J. Nat. Hist. Mus. Vol. 26, 2012, 155-162

PHYSIOCHEMICAL CHARACTERISTICS OF SOIL OF A MIXED *SHOREA ROBUSTA* FOREST IN RUPANDEHI DISTRICT, NEPAL

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ABSTRACT

Physiochemical characteristics of soil of mixed *Shorea* robusta forest in Parroha community forest of Rupandehi district (central Nepal) were analyzed. Soil samples were collected from south eastern (SE) and south western (SE) slopes of the forest and analyzed for water holding capacity (WHC), pH, organic matter, nitrogen, phosphorous and potassium. The soil acidic (pH 4.2-6.2) with organic matter 1.87-2.73 %, nitrogen 0.09-0.13 %, phosphorus 4.7-23.3 kg/ha, and potassium 141-191 kg/ha. The SE slope, with high canopy cover and litter content, had relatively better soil characteristics as compared to the SW slope.

Keywords: conservation, soil nutrients, south-east and south-west facing slope

INTRODUCTION

Soil is the loose, friable, unconsolidated top layer of earth's crust. It is the medium in which roots grow, anchor the plants and is the reservoir of water and nutrient necessary for the terrestrial plant life. Soil has a distinctive type of flora, fauna and microorganisms. The soil surface is often covered with a layer of leaf litter, plant's residue, or other fresh or partially decomposed organic matter (Lekhak and Lekhak 2005). Forest soil influences the composition of the forest stand and ground cover, rate of tree growth, vigor of natural reproduction, and other silviculturally important factors (Bhatnagar 1965). Soil posses many characteristic physical and chemical properties that determine its quality and usefulness. Physiochemical characteristics of forest soils vary in space and time due to variations in topography, climate, physical weathering processes, vegetation cover, microbial activities and several other biotic and abiotic variables. Vegetation also plays an important role in soil formation. For example plant tissues (from above ground litter and below ground root detritus) are the main source of the soil organic matter (OM) which is called 'life blood' of soil because it has an effect upon the physical, chemical and biological properties of the soil (Pandey *et al*. 1996). OM plays a dominant role in supplying plant nutrients especially nitrogen, phosphorus and sulphur. High OM improves infiltration rates and water holding capacity (WHC). Soil organic matter acts as buffering in soil pH, improves soil texture, increase the activities of soil organisms. The pH value of soil ranges from 3-10 (FORSPA 2002). Soils with a near neutral pH (6.0-7.0) are the most fertile. Soil microorganisms thrive best between pH 5.5 to 7.8. The soil pH determines the kind of plants it can support by influencing availability of nutrient and their uptake by plants. Nitrogen (N) is most often the limiting nutrient in plant growth; it is a constituent of chlorophyll, plant proteins and nucleic acids. The amount of N in most natural soil may vary from 0.03 to 0.10% in the surface layer (Etherington 1974). Phosphorous has been called 'the key to life' because it is directly involved in most of the life processes (Pandey *et al*. 1996). Phosphorous

(P) occurs in the soil in both organic and inorganic forms. Natural soil usually contains P between 0.02-0.5% most of which derived from parent materials (Etherington 1974). Similarly, potassium (K) is the third most likely nutrient element to limit plant growth. Natural soil usually contains much more K than P or N and the value ranges between 0.03-2.5 % (Black 1968).

Generally the sal forests in Nepal are in a degraded state because of indiscriminate cutting, recurring forest fire, and uncontrolled grazing, leading to nutrient impoverishment. In fact, more than half of the tropical soil in the world is highly weathered, leached and impoverished, and therefore mechanisms to conserve nutrient in the ecosystem are important (Sanchez 1976, Jordan 1985). The objective of the present study was to analyze the physiochemical characteristics (water holding capacity, texture, pH, OM, N, P and K) of soil at two slopes (south-east and south-west facing) of Parroha community forest in Rupandehi district where south-east facing slope is dominated by *Terminalia alata* and south-west by *Shorea robusta*.

