted to 1.25 meter in the north side. Cluster of 50 and 60 per cent disease severity concentrated very near to focus up to 0.5 meter distance only. The disease spread to entire plot after 6th week. The 30 per cent disease severity crossed 4 meter area in all the four direction expect corner where severity was only 10 per cent. In the west side from the focus 40 per cent disease severity touched 4 meter distance, just crossed 3 meter in south and east direction but restricted to 3 meter in the north side. More distance in the western side i.e., 2.5 and 2 50 covered by 60 per cent disease severity, 1.75 and 1.50 meter in the south western side followed by eastern side with 2 and 1.75 meter, respectively. In the north side the 50 and 60 per cent disease severity spread over area up to 1.2 and 1 meter respectively. The 40 per cent disease crossed the maximum distant point -400 on X- axis and -400 on Y-axis in the south-western and all other side except three corner of the field where the disease was showed 30 per cent severity. The 50 per cent disease severity crosses 3.5 meter in all direction but it touched 4 meter mark in western and south side. In south

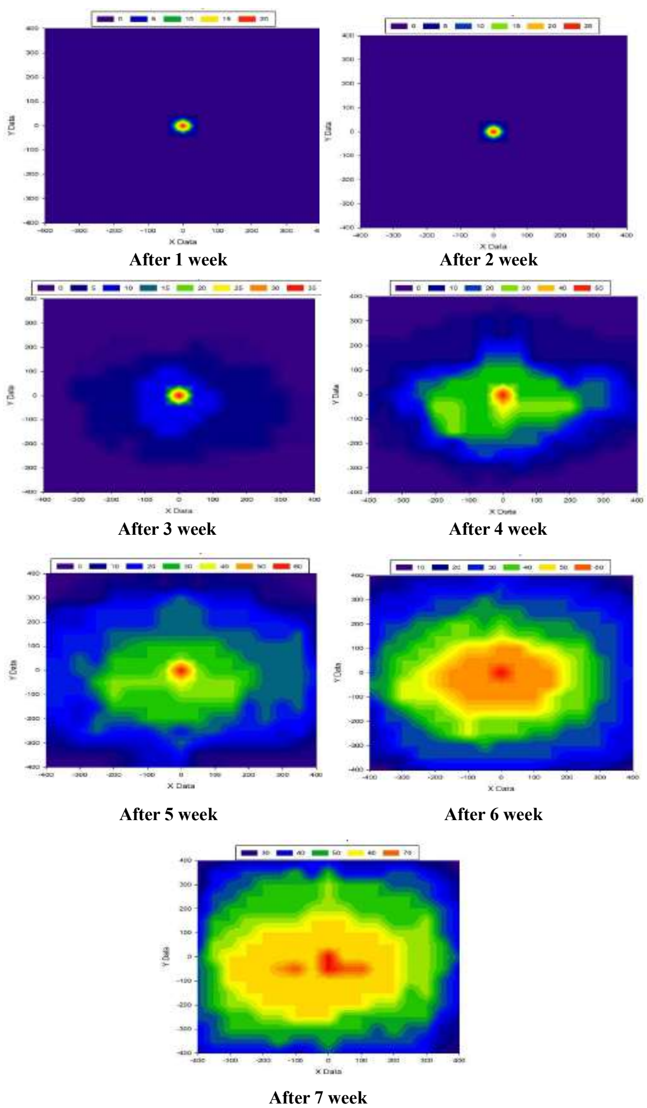

Fig. 1. Spatial and temporal spread of pea rust during 2016-17

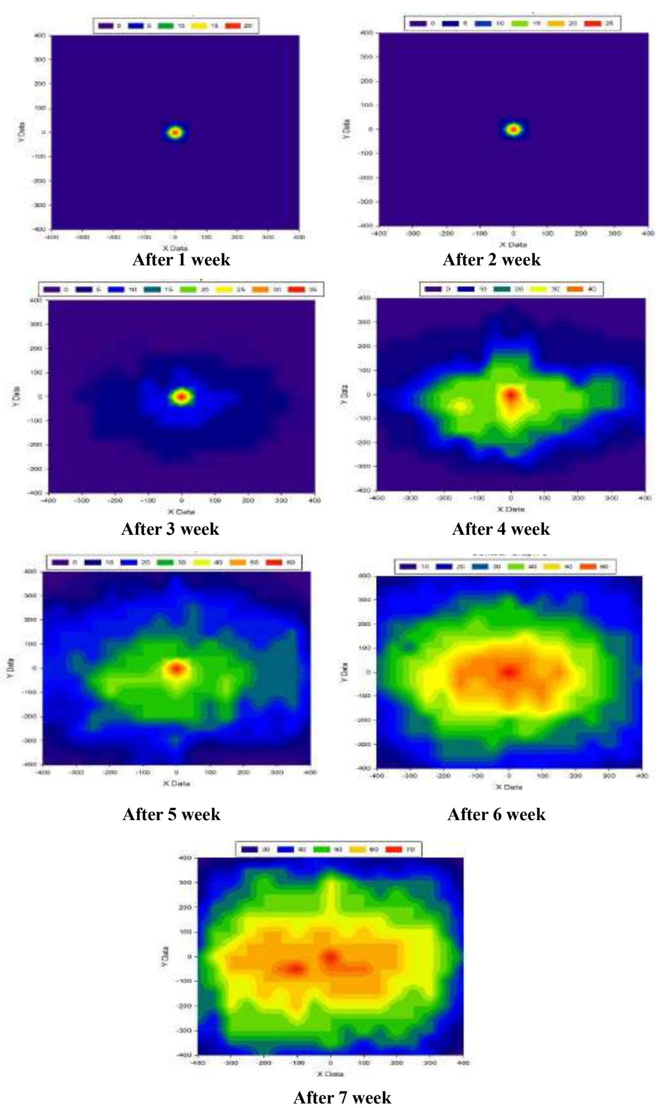

Fig. 2. Spatial and temporal spread of pea rust

west direction 60 per cent disease severity spreaded up to 3.25 meter followed by 2.75 meter distance in south and 2 meter in east side from the focus. Minimum spread of 60 per cent disease was recoded only up to 1.75 meter in north side. The maximum 70 per cent disease severity was recorded in south and east side up to 1 and 1.25 meter from the centre. A point at -50 and -100 axis in south west direction, 70 per cent disease severity was also recorded.

The average velocity of pea rust pathogen was 0.83 m/ week during 2016-17 and 0.89 m/week during 2017-18, respectively. The velocity of the rust spread was calculated after each week and the final velocity was taken out by calculating the mean of each week's velocity. Similarly Zadoks (2001) evaluated the spatiotemporal dynamics of epidemic expansion from foci of plant diseases have been the subject of considerable study because these spatiotemporal expansions results in disease epidemics and effect the large masses.

CONCLUSION

As the rust diseases are wind born and the spread of the disease through wind currents came from the Himalayans foot hills. The incidence of disease within host was significantly affected by wind direction and distance from the initial foci. The intensity of disease spread was found more towards the south western side as it influenced by wind direction.

