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Impact of Three Different Individual Tree Species on the Chemistry of Mineral Top Soil in Kashmir Himalaya

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ABSTRACT

Influence on chemistry of the mineral top soil of two coniferous gymnosperm trees, *Pinus wallichiana* and *Cedrus deodara*, and a deciduous angiosperm tree *Platanus orientalis*, growing in the northeastern side of University of Kashmir campus and lying in the immediate catchment of the world famous lake Dal was studied. The trees were more than 50 years old and all the study sites were situated within 100m of each other. Composite soil samples from two depths (0-10cm and 10-20 cm) collected in the months of August, October and December, 2006 were compared in terms of different physical and chemical parameters. Highly significant differences were obtained for parameters like pH, Conductivity; extractable ammonium-nitrogen, nitrate-nitrogen, nitrite-nitrogen, calcium, magnesium, sodium, potassium, phosphorus, total phosphorus, total carbon and total Kjeldhal nitrogen. The differences although more distinct in the upper 0-10cm soil layer had percolated to the lower 10-20cm soil layer also.

Key words: Soil chemistry, tree species, extractable nutrients, carbon, nitrogen

INTRODUCTION

Tree species can influence the chemical properties of the soil by several mechanisms. Differences in litter quantity and nutrient status, root nutrient uptake and activity, interception of atmospheric deposition, canopy interactions and leaching as well as alterations to the microclimate and the soil's biological community can cause differences in the physical and chemical characteristics of top soils under various species (Binkley and Riehter, 1987; Binkley *et al*., 1989; Finzi *et al*., 1990; Binkley, 1995; Hagen-Thorn *et al*., 2004; Reich *et al*., 2005). Globally a number of studies have been carried out to study the impact of different tree species on soil properties and there is a difference of opinion as to the scale at which overstory vegetation influences soil properties (Ovington, 1953 and 1954; Nihlgard, 1971; Finzi *et al*., 1990; Binkley and Valentine, 1991; Sow and Gower, 1992; Binkley, 1995; Raulund-Rasmussen and Vejre, 1995; Brandtberg *et al*., 2000; Sanborn, 2001; Berger *et al*., 2002; Hagen-Thorn *et al*., 2004).

Given the dynamic and interactive nature of plant-soil interactions, increased understanding of the role of different plant traits and of the generality of species effects are critical to the understanding of the plant-soil system and in the management of terrestrial and aquatic ecosystems.

In the present study we investigated the top soils which had developed under closely situated (within 100m of each other), >50 year old tree species of coniferous gymnosperms *Pinus wallichiana* and *Cedrus deodara* and a deciduous angiosperm *Platanus orientalis*. The underlying hypotheses were that the chemical characteristics of the soil will be different under different tree species and the differences will be more distinct in the upper soil layer.

STUDY AREA

The study area is located in the northeastern side of the University of Kashmir campus lying in the immediate catchment of the world famous Dal lake. Only a few coniferous trees are present in the study area and they are well protected from anthropogenic interferences including the removal of litter being restricted.

MATERIALS AND METHODS

Top soil produced under individual tree species of *Pinus wallichiana* (Himalayan blue pine), *Cedrus deodara* (Himalayan cedar) and *Platanus orientalis* (oriental plane) were studied for their chemical characteristics. Soil sampling was conducted in the months of August, October and December, 2006. Composite soil samples were collected from each study site by using an all stainless steel augur. At each point the soil sample was separated into two layers of 0-10cm and 10-20cm depth. Prior to soil collection, the organic layer and loose litter were removed. For each layer, samples from ten points at each site were pooled together to make one composite sample per site and <2mm fraction was analysed for different parameters. pH and conductivity were determined by electrometric method using 1:2 soil: water (w/v) suspension. NH_4 -N, NO_3 -N and NO_2 -N were extracted by 2M KCl solution and analysed by indophenol blue method, modified salicylate method and modified Gries-Ilosvy method respectively. Extraction of P, Fe, Ca, Mg, Na and K was done by Mehlich-3 reagent and then extractable phosphorus was determined by ascorbic acid method and total extractable Fe by KSCN method after digestion with HCl and H_2O_2, extractable Ca and Mg were analyzed by titration method and extractable Na and K by flame photometry. Total Kjeldahl nitrogen (TKN) was determined by Nelson and Sommers modified method, total phosphorus by ascorbic acid method after perchloric acid digestion, and total carbon and organic matter (OM) were estimated from Walkley-Black method. All the analyses were done on field moist samples and results expressed on oven dry basis (Jackson, 1958; Page *et al*., 1982; Yang *et al*., 1998; Burt 2004).