STUDY AREA

Parroha Village Development Committee (VDC) area is located in Rupandehi district which lies between 27°20' to 27°45' N latitude, 83°10' to 83°30' E longitude. It is a part of Terai region of Nepal and covers a total area of 73196.1 ha of which about 73% is agricultural land, urban areas and roads, 23% forest and remaining 4% water resources (Anonymous 2007). Present research was conducted in Parroha community forest of Parroha VDC with an area of 633 ha. The users' group of the forest includes 1267 households (HH) and 8849 members. The landscape is south facing with several micro aspects ranging from south-east to south-west facing slopes. Two sites (SE slope: South-East facing slope and SW slope: South-West facing slope) lying between 250 and 550 m asl were selected for the present study. For management purposes the Parroha Community Forest has been divided into three blocks. Present study was carried out at Rani block in SE slope and Kapase block in SW slope of PCF separated by a Ghamaha Khola, a perennial river. The SE slope is dominated by *Terminalia alata* whereas SW slope by *Shorea robusta* with their associated species like *Anogeissus latifolia*, *Lagerstroemia parviflora*, *Buchanania* latifolia, etc.

The climate of the study area is typically tropical, dominated by South east monsoon. A hot climate generally prevails throughout the years except in the short winter. Mean temperature ranges from nearly 10°C during winter to >35°C during late summer (April-May).

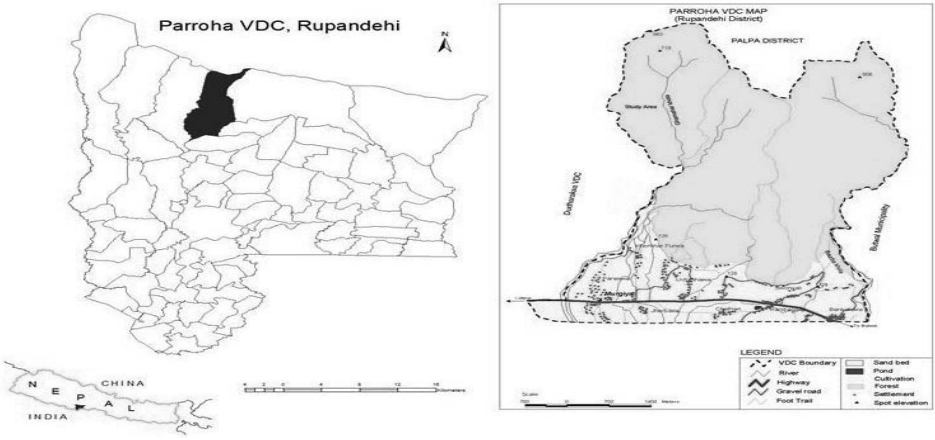

Figure 1. Map of the study area

MATERIALS AND METHODS

Soil Sampling and Laboratory Analysis

Soil was sampled during October-November of 2005. In each slope (site) three parallel transects were visually defined from 250 to 550 m asl. Each transect was divided into four elevation bands at the interval of 100 m elevation increment. In each elevation band of each transect three quadrats (10 m × 10 m) were sampled. Among these three quadrats one lied along the transect line and two on either sides at a distance of 40 to 100 m. Soil samples (15 cm depth) were collected from the four corners and centre of the 10 m × 10 m quadrat following the method given by Saxena (1989). Soil from three quadrats of each elevation band of each transect were mixed homogeneously to make a single sample and packed in an airtight poly bag until the determination of moisture. Thus, 12 samples were collected from each slope. After moisture estimation the soil was air dried in shade. Water holding capacity was analyzed at Laboratory of Ecology, Central Department of Botany, Tribhuvan University while total nitrogen (N, %), available phosphorus (P) as P_2O_5 (kg/ha), available potassium (K) as K_2O (kg/ha), pH and organic matter (OM, %), were determined at Soil Management Directorate of the Department of Agriculture, Hariharbhawan, Lalitpur. Water holding capacity was analyzed following the methods described in Zobel *et al*. (1987). Organic matter was determined by Walkey and Black rapid titration method, soil pH by using electric pH meter, total nitrogen by modified micro-Kjeldahl method, available phosphorous by Olsen's modified carbonate method and available potassium by flame photometer. All these methods of soil chemical analyses have been described in Gupta (2000). Mean of different soil variables at two slopes were compared by Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS ver. 11.5).

