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Seasonal fluctuation of soil fertility status associated with *Mikenia micrantha* H.B.K. infestation in Abhoypur and Dilli Reserve Forest of Assam, India

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Abstract

Tropical forest is one of the most species diverse terrestrial ecosystems. Forest soil influences the composition of the forest stand, ground cover and rate of tree growth. Invasion of exotic species may contribute to changes the forest ecosystem through litter inputs and soil properties. Mikenia micrantha H.B.K., a noxious invasive weed has invaded forest of upper Brahmaputra valley creating a major impact on soil fertility. Two different forest i.e. Abhoypur and Dilli located in transition area between Assam-Nagaland and Assam-Arunachal Pradesh boarder was studied for seasonal fluctuation of soil fertility due to M. micrantha infestation. Average soil pH of all forest was quite acidic in nature. The value of pH (4.88) was in decreasing trend with increment of depth (4.39). Highest value was recorded during pre monsoon followed by monsoon, post monsoon and winter season respectively. Soil moisture gradually increased with increasing depth (41.59%) and found to be inversely proportional to pH. Highest amount of moisture content recorded in Monsoon season (41.59%) followed by post monsoon, pre monsoon and winter season (21.78%). Bulk density was increases with increasing soil depth and varied from 0.87g^{-cm3} to 1.08g^{-cm3} in different soil layer. Abhoypur RF recorded more pH, bulk density and moisture content as compared to Dilli reserve forest. Soil organic carbon varied from 1.38%-2.19% in surface layer during post monsoon season and least value was noticed in both forests during winter season (1.08%). Available nitrogen (246.5kgh^{-1}) and organic carbon (2.19%) was recorded significantly high in Abhoypur RF (2.19%) during post monsoon season. The range of available phosphorus and exchangeable potassium were observed from 24.59kg h^{-1} to 38.55kg h^{-1} and 284.22kg h^{-1} to 313.2 kg h^{-1} respectively during pre monsoon season and gradual declination was observed by monsoon, post monsoon and winter season. Comparatively more value was noticed in surface soil which gradually decreases in deeper layer. Observations concluded that invasion of M. micrantha had profound effects on the soil fertility which may be detrimental to natural vegetation and management strategy for control of invasions to be needed for protection of forests.

Keywords: *Mikenia micrantha,* forest, seasonal fluctuation, soil fertility, infestation.

Introduction

Forest represents the different successional stage and had great difference in plant diversity and soil condition. It helps in supporting nutrient cycling and soil fertility through litter decomposition and mineralization. Invasion of non native plant in forest ecosystem is one of the major problems in natural forest. Forests have a greater influence on soil conditions than most other plant ecosystem types, due to a well-developed ''O'' horizon, moderate temperature and humidity at the soil surface, input of litter with high lignin content, high total net primary production, and high water and nutrient demand[1]. Physiochemical properties of forest soils may be varied in space, topography, climate, vegetation cover, microbial activities and several other biotic and abiotic factors. Litter in forest depends on the canopy cover and possesses the potential of improving soil fertility. The surface layer of soil is often covered with leaf litter, plant residues or partially decomposed material which enhances the fertility status in soil[2]. Different tree species can differ significantly in their influence on soil properties as well as soil fertility[3]. Many workers[4-6] studied the nutrient cycling system of different forest types of India and Nepal. Invasive weed sparsely distributed in forest and quickly absorbed nutrient through their root system which resultant in losses of soil properties. Organic matter ensures the regulation of flow of soil nutrients, which decreases nutrient loss due to leaching[7].

M. micrantha H.B.K. (Asteraceae), is one of the most destructive, perennial, invasive herb vine, native in Central and South America[8]. It includes among 100 worst invasive species and one of the top 10 noxious weeds in the world[9]. The invasive plant altered the soil environment as well as ground cover of forest stand. Invasive plants have the potential to alter soil nutrients, which in turn can affect plant and microbial communities of the invade ecosystem[10,11]. The variation of soil nutrients depends on land use and management. The plant growth is directly dependent on good soil functions. *M.micrantha* invasion had profound effect on the soil system of broad leave forest in China[11] and also had inhibitory effects on seed germination and seedling growth[12]. The present study was aimed to determine the seasonal fluctuation of physico-chemical

properties of different forest soil causes due to infestation of *M. micrantha*.