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Acaricide Resistance in Field Collected Two-spotted Spider Mite, *Tetranychus urticae* from Okra in Punjab

Hany M. Heikal[1], Manmeet Brar Bhullar* and Paramjit Kaur

Department of Entomology, Punjab Agricultural University, Ludhiana-141 004, India
[1]Department of Economic Entomology and Agric. Zoology, Menoufia University, Shebin El-Kom, Menoufia, Egypt
**E-mail: manmeet@pau.edu*

Abstract: Bioassay studies were conducted in the laboratory to determine the effect of four acaricides on different field collected populations of two-spotted spider mite, *Tetranychus urticae* Koch, from okra. There were statistical differences in susceptibility to different acraicides (propargite, spiromesifen, fenpyroximate and fenazaquin) in different regions (Abohar, Malerkotla, Ludhiana) of Punjab. The population with a resistance ratio of more than 60 with respect to an acaricide was considered as resistant population to the acaricide. Among all the acaricides, low to higher levels of resistance (0-27, 550 fold) was observed in mites to tested acaricides in Punjab. The highest resistance ratio (27,550 fold) was found in Malerkotla population for fenazaquin as compared to Ludhiana populations, while Ludhiana populations had more resistance ratio (11,720 fold) for spiromesifen as compared to the other populations. In case of propargite, highest resistance ratio was 3,725-fold in Ludhiana population.

Keywords: Acaricides, Monitoring, Resistance, *Tetranychus urticae*

The two-spotted spider mite, *Tetranychus urticae* Koch is the most economically important arthropod pest among phytophagous mite species in India and has the potential to build its population in favourable temperature and relative humidity (Zhang 2003). Control of spider mite populations in India has been principally provided by the use of acaricides. However, continued or repeated use of acaricides has disrupted natural biological control system and led to resistance development. Increasing levels of resistance to the most widely used acaricides have caused multiple treatments and excessive doses, raising serious environmental and human health concerns. From field surveillance and screening of various acaricides, it was speculated that *T. urticae* has developed resistance to most of the conventional acaricides (Hoy 2011, Van Leeuwan et al 2012). There are reports of resistance development in more than 550 species of insects and mites to one class of insecticides and acaricides (Van Leeuwan et al 2012). This wide spread acaricide resistance has been a major obstacle in the cost-effective integrated mite management programme in India. In addition, factors such as increased costs of labour and pesticide application and safety issues have made cultivation of crops difficult for the farming community. The continuous exposure of two-spotted spider mite to different acaricides has resulted in resistance development both in greenhouse and field conditions (Georghiou and Lagunes 1991). The higher levels of resistance in two-spotted spider mite to different acaricides were detected for dicofol (Kaur and Bhullar 2011), propargite and spiromesifen (Kaur and Bhullar 2016, Kim et al 2006, Kumari et al 2017, Mohammad et al 2012 and Sato et al 2016), organophosphates (Sato et al 2004), organotin (Edge and James 1986), hexythiazox (Herron and Rophail 1993), fenpyroximate (Stumpf and Nauen 2001 and Van Pottelberge et al 2009), fenazaquin (Moghadam et al 2012, Vassiliou and Kitsis 2013, Sharma and Bhullar 2018) and bifenazate (Van Leeuwen et al 2006). Due to the fast evolution of resistance development, two-spotted spider mite has now attained status of most resistant species in world (Van Leeuwan et al 2010). In India, little work has been done on resistance patterns in two-spotted spider mite to currently used acaricides on vegetables grown under both open and protected cultivation and no information is available on okra under Punjab conditions. It is quite possible that their susceptibility to acaricides would differ between okra grown in different localities. Therefore, it is important to study acaricide susceptibilities of *T. urticae* collected from okra grown under open field cultivation in Punjab. Our paper reports the results of laboratory-based tests that determine the response of the three collected populations and susceptible strain of *T. urticae* to four commonly used acaricides (propargite, spiromesifen, fenpyroximate and fenazaquin) by the farmers.

MATERIAL AND METHODS

Chemicals: Commercial formulations of propargite 57% EC (inhibitors of mitochondrial ATP synthase Energy metabolism), fenazaquin 10 % EC, spiromesifen 240 SC and fenpyroximate 5 % EC (mitochondrial complex I electron transport inhibitors) were used for the present study.

Collection and maintenance of *T. urticae*: Collection was done for two-spotted spider mite on okra under open field cultivation from different districts i.e. Fazilka, Abohar (,30° 08' 40.31"N 74° 11' 43.87"E), Ludhiana (30° 54' 3.4740"N and 75° 51' 26.1972"E.) and Sangrur (Malerkotla) (30° 31' 30.0180"N and 75° 53' 24.4356"E.) of Punjab, India, during 2019. The mite infested okra foliage was collected and placed in polyethylene bags and brought to the laboratory.

Susceptible population was maintained in polyhouse at Punjab Agricultural University, Ludhiana on potted plants of French bean (*Phaseolous vulgaris*) without exposing to any acaricides for more than 30 generations, in 2019 with each generation of 8-10 days each. Then this population was bioassayed with different acaricides at different concentrations.

Bioassay: Response of populations of two-spotted spider mite collected from different areas was studied by bioassay conducted on female adult gravid mites. The serial doses of propargite were 240, 120, 60, 30 and 15 µl 100 ml^{-1}; fenazaquin 200, 100 50 25 12.5 µl 100 ml^{-1}; spiromesifen 64, 32, 16, 8, 4 µl 100 ml^{-1}; fenpyroximate 60, 30, 15 ,7.5, 3.75 µl 100 ml^{-1}, respectively. Leaf-dip method was followed for bioassay studies. Leaf discs were prepared by punching leaves of okra plants and were dipped in respective test acaricidal solutions for 10 seconds. Control leaf discs were treated similarly with water. After shadow drying, they were placed on wet cotton pads in Petri dishes (9 cm diameter and 2 cm in height) and maintained in laboratory conditions at 26±1°C, RH 60-70%. Twenty adult gravid females were transferred to each leaf disc. Each acaricide concentration and control treatment was replicated thrice to get more accuracy in result. Mortality of mites was determined after 24 hours of treatment, and mites were considered dead if appendages did not move when prodded with camel hair brush. Treated adult mites were kept at 25 to 27ºC temperature.

Statistical analysis: Lethal concentration values (LC_{50}) were calculated using the Probit analysis (Finney 1971) with chi-square and the slope associated with dose-response relationship using the computer programme 'POLO'. The level of resistance (RR) acquired by two-spotted spider mite was calculated by dividing LC_{50} of resistant population with LC_{50} of susceptible population. The RR values of <10, 10-40, 40-60 and >60 indicate low, moderate, high and very high resistance levels, respectively (Fukami et al 1983).

RESULTS AND DISCUSSION

Susceptible population: The LC_{50} of propargite, fenazaquin (inhibitors of mitochondrial ATP synthase Energy metabolism), fenazaquin 10% EC, spiromesifen 240 SC and fenpyroximate 5% EC (mitochondrial complex I electron transport inhibitors) was 0.002, 0.0004, 0.0005 and 0.0001 per cent, respectively for susceptible population.

