Nutrient Dynamics under Different Plantations in Subtropical Forest Ecosystem

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Abstract: A study was conducted to estimate the nutrient status of soil under Sal (*Shorea robusta*) and Teak (*Tectona grandis*) plantations in Motichur and Chilla forest ranges of Rajaji National Park in Uttarakhand, India. Overall the mean values of Moisture Content, Water Holding Capacity, Organic Carbon and Organic Matter and Soil Fertility Index were recorded relatively higher in Motichur forest range under both the plantations as compare to the Chilla forest range. The student's t-test was also analysed and results showed that all the soil properties in the Motichur and Chilla forest ranges were significantly different between Sal and Teak plantations.
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1. Introduction:

Soils differ under different types of vegetation and, within forest vegetation, under different species of trees (Binkley, 1995). Different forest vegetation gives rise to different soil. Local inhabitants have long noted that land formerly under forest has different qualities according to the kind of forest which it bore (Dokuchaev 1900, cited in Remezov and Pogrebnyak 1965). From its inception, forestry showed interest in the manner of influence of tree stands on soils; such effects of the canopy and of the litter were regarded by the forester as a means of changing the soil in order to conserve its fertility (Morozov 1904, cited in Remezov and Pogrebnyak 1965). Plant tissues (above and below ground litter) are the main source of soil organic matter, which influences the physico-chemical characteristics of soil such as, texture, water holding capacity, pH and nutrient availability (Johnston ,1986). The nature of soil profile, pH and nutrient cycling between the soils and trees are the important dimensions to determine the site quality. Soil organic matter (SOM) is an important factor in evaluating management system of the forest soil fertility (Doran and Parkin, 1994). In tropical and subtropical regions, where soils are strongly weathered and contained variable charged mineral, interaction of SOM and these soils can result in increasing SOM protection from microbial attack compared with that found in less weathered temperate soils (Martin et al. 1982; Parfitt et al. 1997). Nitrogen is considered to be the pulse of the soil and intimately connected with the decomposition of organic matter and biochemical activity. Soil fertility is the 'capacity of a soil to produce a large harvest'. So, it is clear that the concept of soil fertility is linked to the physical, chemical, biological, climatic and anthropic characteristics of the site. Considering the numerous studies that have been done on the effects of different tree species, it appears that the overstory composition probably does impact soil fertility. The crucial point is to determine if the nature and the intensity of the modifications caused by a tree species are sufficient to significantly decrease or increase soil fertility (Binkley and Giardina, 1998). The cycling of nutrients has been studied in the stable woodland ecosystems and in different forest type of India and the world (Bajrachyara et al. 2007). The objective of this study was to examine and compare the influence of different tree species on the nutrient status of soil in two forest ranges.

2. Materials and Methods:

2.1 Study site:

Two dominant tree species *i.e*. *Shorea robusta* and *Tectona Grandis* were selected from two forest ranges *i.e.* Motichur and chilla of Rajaji National Park in Uttarakhand. Motichur forest range is in the eastern region and the chilla forest range lying in the western region of Rajaji National Park, located at 29º15′-30º 15′ N and 77º55′- 78º30′ E.

2.2 Soil sampling and analysis:

Field survey was conducted from July 2011 to June 2012 .Soil samples were collected in the polythene bags in triplicates from 0-30 cm depth from both the sampling sites at seasonal intervals. Soil samples were dried in shade, lightly ground in mortar and passed through a 2mm sieve. Standard procedures were followed in analyzing the soil samples. The average soil temperature was measured using soil thermometer and moisture content of fresh soil samples was determined after oven drying them at 105°C and expressed as a percentage of weight of the soil samples. Humidity was measured by using hygrometer. Soil pH was measured using digital pH meter. Calcium and magnesium were determined in ammonium acetate extract of soil by direct titration with

EDTA (Trivedy and Goel, 1986). Soil sodium and potassium were measured using flame photometry. Organic carbon and organic matter was determined following the wet digestion (Walkely and Black 1934). Aluminium was determined using colorimeter (HACH DR 820). Total nitrogen was determined by Kjeldahl method. Available phosphorous was determined spectrophotometrically (Trivedy and Goel, 1986).