RESULTS AND DISCUSSION

Except for total extractable iron, for all other chemical parameters highly significant differences were detected under different tree species both in the upper (0-10cm) soil layer (Table 1) and in the lower (10-20cm) soil layer (Table 2). The differences were more prominent in the upper soil layer.

Differences in pH were prominent in both the soil layers, with the lowest pH recorded in the soil under *Pinus*, both in the upper and the lower layer. The highest pH for the upper layer soil was shown by *Platanus* and for lower layer it was for *Cedrus*. Conductivity was lowest for *Platanus* soil while it was highest for *Cedrus* soil in both the layers. Among the inorganic forms of nitrogen, NH_4 - N was lowest under *Cedrus* and recorded the highest value under *Platanus* in both the layers. NO_3 - N was lowest under *Platanus* and highest under *Pinus* while the reverse was true for NO_2 - N in both the layers

Table 1 Average values, standard deviations (in parentheses), F-values and P-values for different physical and chemical characteristics of the upper soil layer (0-10cm) under different tree species

S. No.	Parameter	*Pinus wallichiana*	*Cedrus deodara*	*Platanus orientalis*	F value	P
1	pH	6.12 (0.07)	6.95 (0.09)	7.24 (0.04)	213.16	<0.001
2	Conductivity (μScm^{-1})	161.33 (6.11)	169.00 (6.00)	138.33 (7.09)	18.54	0.003
3	NH_4-N(ppm)	30.29 (3.70)	17.96 (2.01)	34.29 (2.61)	26.59	0.001
4	NO_3-N (ppm)	25.09 (2.92)	19.42 (2.40)	16.75 (2.01)	8.88	0.016
5	NO_2-N (ppm)	1.05 (0.04)	1.75 (0.09)	2.86 (0.11)	359.10	<0.001
6	Fe (ppm)	109.40(13.33)	89.26 (6.70)	94.57 (10.13)	2.02	0.124
7	Ca^{2+} (ppm)	3211.1 (284.2)	4029.1 (221.4)	4446.5 (205.2)	20.68	0.002
8	Mg^{2+} (ppm)	834.3 (73.8)	719.2 (39.5)	851.5 (39.3)	5.44	0.045
9	Na^+ (ppm)	102.3 (8.5)	145.7 (10.0)	99.8 (5.8)	29.27	0.001
10	K^+ (ppm)	525.1 (9.3)	322.6 (5.8)	798.1 (13.0)	1780.90	<0.001
11	Extractable PO_4-P (ppm)	145.07 (11.07)	30.43 (3.66)	37.77 (6.00)	215.53	<0.001
12	Total PO_4-P (ppm)	1827.33 (45.65)	996.10 (14.46)	1216.03 (26.77)	554.82	<0.001
13	TKN (ppm)	5779.3 (90.5)	4100.0 (59.6)	6226.7 (110.2)	473.91	<0.001
14	Total C (ppm)	81749 (1280)	57641 (838)	71276 (1261)	334.59	<0.001
15	OM (%)	14.1 (0.2)	9.9 (0.1)	12.3 (0.2)		
16	C:N ratio	14.1	14.1	11.4		

Table 2 Average values, standard deviations (in parentheses), F-values and P-values for different physical and chemical characteristics of the lower soil layer (10-20cm) under different tree species

S. No.	Parameter	*Pinus wallichiana*	*Cedrus deodara*	*Platanus orientalis*	F value	P
1	pH	6.21 (0.03)	7.36 (0.03)	7.29 (0.03)	1355.72	<0.001
2	Conductivity (μScm^{-1}	137.33 (5.86)	134.67 (3.06)	123.67 (4.73)	7.16	0.026
3	NH_4-N (ppm)	30.04 (2.32)	28.94 (1.28)	33.09 (1.18)	4.95	0.054
4	NO_3-N (ppm)	15.33 (0.72)	11.98 (0.81)	9.91 (0.64)	42.63	<0.001
5	NO_2-N (ppm)	0.89 (0.24)	1.93 (0.42)	2.15 (0.58)	7.20	0.025
6	Fe (ppm)	105.41 (14.73)	86.12 (11.08)	89.67 (7.39)	2.41	0.171
7	Ca^{2+} (ppm)	2760.4 (135.6)	3487.4 (234.2)	3470.8 (133.2)	17.05	0.003
8	Mg^{2+} (ppm)	837.0 (41.1)	987.5 (66.3)	280.6 (10.8)	201.43	<0.001
9	Na^{+} (ppm)	146.7 (15.8)	127.2 (15.5)	88.8 (6.7)	14.59	0.005
10	K^{+} (ppm)	332.2 (12.0)	168.3 (5.9)	766.0 (10.8)	2920.52	<0.001
11	Extractable PO_4-P (ppm)	64.69 (10.22)	9.62 (0.95)	16.64 (0.70)	76.37	<0.001
12	Total PO_4-P (ppm)	336.50 (11.29)	977.20 (12.40)	1085.97 (9.87)	3898.54	<0.001
13	TKN (ppm)	4447.0 (91.7)	4024.7 (58.8)	5541.0 (50.1)	383.41	<0.001
14	Total C (ppm)	35235 (726)	29718 (434)	35043 (317)	108.08	<0.001
15	OM (%)	6.1 (0.1)	5.1 (0.1)	6.0 (0.1)		
16	C:N ratio	7.9	7.4	6.3		