Response of *T. urticae* to propargite: The Ludhiana population showed maximum LC_{50} for propargite (0.00745%) followed by Abohar while the Malerkotla population was susceptible resulting in death of all the individuals (Table 1). The level of resistance to propargite was found to be highest in population collected from Ludhiana (RR = 3,725), and least in Abohar population (RR=7.46). The population of *T. urticae* collected from Malerkotla showed high susceptibility to propargite (Table 2). Sharma and Bhullar (2018) on brinjal, Goodwin et al (1995) and Ay et al (2005) observed low to moderate level of resistance against propargite in two-spotted spider mite populations. Koh et al (2009) and Vostre et al (2010) documented low level of resistance against propargite (6-15 fold) in two-spotted spider mite from apple orchards and hop yards in Korea and Czech Republic. The results are corroborate with the study conducted in Gandevi and Gadat areas of Navsari against propargite in two-spotted spider mite on the brinjal exhibiting moderate level of resistance 32.08 and 28.43 fold (Anonymous 2015, Kaur and Bhullar 2016).

Response to fenazaquin: The LC_{50} fenazaquin was highest in in Abohar (0.01289%) followed by Malerkotla population and least in Ludhiana population (0.00064 per cent) (Table 1). In comparison to susceptible population of *T. urticae*, the resistance ratio was very high to fenazaquin in population collected from Malerkotla (RR = 27,550), Abohar (RR = 17,657) and Ludhiana (RR = 1600) (Table 2). Similar results of low to moderate level of resistance were reported on tomato (310-folds) and roses (189-folds) to fenazaquin in two-spotted spider mite in Cyprus (Vassiliou and Kitsis 2013). The high level of resistance was also reported from Vadugar (168-249 fold) of Kolar district in 2007 to 2009 from Tomato crop (Anonymous 2009). Kaur and Bhullar (2016) and Sharma and Bhullar (2018) also observed high level of resistance to fenazaquin in two-spotted spider mite collected from brinjal in various regions in Punjab. The results of Moghadam et al (2012) observed that resistance ratios of Isfahan, Yazd and Rasht population of two-spotted spider mite from Iran were 3109, 439.5 and 10.53 fold, respectively, compared with the susceptible population.

Response to spiromesifen: Spiromesifen was least effective against Abohar population as compared to other populations. The LC_{50} of populations from Malerkotla, Ludhiana and Abohar was 0.00158 per cent, 0.00586 per cent and 0.00564 per cent, respectively (Table 1). Higher resistance ratios were in spiromesifen for Abohar population (12,465) and Ludhiana population (11,720) followed by Malerkotla population (3160) (Table 5). Mohammad et al (2012) and Sharma and Bhullar

Table 1. Toxicity of various acaricides against *T urticae* on okra

Acaricides	Chi-square	Heterogeneity	LC_{50} (%)
Ludhiana population			
Spiromesifen	6.72	2.24	0.00586
Propargite	0.37	0.12	0.00745
Fenazaquin	5.64	1.88	0.00064
Fenpyroximate	9.35	3.12	0.00035
Malerkotla population			
Spiromesifen	8.25	2.75	0.00158
Propargite	0	0	0
Fenazaquin	0	0	0.01102
Fenpyroximate	2.77	0.92	0.00099
Abohar population			
Propargite	2.74	0.92	0.00005
Spiromesifen	3.65	1.21	0.00536
Fenazaquin	1.50	3.50	0.01289
Fenpyroximate	2.73	0.91	0.00002

(2018) observed moderate level of resistance to spiromesifen in *T. urticae* population collected from cucumber in Jordan (17.96 fold) and Punjab, India (11.14 to 21.40- fold). Kumari et al (2015) also *T. urticae* showed resistance ratio of 32.13-fold to spiromesifen in *T. urticae*..

Response to fenpyroximate: Fenpyroximate (LC_{50} of 0.00002 – 0.00099 per cent) was the most toxic against all the tested populations (Table 1). The population of two-spotted spider mite collected from different districts showed low LC_{50} value for fenpyroximate as compared to other acaricides. The population of *T. urticae* exhibited low to high level of resistance to fenpyroximate and was in range of 21.76 (Abohar) to 9900-fold (Malerkotla, Sangrur) (Table 2). The resistant strain of *T. urticae* from apple in Korea after selection pressure for 20 generations with fenpyroximate exhibited 252-fold resistance (Kim et al 2004). The resistance to fenpyroximate ranged from 6.07 to 977.39 fold in *T. urticae* population collected from commercial green house crops and from 1.43 to 933.26 fold from 10 apple orchards, respectively in Korea (Suh et al 2006). There are reports of cross resistance in pyridaben resistant strain (373-fold) and dicofol resistant strain (67.7-fold) of *T. urticae* to fenpyroximate (Kim et al 2006, 2007). Tirello et al (2012) observed 74.1 and 25.9 fold resistance in rose to fenpyroximate in SAN and PSE strains, respectively. Similarly, in India, Kumari et al (2015) observed 14.54 fold level of resistance to fenpyroximate in *T. urticae* population collected from Palampur and Sharma and Bhullar (2018) observed resistance ratios of 2.8 to 10.15 in *T. urticae* to fenpyroximate in Punjab.

Table 2. Resistance ratio of mites against Propargite, Spiromesifen, Fenazaquin and Fenpyroximate

Populations	Resistance ratio			
	Propargite	Spiromesifen	Fenazaquin	Fenpyroximate
Ludhiana	3725	11720	1600	3500
Malerkotla	0	3160	27550	9900
Abohar	7.46	12465	17657	21.76

CONCLUSION

The population of *T. urticae* showed very high level of resistance to fenazaquin, fenpyroximate and spiromesifen and moderate level to propargite on okra in Abohar, Malerkotla, Sangrur and Ludhiana districts of Punjab.

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Plant Nutrient Dynamics in Different Ecosystems of Cold Deserts of Himachal Pradesh, India

Poonam, Sanjeev Kumar, Avanish Sharma and Rajan Bawa

[1]*College of Forestry, Dr YS Parmar University of Horticulture and Forestry Nauni, Solan-173 230, India*
E-mail: poonamwarpa008fty@gmail.com

Abstract: The present study was conducted in cold desert area to study the nutrient status and their utilization for understanding the importance, utilization and exploitation of the alpine pastures and other grazing areas. The fields where peas and pulses were planted were found to be possessing higher nitrogen contents than other areas due to the fixation of atmospheric nitrogen. However, the concentration of other nutrients such as P, K, Na and Ca was also found higher in agricultural crops, which was due to continuous cultivation plus the annual addition of farm yard manure and other fertilizers during the cropping season; associated with different annual crop rotation and long fallow period of nearly six months each year.