Value of soil fertility index (Moran et al. 2000) was calculated to quantify soil fertility. The following equation was used to calculate value of the soil fertility index (Lu et al. 2002).

Soil Fertility Index = pH + organic matter (%, dry soil basis) + available P (mg/kg, dry soil)+ exch K(c eq kg^{-1} dry soil)+ exch Ca (c eq kg^{-1} dry soil)+ exch Mg (c eq kg^{-1} dry soil)- exch Al (c eq kg^{-1} dry soil).

2.3 Statistical analysis:

The descriptive Statistics of all the physico-chemical properties of soil was calculated by Microsoft Office Excel 2007 and to determine the significance between two tree species student's t- test was performed using the statistical software SPSS .

3. **Results and Discussion:**

Trees play a crucial role in maintaining and regenerating soil fertility through the action of their roots and litter (Kjoller and Struwe, 1982). The vegetation of the study area was dominated by *Shorea robusta* (Sal) and *Tectona grandis* (Teak). Other important associated tree species, shrub and herbs found in the region were: *Acacia catechu, Dalbergia sisso and Bombax ceiba, Zizyphus jujuba, Melotus sps.* and *Adathora vesica* .

Table -1 depicts the characteristics of the soil under Sal plantation in Motichur and Chilla forest. The mean values of all the variables under Sal were recorded relatively higher in Motichur forest range than those of chilla forest range except in case of Potassium (9.86 mg/L)where lower value was recorded when compared to the Chilla forest range. The mean value of Total Nitrogen (0.28 %) was found higher in the Motichur as compared to Chilla forest range. These differential effects could be attributed to the fact that the organic matter (3.18%) which is a major source and store of nitrogen components was recorded higher in Motichur thus, total nitrogen will respond to the level of organic matter content in the soil. The role of organic matter in the build up of soil nutrients appears crucial in all ecosystems and depends on the high foliage cover and vegetation biomass and higher rate of litter production and subsequent decomposition. Hence, it can be deduced that the nutrient return from vegetation to the soil would depend on the nutrient uptake by the biomass of each plant community (Awotoye et al. 2009). The mean value of pH under Sal in Motichur was ranged from 6.12 to 6.40 which is similar to the findings of Singh and Ramakrishnan(1981) *i.e*. 6.1 to 6.5.

Table- 1. Descriptive statistics of soil physico-chemical properties under *Shorea robusta* in Motichur and Chilla forest range.

Soil Properties	Motichur Forest Range				Chilla Forest Range			
	Mean	Min.	Max.	S.E.	Mean	Min.	Max.	S.E.
Temp(°C)	20.85	15.60	25.60	0.98	20.38	15.6	25.20	0.92
Humidity (%)	68.86	60.00	80.00	2.21	68.71	60.00	78.00	2.09
Moisture Content (%)	10.48	7.60	12.00	0.41	10.30	7.20	12.80	0.52
Water Holding Capacity(%)	69.90	60.00	80.00	1.71	66.40	56.00	76.00	1.94
pH	6.25	6.12	6.40	0.02	6.21	5.94	6.44	0.04
Organic Carbon (%)	1.92	1.53	2.99	0.11	1.72	1.29	2.20	0.07
Organic Matter (%)	3.18	2.66	3.95	0.10	3.00	2.24	3.83	0.12
Total Nitrogen (%)	0.28	0.24	0.32	0.05	0.27	0.20	0.32	0.01
Phosphate(mg/L)	0.82	0.68	0.90	0.02	0.82	0.72	0.91	0.01
Sodium(mg/L)	5.08	4.10	6.33	0.19	4.69	3.74	5.22	0.14
Potassium(mg/L)	9.86	8.24	10.50	0.21	11.15	10.00	15.04	0.36
Calcium(meq/100gm)	7.03	6.26	7.86	0.19	6.75	6.54	7.00	0.05
Magnesium(meq/100gm)	2.77	2.64	2.90	0.03	1.76	1.36	2.00	0.08
Aluminium (mg/L)	0.16	0.10	0.28	0.01	0.13	0.06	0.19	0.01
Soil Fertility Index	20.02	19.15	20.92	0.18	18.41	17.11	19.22	0.18