Among the cations, Fe showed the highest value under *Pinus* and the lowest under *Cedrus* in both the layers. Na recorded lowest values for *Platanus* for both the layers while the highest value in upper layer was for

Cedrus and in the lower layer, it was for *Pinus*. Differences in K concentrations were very prominent with the lowest values being obtained for *Cedrus* and the highest for *Platanus* in both the layers. Soil under *Pinus* had the lowest Ca concentrations in both soil layers while the highest Ca concentration in upper soil layer was for *Platanus* and in the lower soil layer it was noticeable for *Cedrus*. Mg concentrations were highest in the 0-10cm layer for *Pinus* and in the 10-20cm layer for *Cedrus* while the lowest concentrations in the 0-10cm soil layer were registered for *Cedrus* and in the 10-20 cm soil layer it was obtained for *Platanus*. Total carbon had a higher variability in the upper 0-10cm soil layer with the highest value for *Pinus* and the lowest for *Cedrus* while in the lower 10-20cm soil layer the varribility was comperatively lesser with Pinus higher value as against *Cedrus* which showed a lower value. The total Kjeldahl nitrogen was highest under *Platanus* and lowest under *Cedrus* in both the layers. The 0-10cm soil maintained a higher C:N ratio as compared to the 10-20cm soil layer under all the tree species. Total and extractable phosphorus were markedly higher under *Pinus* in the upper soil. The situation was different for the lower soil layer with *Pinus* showing the lowest total but highest extractable phosphorus and *Platanus* showing the lowest extractable but highest total phosphorus.

The results of the present study showed that there were considerable differences in chemical characteristics of the soils under different tree species. The differences although more prominent in the upper 0-10cm soil layer had percolated down to the lower 10-20cm soil layer, because of the older age of the tree species. All the parameters except for total extractable iron showed highly significant differences under different tree species (Tables 1 and 2).

The differences in soil chemistry are more likely to be caused by the differences in foliage properties, the amount and quality of litter and by differences in processes taking place in soil floor, than differences in root activity and turnover. Evidencing this are the studies in which soil differences in younger stands were only detected in the upper soil layers (Raulund-Rasmussen and Vejre, 1995; Alrickson and Erickson, 1998; Vesterdal and Raulund-Rasmussen, 1998; Hagen-Thorn *et al*., 2004). The changes seem to percolate to lower layers of soil under older stands (Norden, 1994a) as also evidenced by the present study.

The significantly lower pH under *Pinus,* compared to other species, can be explained by slower litter decomposition which leads to the production of organic acids and also delays the return of base cations to the soil. The concentration of Ca was significantly lower under *Pinus* in both soil layers. The concentration of Mg in the soil under *Cedrus,* again a coniferous gymnosperm, had the minimum concentration; K concentration was also lowest under *Cedrus*. On the other hand, *Platanus,* a deciduous angiosperm, had the highest Ca and K concentrations in the upper layer. Studies by Brandtberg *et al*. (2000) and Sanborn, (2001) have also reported a higher pH and base cation concentrations in the birch forest floors as compared to pine forest floors. In the present study, soil under *Pinus* showed highest concentration of total extractable Fe, possibly because of the lower pH.

The extractable phosphorus concentration was highest in the 0-10cm soil layer under *Pinus* which seems to be influenced by the lower pH of the soil induced by the tree species. The greater mobilization of phosphorus under *Pinus* seems to degrade the total phosphorus pool in the lower soil.

The present study showed distinct differences in the soil C, N and organic matter pools under different tree species and the conclusion that there were not any differences in the soil C, N and organic matter pools in the soil under different tree species (Raulund-Rasmussen and Vejre, 1995; Norden, 1994c; Berger *et al*., 2002; Hagen-Thorn *et al*., 2004) does not seem to hold true here. The variation in the size and distribution of C and N pools under different tree species may be regulated by a combination of interspecific differences in litter production and the rate of litter decomposition as reported by a number of other studies (Melillo *et al*., 1982 and 1989; Prescott *et al*., 1993; Stump and Binkley, 1993; Finzi *et al*., 1998).

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