***Keywords**:* Agricultural crops, Alpine pasture ecosystem, Agro-ecosystem, Cold desert, Forest ecosystem, Plant nutrient storage

An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the non-living components of their environment (air, water, soil minerals, etc.), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycling and energy flow. Mountain ecosystems are highly fragile as simple degradation of forest cover leads to severe soil erosion and even changes in river courses (Anonymous 2003). Cold deserts are the lands at the polar fringes of the northern hemisphere continents and the ice covered water of Greenland and Antarctica (Khosla et al 1993). Cold deserts mainly occur in the interior of Asia and in the mountain zone of North America. The Himalayan region in Himachal Pradesh India is very well known for its representative, natural, unique and socioeconomically important plant diversity (Samant et al 1998). It is designated as one of the Biodiversity Hot Spots. It supports 18 440 species of plants with 25 to 30 per cent of endemics (Samant et al 1998, Singh and Hajra 1996). The cold desert of India is located mainly in two states, viz., Himachal Pradesh and Jammu and Kashmir. In Himachal Pradesh, the cold deserts are restricted to the districts of Lahaul and Spiti, parts of Kinnaur (Sumdo side) and Pir Panjal in Chamba district. The region is characterized by low precipitation, a short growing season, low primary productivity and high stocking density (Mishra 2000). Temperatures generally do not exceed 30°C with July and August as the hottest months. December-February are the coldest months, with a mean temperature of -20°C. Dry land cultivation is not possible and the entire cultivated area depends on assured irrigation through long, winding streams from the upper mountain reaches (Oinam et al 2005). The vegetation cover is generally sparse and rarely exceeds one meter in height. Several species of herbs and graminoids such as *Festuca, Poa, Stipa* and few sedges constitute the forage biomass (Bawa 2000). The vegetation of a major part of the district is of dry temperate to dry alpine type. Presently, the biodiversity of Lahaul is under threat through both abiotic and biotic interferences. The main and immediate causes of biodiversity loss in Lahaul can be attributed to habitat loss, degradation and resource over exploitation and climate alteration. Of these by far the most important factor is habitat loss due to over grazing, lopping for fodder and fuel wood, construction of roads and other developmental projects, etc. Therefore, objectives of the present study were holistic/ integrated and interdependence study of the major ecosystems of cold deserts on the basis of nutrient utilization and storage in woody species, herbs and grasses in for sustainability.

MATERIAL AND METHODS

The present investigation was conducted during 2010 to 2013 in village Goshal, located in Lahaul and Spiti district of Himachal Pradesh, India, between 32°3315.52N and 76°5747.34E at a mean altitude of 2,930 m amsl. Goshal is one of the largest villages in the district with maximum cropping diversity, abundant alpine pastures and adjoining forest area. Village Goshal in the Lahaul Valley is situated on the left bank of the river Chandra just before it merges with river Bhaga. Goshal village is located on a fan shaped alluvial deposits and occupies 28.90 ha of land. Above the agricultural fields, the area supports grazing lands. As the grazing land rise up, we find the invasion of shrubs. On higher reaches, the area supports conifer forest and above that the glacial level exists from where the melt flow down through gorges and feeds the entire village. The village is well known for its productive fields and farmers prefer to grow peas, potato, vegetables (cabbage), apple, barley and medicinal plants.

Ecosystem classification: The residents of village Goshal follow agropastoral livelihood and with the age old experience had developed their own land use pattern depending upon availability and quality of land, availability of water for irrigation plus their requirements for growing of crops, grazing areas for their husbandry and forest areas for other uses. The entire village area as per Revenue records and the adjoining alpine pastures and forest areas under the usage of village residents was differentiated as per the khasra numbers for Forest ecosystem, Alpine ecosystem and Agricultural ecosystem.

Each ecosystem (forest ecosystem, alpine pasture eco system and agro-ecosystem) was divided into nine different grids for sampling. Sampling in each grid was carried out following quadrate method. Size of quadrate for forest ecosystem, alpine pasture ecosystem and agro-ecosystem was estimated following Species Area Curve as proposed by Oosting (1958). On the basis of Species Area Curve, the quadrate size for forest ecosystem came out to be 50×50 m for trees and shrubs; in alpine pasture ecosystem the quadrate size for shrubs was 25×25 m, while for grasses and herbs it was 1×1 m; however in agro-ecosystem the quadrate size for crops was 1×1 m and for grasses and herbaceous flora it was also 1×1 m. Three quadrates were laid in each grid in all the three ecosystems for recording of phyto-sociological data. Nitrogen contents (%) were estimated through Micro Kjeldahl method (Black 1968). Phosphorus (%) was determined through chlorostanate molybdophosphoric acid (Jackson 1973) and the intensity of blue colour developed was read on Spectronic-20 at 660 nm against a blank. Estimations of K, Ca, and Na percentages were carried out through Flame Photometer using their respective filter.

RESULTS AND DISCUSSION

Plant nutrient contents in forest ecosystem: The leaf nitrogen content in tree species were found maximum in *Juniperus macropoda* (2.28%) and least in *Salix fragilis* (1.33%). The maximum leaf phosphorus and sodium contents was found in *Cedrus deodara* (0.19%) and *Salix alba* (0.19%), maximum twig phosphorus was reported in *Juniperus macropoda* and *Salix fragilis* with 0.17 per cent and minimum in *Pinus wallichiana* depicting 0.13 per cent values**.** The calcium contents in leaves ranged between 0.26 per cent in *Pinus wallichiana* to 0.45 per cent in *Populus deltoides* (Table 1).

Table 1. Nutrient contents present in different parts of trees and shrubs in forest ecosystem

Species	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Calcium (%)	
	Leaves	Twigs	Leaves	Twigs	Leaves	Twigs	Leaves	Twigs	Leaves	Twigs
Trees										
Betula utilis	1.93	1.88	0.14	0.14	0.55	0.41	0.33	0.32	0.31	0.22
Cedrus deodara	1.87	1.74	0.19	0.14	1.06	0.83	0.22	0.17	0.32	0.24
Juni perus macropoda	2.28	2.16	0.15	0.17	1.09	0.94	0.31	0.26	0.42	0.32
Juniperus recurva	1.64	1.82	0.13	0.15	0.97	0.83	0.3	0.25	0.28	0.24
Pinus wallichiana	1.9	1.96	0.17	0.13	1	0.82	0.34	0.32	0.26	0.22
Populus ciliata	2.05	2.13	0.16	0.16	1.1	1.14	0.32	0.33	0.41	0.3
Populus deltoides	2.1	2.05	0.18	0.15	1.11	1.17	0.35	0.32	0.45	0.27
Salix alba	2.03	1.89	0.19	0.15	0.9	0.84	0.27	0.21	0.38	0.31
Salix fragilis	1.33	1.3	0.16	0.17	0.87	0.71	0.26	0.24	0.32	0.28
Salix tetrasperma	1.98	1.91	0.18	0.15	1.2	1.14	0.26	0.22	0.42	0.38
Shrubs										
Berberis jaeschkeana	2.08	1.95	0.13	0.13	0.59	0.43	0.31	0.22	0.24	0.23
Ephedra geradiana	2.32	2.06	0.21	0.17	0.89	0.73	0.25	0.23	0.34	0.32
Fraxinus xanthoxyloides	1.85	1.36	0.18	0.16	0.48	0.44	0.28	0.21	0.22	0.11
Hippophae rhamnoides	1.94	1.14	0.2	0.16	0.43	0.36	0.27	0.24	0.23	0.2
Juniperus communis	1.97	1.55	0.14	0.13	0.86	0.75	0.32	0.25	0.26	0.21
Rosa macrophylla	1.72	1.68	0.18	0.14	0.52	0.47	0.31	0.22	0.32	0.24
Rosa webbiana	1.44	1.35	0.17	0.15	0.69	0.45	0.23	0.22	0.26	0.2

Plant nutrient contents in alpine pasture ecosystem: In alpine pasture ecosystem among shrubs, *Ephedra gerardiana* showed maximum nitrogen contents in leaf (2.12%) and twig (1.85%). Potassium contents were found maximum in leaves (0.86%) and twigs (0.69%) of *Juniperus communis* and leaves of *Ephedra gerardiana* (0.86%). However, the sodium contents were found to vary between 0.24 per cent in leaves of *Lonicera myrtillus* and *Rosa webbiana* to 0.32 per cent in leaves of *Rosa macrophylla*. The calcium contents in leaves ranged between 0.22 per cent in *Ephedra gerardiana* to 0.31 per cent in *Rosa macrophylla*. The twigs depicted a range between 0.20 per cent in *Lonicera myrtillus* to 0.24 per cent in *Rosa webbiana* (Table 2).