Table- 2. Descriptive statistics of soil physico-chemical properties under *Tectona grandis* in Motichur and Chilla Forest range

Soil Properties	Motichur Forest Range				Chilla Forest Range			
	Mean	Min.	Max.	S.E.	Mean	Min.	Max.	S.E.
Temperature(°C)	20.50	15	25.4	1.01	20.66	15.2	27.2	1.03
Humidity (%)	68.23	60	80	2.15	69.88	60.00	78	1.67
Moisture Content (%)	9.78	7.6	11.6	0.34	9.63	6.80	11.6	0.40
Water Holding Capacity(%)	64.83	56	76	1.44	63.58	52	71.6	1.56
pH	6.19	6	6.52	0.04	6.21	6.02	6.54	0.045
Organic Carbon (%)	1.62	1.27	1.89	0.09	1.60	1.25	1.87	0.048
Organic Matter(%)	2.83	2.21	3.29	0.05	2.8	2.17	3.26	0.08
Total Nitrogen(%)	0.27	0.22	0.32	0.07	0.22	0.19	0.26	0.06
Phosphate(mg/L)	0.85	0.79	0.90	0.01	0.87	0.78	0.96	0.01
Sodium(mg/L)	4.94	4.57	5.2	0.05	4.61	3.83	5.24	0.12
Potassium(mg/L)	10.48	10	11	0.07	10.39	7.86	11.22	0.34
Calcium(meq/100gm)	6.49	5.23	7.26	0.27	7.0	6.45	7.36	0.12
Magnesium(meq/100gm)	2.59	2.43	2.73	0.03	1.52	1.10	1.86	0.09
Aluminium (mg/L)	0.15	0.1	0.23	0.01	0.10	0.02	0.18	0.01
Soil Fertility Index	18.98	17.48	20.08	0.28	18.40	17.32	19.34	0.20

The soil characteristics (Table-2) under Teak plantation in both the forest ranges exhibited similar pattern of distribution as under Sal. The minimum and maximum values of WHC, pH,OM and Ca were recorded Higher under Teak in Motichur forest range as compared to the Chilla forest range. This is similar to the works of Awotoye et al. (2009) who reported the values of WHC, pH,OM and Ca as 56.86%, 6, 3.13% and 5.13meq/100gm respectively.

In the present study, mean values of Soil Fertility Index were found higher in Motichur (20.02 and 18.98) as compared to Chilla (18.41 and 18.40) forest range under both the plantations. Several studies have reported that soil fertility under tree situation is improved due to increased input of organic matter through litter (Dunham,1991; Kesseler ,1992; Campbell et al. 1994 ; Dhyani, 1997).

Table-3. Results of t- test comparing soil properties under *Shorea robusta* and *Tectona grandis* in two forest ranges.

Soil Properties	Motichur Forest Range	Chilla Forest Range
Temperature(°C)	29.82	30.06
Humidity (%)	45.33	52.64
Moisture Content (%)	36.81	30.07
Water Holding Capacity (%)	55.52	51.69
pH	252.26	203.34
Organic carbon(%)	25.06	37.23
Organic Carbon(%)	37.96	37.64
Total Nitrogen(%)	27.89	35.03
Phosphate(mg/L)	68.27	68.64
Sodium(mg/L)	49.89	50.05
Potassium(mg/L)	78.87	41.16
Calcium(meq/100gm)	38.69	97.31
Magnesium (meq/100gm)	86.29	23.64
Aluminium (mg/L)	11.53	8.36
Soil Fertility Index	95.37	23.57

Student's t-test: $t_{0.05,23} = 1.714$. All values are significantly different between two populations at 5% level.

The student's t-test showed that all the soil properties measured in the Motichur and Chilla Forest ranges were significantly different ($t = 0.05$) between the Sal and Teak plantations (Table-3).

As evident in Table 1 and 2, the present study showed that the soil under *Shorea robusta* and *Tectona grandis* was relatively better enriched with nutrients in Motichur forest range as compared to Chilla forest range.

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