RESULTS AND DISCUSSION

Soil was acidic with pH 5.2 - 6.2 at SE slope and 4.2 - 5.0 at SW slope (Table 1 and 2). Higher acidity of soil at SW slope may be due to dominance of *Shorea robusta*, which favors strongly the acidic soil than *Terminalia alata*. The range of soil pH (4.2-6.2) in the studied forest was

close to the earlier reports in Churia forest of Rupandehi (4.5–5.5) (Marasini 2003), tropical *Shorea robusta* forests (mean 5.3) (Bashyal 2005), (5.26) (Paudel and Sah 2003), (4.4–5.5) (Shrestha 2003), hill *Shorea robusta* forests (4.0-5.1) (Pant 1997), (4.5–5.5) (Shrestha 1997), (4.3–5.6) (Dhungana 1997) and *Shorea robusta* forest of Arun river basin (4.10–4.32) (Duwadee 2000). But this range of value (4.2-6.2) of the present study forest was lower than the value reported by Chhetri (1997) in Chitwan National Park (6.62-6.8), and Karki (1999) in Koshi Tappu Wild Life Reserve (6.4-7.1).

The acidic nature of soil of the study area may be attributed to the high rainfall (average annual rainfall 1391 mm), which is sufficient to remove basic cat ions from the soil surface. Moreover density and crown cover of trees were lower, which has enhanced the growth of grasses. The grasses tend to use more bases, resulting decrease in soil pH (Barbour *et al.* 1999).

Table 1. Average soil pH, Water Holding Capacity (WHC), Organic Matter (OM), Nitrogen (N), Phosphorus (P) and Potassium (K) at SE slope.

Altitude	pH	WHC (%)	OM (%)	N (%)	P (kg/ha)	K (kg/ha)
250 m	6.2	49.16	2.68	0.13	17.8	141.90
350 m	5.7	44	2.43	0.12	15.6	144.10
450 m	5.8	44.16	2.44	0.12	23.3	190.60
550 m	5.2	49	2.73	0.13	17.2	175.13

Table 2. Average soil pH, Water Holding Capacity (WHC), Organic Matter (OM), Nitrogen (N), Phosphorus (P) and Potassium (K) at SW slope.

Altitude	pH	WHC (%)	OM (%)	N (%)	P (kg/ha)	K (kg/ha)
250 m	5.0	40	1.87	0.09	5.6	161.83
350 m	4.8	38.83	2.09	0.10	17.2	144.13
450 m	4.2	37.66	1.92	0.09	4.7	190.66
550 m	4.9	40.8	2.14	0.11	11.1	175.13

Water holding capacity (WHC) of soil in the studied forest ranged from 39-49 % (Table 1 and 2). The value was similar to the values reported by Poudel and Sah (2003) in tropical *Shorea robusta* forest in eastern Nepal (49%±6.30%) and Bashyal (2005) in tropical forest of Palpa (36%-48%). The present value was lower than the value reported by Pant (1997) in hill *S. robusta* forest (70–78 %). According to Bhatnagar (1965), WHC of soil from regenerating areas is higher due to high litter content.

Table 3. Mean (± SD) of different attributes of soil sample at two sites (N = 12 for all soil attributes for each site). F-value and significance level were obtained from analysis of variance (ANOVA).

Attributes	SE slope	SW slope	Mean of two sites	F	Significance level
pH	5.7±0.42	4.76±0.64	5.23±0.75	14.74	0.001
WHC	46.5±4.87	39.36±3.47	42.97±5.54	17.47	<0.001
OM	2.57±0.46	2.0±0.42	2.285±0.53	10.60	<0.01
N	0.13±0.02	0.09±0.02	0.11±0.02	10.15	<0.01
P	18.5±11.94	11±7.99	14.73±10.65	3.25	0.085
K	163±30	197±60	177±50	3.03	0.095

OM content was higher at SE slope than at SW slope (P<0.01, Table 3) and ranged from 1.87–2.73 (Table 1-2). According to soil fertility rating chart of Soil Management Directorate of the Department of Agriculture, Hariharbhawan, Lalitpur (Annex 1), the soil of present study area had low to medium fertility which might be due to rapid decomposition and mineralization of organic matter under relatively high temperature. Brady (1984) mentioned that the lower soil OM occurred more commonly in warmer climate than in cooler. The OM content in the soil of the study area (1.87-2.73 %) lies within the range of values reported by Marasini (2003) for Churia forest (1.33-2.45 %), and Paudel and Sah (2003) for terai *Shorea robusta* forest in eastern Nepal (1.01-2.42). The soil OM of the present study forest was lower than the value reported by Chhetri (1997) in Chitwan National Park (8.61-10.29 %) and higher than the value reported by Dhungana (1997) in hill *Shorea robusta* forest of Kavrepalanchowk (0.54-1.88 %).