Alpine pasture ecosystem was found uncultivable with minimum productive potential. Cows, sheep, goats, donkey, etc., are allowed to graze during the entire growing season (April to September). Grasses and herbaceous vegetation along with few shrubs species were found to be growing naturally even under intense grazing pressure. These areas did not receive any inputs from the local residents. Perez et al (2006) estimated aboveground net primary productivity (ANPP), nutrient cycling and nutrient use efficiency (NUE) for three 20 year old *Pinus taeda* experimental plantations in the north of the Misiones province, they reported that the requirements of N, P, K, Ca and Mg were 298, 15, 63, 70 and 15 kg $ha^{-1} yr^{-1}$, respectively and the uptake was 161, 8, 36, 70 and 15 kg $ha^{-1} yr^{-1}$, respectively. Murovhi and Materechera et al (2006) analyzed paired soil samples taken under and beyond *Acacia erioloba* tree canopies in the North West Province, South Africa to quantify the concentration of nutrients in two local agroforestry practices on cultivated and grazing lands. In both practices, there was a significantly higher ($p<0.05$) concentration of N, P, Ca, Mg, Zn and Mn in soils collected from under *A. erioloba* canopies compared with those collected beyond the canopies. The nutrient concentrations were consistently higher in soil from trees that were located in grazing land than croplands.

Nutrient content in agro-ecosystem: In agro-ecosystem, among crops pea was rich in aboveground (2.48%) and belowground (2.37%) nitrogen content and aboveground (0.26%) phosphorus content, while low aboveground nitrogen (1.63%) and phosphorus aboveground (0.21%) and belowground (0.20%) was shown by barley. Cabbage showed maximum aboveground potassium content (1.35%) and minimum aboveground (0.31%) and belowground (0.28%) calcium content. Aboveground sodium content was maximum (0.55%) in potato while maximum aboveground (0.63%) calcium content was reported in pea (Table 3).

Among grasses, *Festua rubra* showed maximum (2.91%) aboveground nitrogen, maximum aboveground (0.29%) and belowground (0.27%) phosphorus and maximum belowground potassium (0.25%), while minimum aboveground nitrogen (1.67%) and phosphorus aboveground (0.21%) and belowground (0.21%) was reported in *Agropyron longearistatum*. Maximum aboveground (0.24%) and belowground (0.22%) calcium

Table 2. Nutrient contents present in different parts of shrubs in alpine pasture ecosystem

Species	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Calcium (%)	
	Leaves	Twigs	Leaves	Twigs	Leaves	Twigs	Leaves	Twigs	Leaves	Twigs
Berberis jaeschkeana	1.7	1.62	0.12	0.12	0.53	0.43	0.25	0.23	0.24	0.21
Ephedra geradiana	2.12	1.85	0.21	0.11	0.86	0.68	0.29	0.25	0.22	0.21
Hippophae rhamnoides	1.88	1.1	0.19	0.18	0.42	0.35	0.3	0.27	0.23	0.22
Juniperus communis	1.91	1.5	0.17	0.12	0.86	0.69	0.26	0.26	0.27	0.23
Lonicera myrtillus	0.88	0.76	0.16	0.15	0.41	0.4	0.24	0.22	0.24	0.2
Rosa macrophylla	1.72	1.67	0.19	0.13	0.51	0.5	0.32	0.24	0.31	0.21
Rosa webbiana	1.7	1.3	0.14	0.14	0.63	0.56	0.24	0.23	0.25	0.24

Table 3. Nutrient contents in aboveground (AG) and belowground (BG) parts of crops in agro ecosystem

Crops	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Calcium (%)	
	AG	BG	AG	BG	AG	BG	AG	BG	AG	BG
Peas	2.48	2.37	0.26	0.2	1.04	0.78	0.51	0.39	0.63	0.42
Potato	2.17	1.95	0.24	0.24	1.12	0.8	0.55	0.46	0.61	0.49
Barley	1.63	1.62	0.21	0.2	0.95	0.79	0.51	0.35	0.62	0.32
Cabbage	1.98	1.73	0.23	0.22	1.35	1.05	0.5	0.45	0.31	0.28
Rajmah	2.27	2.1	0.23	0.32	1.16	1.11	0.48	0.46	0.47	0.4

Table 4. Nutrient contents in aboveground and belowground parts of grasses in agro ecosystem

Species	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Calcium (%)	
	AG	BG	AG	BG	AG	BG	AG	BG	AG	BG
Agropyron longearistatum	1.67	1.51	0.21	0.21	0.33	0.24	0.24	0.2	0.22	0.2
Brumus asper	1.68	1.51	0.23	0.21	0.34	0.21	0.24	0.21	0.16	0.14
Dactylis glomerata	1.79	1.59	0.25	0.25	0.26	0.25	0.19	0.12	0.15	0.11
Festuca rubra	2.91	1.45	0.29	0.27	0.33	0.25	0.18	0.11	0.24	0.22

was reported in *Festuca rubra* and minimum calcium was in *Dactylis glomerata* (0.15%) in aboveground parts (Table 4).

Sundaravalli and Kailash (2005) in their study found that the rate of belowground disappearance was higher than that of litter. The maximum concentration of nutrients occurred in the live shoot component followed by belowground parts. The nutrient contents in leaves and twigs of shrubs showed quite a bit of variation from species to species. Kaushal (1998) while working on component interactions in agroforestry systems reported that foliar N, P, K and S content of *Morus alba* decreased while Ca and Mg increased from July to October. Similar findings were reported by Ponder et al (2001) in *Juglans nigra* and Ralhan and Singh (1987) in central Himalayan trees and shrubs. Murovhi and Materechera (2006) reported that the nutrient concentrations were consistently higher in soil from trees that were located in grazing land than croplands. The study of Guleria et al (2002), on nutrient dynamics of grasses under chir pine (*Pinus roxburghii*) stands revealed that nitrogen, phosphorus and potassium increased up to September and declined in October. Minimal difference was observed in nutrient of grasses under chir pine and open grassland. Lower amount of nitrogen, phosphorus and potassium were recorded in belowground biomass compared to aboveground biomass. Overall northern aspect recorded higher amount of nitrogen, phosphorus and potassium under tree and open grasslands. Jain et al (2002) observed significant differences in nutrient composition of leaves of *Azadirachta indica* among different provenances. Jain and Bist (2002) reported that nitrogen, potassium and sodium content of poplar leaves differed significantly among selected clones of *Populus deltoides* after five months of plantation. The amount of nitrogen varied from 1.02 to 3.92 per cent, potassium from 0.79 to 2.35 per cent and sodium from 0.17 to 0.38 per cent. Sundaravalli and Kailash (2005) in their study found that the rate of belowground disappearance was higher than that of litter. The maximum concentration of nutrients occurred in the live shoot component followed by belowground parts. Marell et al (2006) found that the N and P concentrations showed marked seasonal variations with peaks occurring from the middle of June to the end of July depending on species and snowmelt progression. The amount of nutrients taken up by the plants primarily depends upon the concentration of nutrient in the close proximity to the root surface (Black 1968, Russell 1973). Tripathi et al (2007) found that the pool of available nitrogen was slightly higher, while the microbial nitrogen was declined substantially after the conversion of forest into cropland. Cultivation reduced the mean annual net nitrification and net nitrogen mineralization, respectively by 50.71 per cent and 47.67 per cent, respectively.