Materials and methods

The study area was situated in upper Brahmaputra valley zone, covering with semi evergreen, deciduous forest recorded to having high infestation of *M. micrantha* infested reserve forest viz., Abhoypur and Dilli, were considered for studied. The climatic data was collected from Krishi Vigyyan Kendra, Sivasagar district during the period of 2014 to 2017. The climate of the area is tropical monsoon with distinct rainy, summer and winter seasons. Average annual rainfall is 1700.25 to 2136 mm. received from the southwest monsoon during June–August. The average maximum temperature varies from 27.3^{0}C to 36.9^{0}C and the average minimum temperature varies from 5.6^{0}C to 22.8^{0}C. July is the hottest month and January is the coldest month. The average relative humidity was recorded as 79.70% during the study period; highest relative humidity found in the month of September 2015 (96.4%) and June 2016 (98.84%) respectively.

Soil samples were collected from different forest in four different seasons (pre monsoon, monsoon, post monsoon and winter) from three different depths (0-15cm, 15-25cm and 25-50cm). Elevation and area of reserve forest were recorded through GPS survey. Composite soil samples were made by collecting randomly from five sites of each study area. Soil samples were air-dried, grind and passed through 2-mm sieve and store in airtight bottles[13]. Organic carbon was estimated by wet oxidation method[14]. pH, bulk density and moisture content and NPK were determined by standard method[15].

Results and discussion

Soil is an important component of forest and regulates important ecosystem processes such as water availability, nutrient uptake, decomposition etc. Weed infestation are the more pervasive and important threats to natural ecosystem and also has a significant impact on soil properties. Changes of vegetation composition due to exotic invasion are always connected with the changes of soil properties[16]. Invasion of *M. micrantha* may play a major role in nutrient cycling of forest ecosystem.

Table-1: Geographical location and total area covered by different forest of upper Brahmaputra valley.

Name of Forest	GPS data	Elevation (m) MSL	Total Area (ha.)
Abhoypur RF	26°55'91˝N to 26°59'85˝N lati. 94° 00' 0.2˝E to 95° 02' 81.7˝E long.	60 to 463m.	6737.98 ha
Dilli RF	27^{0}4'13.91˝ N to 27^{0}8'41.39˝ N lati. 95^{0}17'25.40˝ E to 95^{0}21'56.07˝ E long.	179 to 197 m	3108 ha.

Table-1, represent the geographical location and total area covered by forest of Abhoypur RF and Dilli RF. Abhoypur reserve forest is a semi evergreen type of forest situated in south-east way of Sivasagar district of Assam ranges between 26°55'91˝N-26°59'85˝N latitude and 94°00'0.2˝E-95°02'81.7˝E longitude and having elevation of 60 to 463msl. Its falls under Charaideo sub-division, Sonari was notifies in the year 1881, located in the foothill of the Patkai range. Abhoypur reserve forest is the transition area in between Assam-Nagaland and Assam-Arunachal Pradesh. The forest comprised an area of 6737.98 ha enriched with plant and wildlife biodiversity. Dilli reserved forest is situated under western part of Sivasagar district of Assam in the foothill of the Patkai range between 27^{0}4'13.91˝N - 27^{0}8'41.39˝N and 95^{0}17'25.40˝E - 95^{0}21'56.07˝ E. It is a part of Jeypore-Dehing forest landscape where the total area covering 575sq. km. The forest area covered nearly 3108 ha; elevation of 179 to 197msl.

Result (Table-2a) represents the seasonal variation of physico-chemical properties of soil in different forest of upper Brahmaputra valley zones. pH value was remarkably high in Abhoypur RF. Highest value was recorded during pre monsoon (4.88±0.015) followed by monsoon (4.73±0.015), post monsoon (4.57±0.02) and winter (4.36±0.02) season and similar trend was also seen in Dilli RF. Least pH value (4.39) was recorded in deeper layer in soil. This may be due to release of acidic compound through the decomposition of organic residues from forest vegetation[17,18]. Soil moisture (Table-2a) gradually increased with increasing depth. It is inversely proportional to pH. Significantly highest amount of moisture content was found during monsoon season followed by post monsoon, pre monsoon and winter season. Highest amount of moisture content was recorded in Abhoypur RF during monsoon season (41.59%) followed by Dilli RF (38.46%) at 25-50cm. depth. Lowest trend was seen in winter season (21.78%) in both study sites. Similar observation also found in *Mikenia* infested Abhoypur reserve forest[19].

Bulk density of the soil is a measure of compactness of soil and it relates core size distribution indicating the range of water holding capacity and soil aeration. Generally surface layer contains more nutrient content due to accumulation of humus content in soil. The bulk density (Table-2b) was increases with increasing soil depths and highest amount of bulk density was recorded in subsurface layer of Abhoypur (1.08g^{-cm3}) during pre monsoon season. It gradually decline in surface layer of Dilli reserve forest (0.99g^{-cm3}) during winter season. Lowest value of bulk density in surface layer may be due to the addition of organic matter through litterfall[20].