The soil nitrogen content at SE slope was higher than at SW slope (P<0.01). It might be due to high OM at SE slope than SW slope (Table 1-2). Higher value of N and OM at SE slope (Table 3) might be due to higher canopy cover and litter accumulation. The N content (0.09-0.13 %) in soil of the study area was similar to N content reported by Marasini (2003) in Churia forest of Rupandehi (0.05-0.15 %). The present value of soil N was less than the value reported by Chhetri (1997) in Chitwan National Park (0.18-19 %). According to soil fertility rating chart of Soil Management Directorate of the Department of Agriculture, Hariharbhawan, Lalitpur (Annex 1), the soil of present study area had low to medium fertility. This might be a common feature of *Shorea robusta* dominant areas (Bhatnagar 1965). The low N content in soil at present study site might have been due to rapid utilization of N by the plant and the continuous losses through leaching, run off, and volatilization process. Nitrogen in soil is quickly exhausted as soil nitrates are highly mobile in water (Larcher 1995).

The two slopes had nearly equal available phosphorus in soil (Table 3). The estimated value (14.73 kg/ha) was within the range of values reported from Churia forest of Rupandehi (6.43-

30 kg/ha, Marasini 2003) and tropical forest of Palpa (6.8-15.57 kg/ha, Bashyal 2005). But the present value was lower than the value reported by Shrestha (2003) in *Shorea robusta* forest of Barandabhar (37-184 kg/ha). The studied forest had low rating of available phosphorus according to soil fertility rating chart of Soil Management Directorate of the Department of Agriculture, Hariharbhawan, Lalitpur.

Potassium content in soil was nearly equal at both slopes (Table 3). The estimated value (177 kg/ha) was higher than the value reported for tropical forest of Palpa (152 kg/ha, Bashyal 2005) and hill *Shorea robusta* forests of Kavreplanchowk (41–88 kg/ha, Pant 1997) . The present value was lower than the value reported for tropical *Shorea robusta* forest of eastern Nepal (234±18 kg/ha, Poudel and Sah 2003) and Churia forest of Rupandehi (197-267 kg/ha, Marasini 2003).

The forest soil in the study area contains adequate quantities of all the nutrients, except phosphorous. According to soil fertility rating of Soil Management Directorate of the Department of Agriculture (Hariharbhawan, Lalitpur), organic matter and nitrogen had a low to medium level and potassium a medium level, while phosphorous had a low rating. Overall, soil of SE slope was better in terms of the measured soil characteristics than of SW slope, probably because of high canopy cover and litter production.

ACKNOWLEDGEMENTS

This article is based on M.Sc. thesis submitted by the first author to the Central Department of Botany, Tribhuvan University, Kathmandu, Nepal. We are thankful to Ramita Aacharya, Mahadev Chaudhary, and the member of the Users' Group of Parroha Community Forest for their help in the field study and to Mr. Kiranhari Maskey (Soil scientist, Soil Management Directorate of the Department of Agriculture, Hariharbhawan, Lalitpur) for his help in chemical analysis soil.

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Annex 1. Soil fertility rating for terai region prepared by Soil Management Directorate of the Department of Agriculture, Hariharbhawan, Lalitpur, Nepal.

Chemical parameters	Rating scale	Value
pH	Acidic	<6.5
	Neutral	6.51-7.5
	Alkaline	>7.51
Organic matter (%)	Very low	<0.75
	Low	0.75-1.50
	Medium	1.50-3.00
	High	3.00-5.00
	Very high	>5.00
Total nitrogen	Very low	<0.03
	Low	0.03-0.07
	Medium	0.07-0.15
	High	0.15-0.25
	Very high	>0.25
Available phosphorus (as P2O5, kg/ha)	Very low	<11.2
	Low	11.2-28
	Medium	28-56
	High	56-112
	Very high	>112
Available potassium (as K2O, kg/ha)	Very low	<56
	Low	56-112
	Medium	112-280
	High	280-504
	Very high	>504

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