CONCLUSION

Nutrient storage through different species was higher in agro-ecosystem than the alpine pasture ecosystem and forest ecosystem. In agro-ecosystem fields, where pulses were raised planted had higher nitrogen contents than other areas due to the fixation of atmospheric nitrogen. However, the concentration of other nutrients such as P, K, Na and Ca was also higher in agricultural crops, which is as a result of a continuous cultivation plus the annual addition of farm yard manure and other fertilizers during the cropping season; associated with different annual crop rotation and long fallow period of nearly six months each year.

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Effect of Water on Birds and Insect Pests in the Rice Fields of Kannur district, Kerala, India

P.V. Prabhakaran and Aravindan Tharemmal

Post Graduate Department of Zoology and Research Centre
Sree Narayana College, Kannur-670 007, Kerala
E-mail: prabharamanthali@gmail.com

Abstract: The vast water bodies of a paddy field attract avian fauna. These water bodies serve as feeding, breeding, nesting and roosting places for the birds. During the winter, migratory birds arrive the water bodies. Since Mundakan (*Rabi*) season coincided with the winter season, there was highest number of birds in the paddy field. Most of the birds were insectivorous and carnivorous. Insectivorous birds consumed insect pests of paddy and as a result the number of insect pests in the paddy field with water bodies was less when compared with other paddy fields.

***Keywords*:** Mundakan, *Rabi*, FWPF, CPF, MLHPF

Paddy fields are the silent victims of the so called developmental boom in Kerala especially in Kannur district. The area under paddy cultivation in Kerala during the agricultural year 2011-12 was 2, 08,160 Hectare. It has decreased by 5027 Hectare (2 %) than the previous year 2010-11. Kannur contributed 2.76 % to the state total with rice cultivation spread over 5740 Hectare. On analysing the area of the state for last 10 years, paddy cultivation was high during the agricultural year 2002-03 and the area was 3,10,521 Hectare. Paddy accounted to 7.82 % of the total cropped area in the state during 2011-12. The percentage of paddy area of Kannur to the total cropped area of the state for the agricultural year 2017-18 was 2.43% (Agricultural Statistics 2017-2018, Department of Economics & Statistics, Thiruvananthapuram, Kerala State, February-2019). Kerala with its long coastal line of about 580 km has several lagoons or backwaters covering a very large area linked to the sea. In most of the coastal land, deltaic areas at river mouths and reclaimed backwaters are either at sea level or 1.0 to 1.5 m below MSL (Mean Sea Level). This leads to intrusion of sea water up to a distance of 10 to 20 km upstream during high tides. These periodically saline water inundated lands constitute the major saline soil areas of the State covering an area of 30,000 hectare (Leenakumary 2011). The various species of birds affecting different stages of the growth of paddy has been investigated and it was observed that the Indian baya or weaver bird (*Ploceus philippinus*) and blue rock pigeon (*Columba livia)* are the major bird pest of paddy feeding on grains, starting from milky stage up to mature harvest stage. However insectivorous and carnivorous species of birds are considered useful to agriculture since they keep a very potent check on insect and rodent pests of crops. But only 2.1 per cent of the total bird species in India has been reported to inflict damage to crops. Pests constitute the most important biotic stress in rice fields. A total of 221 species were reported feeding on rice plants from India (Dhaliwal and Arora 1998). More than fifty species were recorded as pests from the rice tracts of Kerala. Despite the large number of species prevailing in the rice ecosystem, significant damage to the crop is caused only by 5-8 major pests, the intensity of damage inflicted being influenced by the agro-ecological conditions, variety and stage of the crop. To study the effect of water on birds and insect pests that inhabit three different paddy ecosystems (fresh water, coastal and midland laterite hillock) which pass through three growth phases viz. vegetative growth phase reproductive phase, and grain filling stage.

MATERIAL AND METHODS

Study area: The insect pests of paddy, the natural enemy complex in the paddy field and the associated fauna and flora occurring in three different paddy ecosystems (fresh water, coastal and midland laterite hillock paddy ecosystem) of Kannur were surveyed for the entire crop period and classified into vegetative, reproductive and grain filling phases. Insect pests and birds were separately recorded for the three stages. The study was carried out in 3 different paddy field stations in Kannur district each having an area of approximately 0.5 hectare in extent. Okravayal (Fresh Water Paddy Field) is located in the Cheruthazham Village at 12° 04´ N and 75° 15´ E, about 25 km north of Kannur town. The altitude of the Okra vayal is about 10m above sea level. MundapuramVayal (Coastal Paddy Field) is located in Cherukunnu Village at latitude 11°59'N and longitude

Table 1. Status and feeding guild of avian fauna in 3 paddy regions

Avian fauna	Status	Feeding guild	CPF	FWPF	MLHPF
Blue Rock Pigeon *Columba livia* (Gmelin JF 1789)	R	G	–	+	+
Spotted Dove *Streptopelia chinensis* (Scopoli 1786)	R	G	–	+	+
White–breasted Waterhen *Amaurornis phoenicurus* (Pennant 1769)	R	I	+	+	–
Openbill Stork, *Anastomus oscitans* (Boddaert 1783)	R	C	–	+	–
Black Bittern *Ixobrychus flavicollis*(Latham1790)	R	A	+	–	–
Black-crowned Night Heron *Nycticorax nycticorax* (Linnaeus 1758)	R	C	–	+	–
Indian Pond Heron *Ardeola grayii* (Sykes 1832)	R	C	–	+	–
Cattle Egret *Bubulcus ibis* Linnaeus 1758	LM	C	+	+	—
Grey Heron *Ardea cinerea* Linnaeus 1758	R	A	+	–	–
Purple Heron *Ardeapur purea* Linnaeus 1766	R	A	+	–	–
Large Egret *Ardea alba* (Linnaeus 1758)	LM	A	+	+	–
Median Egret, *Ardea intermedia* (Wagler 1829)	LM	A	+	+	–
Little Egret *Egretta garzetta* (Linnaeus 1766)	LM	A	+	–	–
Little Cormorant *Microcarbo niger* (Vieillot 1817)	R	A	+	–	–
Little Ringed Plover *Charadrius dubius* (Scopoli 1786)	BV	A	–	+	–
Red-wattled Lapwing *Vanellus indicus* (Boddaert 1783)	R	I	+	+	–
Spotted Sandpiper *Tringa glareola* (Linnaeus 1758)	M	A	–	+	–
Western Marsh Harrier *Circus aeruginosus* (Linnaeus1758)	M	C	–	+	–
White-bellied Sea Eagle *Haliaeetus leucogaster* (J.F.Gmelin 1788)	R	C	–	+	–
Brahminy Kite *Haliastur indus* (Boddaert 1783)	R	C	_	+	_
Black Kite *Milvus migrans* (Boddaert 1783)	R	C	_	+	_
Blue-tailed Bee-eater *Merops philippinus* (Linnaeus1767)	M	I	_	+	+
Common Kingfisher *Alcedo atthis* (Linnaeus 1758)	R	A	_	_	+
Stork-billed Kingfisher *Pelargopsis capensis* (Linnaeus 1766)	R	C	_	+	_
White-breasted Kingfisher *Halcyon smyrnensis* (Linnaeus 1758)	R	C	_	+	_
Plum-headed Parakeet *Psittacula cyanocephala* (Linnaeus 1766)	R	G	_	+	_
Ashy Swallow-shrike *Artamus fuscus* (Vieillot 1817)	R	I	_	+	_
Black drongo *Dicrurus macrocercus* (Vieillot 1817)	R	I	_	+	_
Indian Treepie *Dendrocitta vagabunda* (Latham 1790)	R	I	_	+	_