Soil organic carbon played a significant role to maintain the fertility status of forest. Highest amount of organic carbon (Table-2c) found during post monsoon season (2.19%) at 0-15 cm. depth and it gradually decline in subsequent layer (1.98%). Soil organic carbon was gradually decreasing down the layers at all altitude and maximum was in surface layer[17].

Abhoypur reserve forest recorded highest amount of organic carbon than Dilli RF. Least value was recorded during winter season (1.46%). The main source of organic carbon is leaf litter and other fragmented part of trees. The rate of decomposition determined the humification activities. Large amount of organic carbon accumulates as humus on the top of forest floor but it may be rapidly disappear due to quick absorption of nutrient by the fast growing *Mikania* species. Surface layer accumulates more organic carbon which is decreased with soil depth[19] and found negative correlation between organic matter and bulk densities of soil samples[21].

More or less equal amount of available Nitrogen (Table-2c) was found in surface layer of Abhoypur (246.5±0.5kg h^{-1}) and Dilli reserved forest (245.4±0.16kg h^{-1}) during post-monsoon season. Season and depth wise variation also observed in post monsoon season followed by pre monsoon, monsoon and winter season respectively. However, during present study higher values of organic C and N found in the surface layer of soil. Invasion of *M. micrantha* decreased nitrogen content in soil due to quick absorption[11] and release more total C and N in soil from the rhizosphere of *Mikania* than open areas. Continuous invasion of *M. micrantha* release more nutrients through litter accumulation[22]. *Lantana camara* alter light and nutrient availability, which may favour its self-perpetuation over the regeneration of other species[23].

Available Phosphorus in forest depends on a number of factors and varied greatly in different forest. Highest amount of available phosphorus was found in the surface layer of Abhoypur RF (38.55kg h^{-1}) and Dilli RF (34.56kg h^{-1}) during pre monsoon season and gradually declined in subsequent layer. The higher phosphorus availability may also facilitate *M. micrantha* infestation[10]. Least value was recorded in winter season (14.67kg h^{-1}). The depth and season wise variations were observed in both study sites which gradually decrease in sub surface layer of soil.

Table-2a: Seasonal fluctuation of pH and Moisture content in different forests soil.

Forest	Depth (cm)	pH				Moisture content (%)			
		RM	M	PM	W	RM	M	PM	W
Abhoypur RF	0-15	4.88 ±0.015	4.73 ±0.015	4.57 ±0.124	4.36 ±0.02	24.62 ±0.072	30.58 ±0.04	26.72 ±0.03	22.57 ±0.02
	15-25	4.73 ±0.015	4.68 ±0.0054	4.53 ±0.012	4.29 ±0.021	28.44 ±0.061	36.64 ±0.02	30.61 ±0.03	25.85 ±0.03
	25-50	4.67 ±0.017	4.69 ±0.0057	4.51 ±0.02	4.24 ±0.012	30.58 ±0.035	41.59 ±0.03	34.52 ±0.02	28.62 ±0.04
Dilli RF	0-15	4.63 ±0.015	4.56 ±0.02	4.48 ±0.017	4.25 ±0.035	22.81 ±0.035	30.11 ±0.04	20.66 ±0.02	21.78 0.025
	15-25	4.52 ±0.031	4.46 ±0.02	4.42 ±0.015	4.25 ±0.035	29.60 ±0.03	35.26 ±0.02	24.8 ±0.03	24.94 ±0.03
	25-50	4.39 ±0.030	4.34 ±0.017	4.39 ±0.021	4.25 ±0.035	31.08 ±0.028	38.46 ±0.03	28.94 ±0.02	26.86 ±0.04

RM- pre monsoon, M-monsoon, PM- post monsoon and W- winter.

Table-2b: Seasonal fluctuation of Bulk Density in different forests soil.

Forest	Depth (cm)	Bulk Density (g^{-cm3})			
		RM	M	PM	W
Abhoypur RF	0-15	1.02±0.005	0.98±0.012	0.98±0.012	1.01±0.01
	15-25	1.05±0.015	0.99±0.01	1.04±0.015	1.02±0.005
	25-50	1.08±0.01	1.05±0.01	1.07±0.011	1.05±0.015
Dilli RF	0-15	1.01±0.01	0.86±0.036	1.03±0.01	0.99±0.015
	15-25	1.04±0.015	0.87±0.03	1.05±0.01	1.03±0.01
	25-50	1.04±0.015	1.02±0.006	1.06±0.01	1.05±0.015

Table-2c: Seasonal fluctuation of Organic Carbon and Available Nitrogen content in different forests soil.