Avian fauna	Status	Feeding guild	CPF	FWPF	MLHPF
Baya Weaver *Ploceus philippinus* (Linnaeus 1766)	R	G	_	+	_
Black-headed Munia *Lonchura malacca* (Linnaeus 1766)	R	G	+	+	_
Paddy field Pipit *Anthus rufulus* (Vieillot 1818)	R	I	_	+	_
Malabar Crested Lark *Galerida malabarica* (Scopoli 1786)	R	G	_	+	+
Ashy Wren Warbler *Prinia socialis* (Sykes 1832)	R	I	_	+	_
Red-rumped Swallow *Cecropis daurica* (Laxmann 1769)	R	I	_	+	_
Wire-tailed Swallow *Hirundo smithii* (Leach 1818)	R	I	_	+	_
Common Swallow *Hirundo rustica* (Linnaeus 1758)	R	I	_	+	_
Common Myna *Acridotheres tristis* (Linnaeus 1766)	R	O	+	+	_
Total			12	32	5

CPF = Coastal Paddy Field; FWPF = Fresh Water Paddy Field; MLHPF = Midland Laterite Hillock Paddy Field, BV = Breeding Visitor, R = Resident, M = Migratory, LM = Local Migrant, A = Aquatic feeder, I = Insectivore, G= Granivore, C = Carnivore, O = Omnivore, + = present, – = absent

75°17'E about 17 km north of Kannur town.The altitude of the Mundapuram Vayal is about 3m above sea level. It is a coastal area. Madayippara (Midland Laterite Hillock Paddy Field) is located in the Madayi village, at latitude 12°03' N and longitude 75°15'E, about 21 km north of Kannur town, the district headquarters of Kannur district in Kerala.The altitude of the Madayippara ranges from a minimum of 40 m to a maximum of 47m above sea level.

Sampling method: The paddy field was sampled once every two weeks for two years. Sampling was done in the morning. At each sampling site, invertebrate animals on the soil surface, vegetation and water were collected manually. The predatory ground beetle (*Ophionea indica*)was noticed in the study area. Rove beetles (Staphylinid beetle) are the ground dwelling predator. They can't live in the ground during rainy season. But in FWPF, the ground is dry during Mundakan (Rabi) season. Hence these beetles are seen in FWPF. The cracks which appeared in the soil during the terrestrial dry phase created new habitats for ground dwelling ants, ground beetles and spiders resulting in the increase of arthropod species. The vertebrate species too increased during this phase, due to invasion by grain feeding species largely birds and rats and others (Crustaceans) who come to feed on these species (Bambaradenya et al 1998). Flying insects and those on vegetation were caught using a sweep net (mesh size: 1 mm). Diameter of the ring of the net was 30 cm and its circumference was 94.2 cm with net of 73 cm. Malay trap was also used for trapping insects. The insect capture was done from vegetative growth phase (germination-panicle initiation), and reproductive phase (panicle development-flowering) to grain filling phase (milk grain-mature grain). Five insects were trapped when sweep net was used for insect capture in FWPF during Vegetative Growth Phase (VGP). They included one rice leaf folder (*Cnaphalocrocis medinalis*), three black ants (*Componotus parius*) and one rice grass hopper (*Hieroglyphus banian*).Insect collection was also made from other growth phases. Quadrat method was used for studying the population of insect fauna from 2m² quadrats. For weeds, one metre square quadrat was used. Animals collected were put into labelled plastic containers and brought to the laboratory for identification. Total count method was used for studying birds and they were observed from 8 am to 10 am.Birds were identified by using the books of Salim Ali (1979) and Richard Grimmett et al (1999).

RESULTS AND DISCUSSION

The presence of vast water bodies adjacent to the fresh water paddy field (FWPF) attracted avian fauna. These water bodies served as feeding, breeding, nesting and roosting places for the birds. During winter season migratory birds arrived here. Rabi season coincided with the winter season. Due to these reasons, there was highest number of birds in FWPF (32). But in CPF the number was only 12. The number of insect pests of paddy in FWPF was 18 against 25 in CPF. Eleven of the bird species in FWPF were insectivorous (I), 10 were carnivorous (C), 6 granivorous (G), 4 aquatic (A) and one omnivorous (O).The bird species in FWPF consisted of 3 migratory species (M), 3 Local Migrants (LM), 25 resident species(R) and 1 breeding visitor(BV). Out of the 12 species of birds in CPF, 2 species are insectivorous (I), 1 carnivorous

(C), 1 granivorous (G), 7 aquatic(A) and 1 omnivorous (O).The absence of water in the Midland Laterite Hillock Paddy Field (Region 3) favoured the excess growth of weeds. But in other two regions (FWPF and CPF), the weed growth was less because these regions were filled with water upto a certain extent during the south west monsoon. According to Ali (1979) Baya Weaver *(Ploceus philippinus* Linnaeus, 1766) cut young leaf blades into strips during the vegetative phase of paddy crop. The food of Black headed Munia (*Lonchura malacca* Linnaeus 1766) and Spotted Munia (*Lonchura punctulata* Linnaeus 1758) through crop analysis revealed that 82 per cent consisted of vegetable matter, 46 per cent paddy and 36 per cent seeds of weed grass and the remaining 17 per cent animal matter. They also observed that large congregations of Munia in company with Baya Weaver invade nurseries of paddy as well as standing crop in pre-harvesting stage and cause considerable damage to paddy cultivation.

Growth stages of the crop too influence the pest status and intensity of damage. Pest population was observed to be

Table 2. Insects infesting paddy crop

Insect pest species	Scientific name / Family	CPF	FWPF	MLHPF
Rice leaf roller	*Cnaphalocrocis medinalis*	+	+	+
Rice stem borer	*Scirpophaga incertulas*	+	-	-
Rice case worm	*Nymphula depunctalis*	+	-	-
Green horned caterpillar	*Melanitis leda ismene*	+	+	+
Rice skipper	*Pelopidas mathias*	+	-	-
Green hairy caterpillar	*Rivula basalis*	+	+	-
Rice bug	*Leptocorisa acuta*	+	+	+
Rice hispa	*Dicladispa armigera*	+	-	+
Rice leptispa	*Leptispa pygmaea*	+	+	-
Gregareous blue beetle	*Haltica cyanea*	+	-	-
Spotted leaf beetle	*Oides affinis*	+	+	+
Pumpkin beetle	*Aulacophora lewisi*	+	-	+
Rice grass hopper	*Hieroglyphus banian*	+	+	+
Mole cricket	*Gryllotalpa africana*	+	+	-
Rice root weevil	*Echinocnema oryzae*	+	-	-
White rice leaf hopper	*Cicadella spectra*	+	+	+
Striped bug	*Tetroda histeroides*	+	-	-
Red spotted ear head bug	*Menida histrio*	+	+	+
Pentatomid bug	Pentatomidae	+	-	-
Rice seedling fly	*Atherigona exigua*	+	+	+
Whorl maggot	*Hydrellia* sp	+	-	-
Gall midge	*Orseolia oryzae*	+	-	-
Brown plant hopper	*Nilaparvata lugens*	+	-	-
Awl butterfly	*Hasora* sp	-	-	+
Rice mealy bug	*Heterococcus rehi*	-	-	+
Long horned grass hopper	*Conocephalus pallidus*	+	+	-
Rice swift butterfly	*Borbo cinnara*	-	+	+
Yellow hairy cater pillar	*Psalis pennatula*	-	+	-
Green grass hopper	*Attractomorpha crenulata*	-	+	-
Bush hopper	*Ampittia discorides*	-	+	-
Green leaf hopper	*Nephotettix nigropictus*	-	+	-
White backed rice plant hopper	*Sogatella furcifera*	-	+	-
Total		24	18	13

+ = Present, – = Absent

low during early stages of the crop and gradually increased and reached higher level during maximum tillering and flower initiation stages and then showed declining trend (Ajayakumar 2000, Smithagopan 2004).

CONCLUSIONS

The vast water bodies of paddy field serve as feeding, breeding, nesting and roosting places for the birds. Since Rabi coincided with the winter season, there was highest number of birds in the paddy field. Since most of the birds were insectivorous and carnivorous, they consumed insect pests of paddy and that resulted in the decrease in the number of pests in the paddy field with water bodies.

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Book Review

Title of the Book: Ecological Living

Author: John Gusdorf
Publisher: Earthscan from Routledge, London and New York
Year of Publication, etc.: 2019. Pp.286. Hardback

There are two systems on planet Earth—the biosphere and the productive system. We all depend on them for our survival. Biosphere is the system of all life on Earth. We depend on it for the air we breathe, the water we drink, and the food we eat. The productive system comprises mines, wells, refineries, factories, warehouses and shops that supply us with many goods and services we have come to need and take for granted. It includes the world's farms and ranches, and also its ships, railroads, trucks, highways, etc. It is the extended order of human cooperation that not only includes systems of production and transportation but also political, legal, financial, cultural and ethical systems.

There is a basic conflict between these two systems.

The productive system extracts more and more resources from Earth and turns them into pollution of all kinds that damages ecosystems. The extinction of species, which is rapidly reducing the diversity that the biosphere depends on, and the climate change, which is disrupting the biosphere in many known and unknown ways, are the most harmful effects of the productive system. Furthermore, the productive system's incessant need for ever-increasing extraction of resources also means that it is running out of high-quality, easy to get resources and must use more energy, and do more harm, to get more materials out of low-grade, harder to get ores or deposits. So, in light of this basic antagonism between the biosphere system on the one hand and the human productive system on the other, the most important question of our time is this: Can the two systems work well together, and if so, how? Is it possible to have thriving life on Earth and at the same time supply people with at least the most important goods and services from our productive system?

The author is an independent consultant, and addresses this question with his forty years of experience with environmentalism. His book is well-structured to clarify all the things that constitute his optimistic answer, which is very simple to state. The human extended order has to change from extracting more resources each year to extracting fewer. In order to do that, it must use resources less wastefully and must depend more and more on renewable energy and recycling instead of extraction. This means making the extended human order work like the biosphere-making it a renewably powered recycler of materials. This is what is fundamentally meant by "ecological living".

Ecological living is physically possible. Neither running entirely on renewable energy nor decreasing extraction and pollution violate any laws of physics, chemistry or biology. It is also economically possible. There is no reason why you should think of an economy with zero or low economic growth to necessarily go into a permanent recession or depression. Whether it is also politically possible is the real problematic question. The author writes: "But as many people know, extremely powerful interests are in denial, focused on the short term, mired in greed or ideology or without any vision of how things would be better. Overcoming their opposition will require a powerful and coordinated movement with clear goals and well-defined means of achieving them."

The book is a useful reading for students of hopeful environmentalism. The ideas of John Stuart Mill, Kenneth Boulding, Herman Daly, Tim Jackson, Richard Wilkinson, Kate Pickett, Walter Scheidal and the like environmentalist stalwarts are reviewed. These ideas crystallize into a non-negotiable wisdom as follows:

"Ecological living will almost certainly involve a steady-state, or slowly growing, economy. It may even go through a period of economic de-growth as particularly wasteful consumption is eliminated.For this to work, societies will have to be more economically equal than they are today. Extreme and increasing inequality is very harmful to most people—not just the poor—and should be reduced in any case."

The baffling idea of "decoupling" is explained. It means producing an amount of goods and services with less resource extraction and less pollution. It can mean producing more with the same amount of extraction-pollution, the same amount with less or a smaller amount with even less. Energy decoupling means using energy more efficiently and using renewable energy instead of fossil fuels. Material decoupling means using materials more efficiently and recycling more of them. There are many questions including some troubling questions about decoupling. Is it real? Could it allow continued economic growth with less resource extraction? Could it help to provide a decent standard of living for all the billions of people on Earth now and in the future? Could it allow a slowly growing or stead-state economy to get along with less extraction each year? If so, how long could that go on?

There is also some serious and technical discussion on material resources, renewable energy, agriculture, and recycling. It is useful to read on industrial agriculture now as it is linked by evolutionary biologists to the pathogenic-zoonotic pandemic disease Covid-19 with its genesis in China.

There are two irresistible conclusions. The first is that "we can achieve the goal of ecological living without a complete overhaul of our economic system or human nature." Secondly, "If ecological living is done right, it should involve less production because goods will use fewer resources, and they will be more durable and recyclable. Combined with continuing automation, this would mean that less labour will be required. In a more equal society, this cannot mean more unemployment. It would mean that people will work less, work weeks will get shorter, and/or people will take longer vacations. As people have more free time, they'll have the freedom to become what they want to be and to make ecological living what they want to be."

Most of the book is within the grasp of the average reader with a general curiosity about humanity's relationship with its environment.

Annavajhula J.C. Bose, PhD
Department of Economics
Shri Ram College of Commerce, Delhi
(ajc.bose@srcc.du.ac.in)

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