Forest	Depth (cm)	Organic Carbon (%)				Av. Nitrogen (kg h^{-1})			
		RM	M	PM	W	RM	M	PM	W
Abhoypur RF	0-15	1.74 ±0.025	1.57 ±0.025	2.19 ±0.021	1.46 ±0.025	148.6 ±0.21	126.4 ±0.35	246.5 ±0.5	118.5 ±0.45
	15-25	1.52 ±0.03	1.26 ±0.021	2.06 ±0.015	1.18 ±0.025	129.8 ±0.15	114.6 ±0.35	218.4 ±0.45	112.4 ±0.4
	25-50	1.38 ±0.026	1.17 ±0.025	1.98 ±0.015	1.08 ±0.015	118.6 ±0.6	108.8 ±0.25	215.1 ±0.2	100.2 ±0.2
Dilli RF	0-15	1.76 ±0.024	1.41 ±0.032	1.98 ±0.028	1.32 ±0.020	136.8 ±0.20	114.8 ±0.58	245.4 ±0.16	109.4 ±0.36
	15-25	1.58 ±0.028	1.26 ±0.021	1.65 ±0.024	1.24 ±0.028	125.5 ±0.28	109.2 ±0.16	220.7 ±0.24	104.8 ±0.12
	25-50	1.47 ±0.02	1.08 ±0.015	1.34 ±0.009	1.15 ±0.014	115.8 ±0.1	104.8 ±0.17	211.5 ±0.20	100.2 ±0.47

Table-2d: Seasonal fluctuation of Available Phosphorus & Exchangeable Potassium (kg h^{-1}) in different forests soil.

Forest	Depth (cm)	Available P (kg h^{-1})				Exch. K (kg h^{-1})			
		RM	M	PM	W	RM	M	PM	W
Abhoypur RF	0-15	38.55 ±0.06	29.41 ±0.08	16.75 ±0.05	14.67 ±0.08	313.2 ±0.4	235.6 ±0.04	192.4 ±0.1	156.8 ±0.45
	15-25	31.22 ±0.37	24.48 ±0.06	15.84 ±0.02	13.45 ±0.05	251.58 ±0.18	223.5 ±0.14	186.2 ±0.35	128.5 ±0.25
	25-50	24.59 ±0.45	19.56 ±0.08	15.26 ±0.03	12.58 ±0.06	158.46 ±0.08	195.1 ±0.07	174.5 ±0.3	117.8 ±0.35
Dilli RF	0-15	34.56 ±0.04	25.32 ±0.024	15.42 ±0.036	12.88 ±0.028	284.22 ±0.024	229.6 ±0.28	189.5 ±0.12	158.6 ±0.12
	15-25	30.12 ±0.028	20.65 ±0.053	14.55 ±0.028	10.59 ±0.028	261.45 ±0.04	216.5 ±0.4	164.2 ±0.32	136.5 ±0.08
	25-50	25.44 ±0.036	18.72 ±0.04	12.49 ±0.04	9.85 ±0.028	196.90 ±0.08	208.1 ±0.01	125.9 ±0.28	118.5 ±0.2

RM- pre monsoon, M-monsoon, PM- post monsoon and W- winter.

Highest amount of exchangeable potassium was found in pre monsoon (313.2±0.4 kg h^{-1}) followed by monsoon (235.6±0.04 kg h^{-1}), post monsoon (192.4±0.1kg h^{-1}) and winter (156.8±0.45kg h^{-1}) season. Abhoypur reserve forest recorded more potassium content than Dilli RF. The depth wise variations of values were observed in all the study sites which gradually decrease in sub surface layer of soil. Potassium is required to performed vital processes like regulating transpiration and respiration, synthesis of carbohydrate and protein and has a major influence on enzyme action[24]. Potassium is locked up in plant roots and the small gain in surface layer can be attributed to improve physical and chemical soil condition due to influence of tree canopy[25].

Conclusion

The result of the study also concluded that the invasion of weed species could alter the forest cover as well as soil structure. Exotic plants can create a new habitat by altering the attributes of native ecosystems[26,27]. As the invasion of exotic species differs in different forests which may be due to the influence of site, composition of native vegetation, climate etc. therefore, its impact on soil properties also differed, thus to develop a management strategy to control the invasion.

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