SOIL AND FOLIAR NUTRIENTS CONCENTRATION OF CONIFER SPECIES IN THE COMMUNITIES OF MOIST TEMPERATE AREAS OF SOUTHERN HIMALAYAN AND HINDUKUSH REGION OF PAKISTAN

MUHAMMAD FAHEEM SIDDIQUI, MOINUDDIN AHMED, S. SHAHID SHAUKAT AND MUHAMMAD AJAIB[1]

Laboratory of Dendrochronology and Plant Ecology, Department of Botany,
Federal Urdu University of Arts, Science and Technology, Gulshan-e-Iqbal, Karachi, Pakistan
[1]Department of Botany, GC University Lahore, Pakistan

Abstract

This study provides foliar nutrient concentration distribution of thirteen conifer communities, recorded from moist temperate area of Pakistan. The influence of soil nutrients that may affect the vegetation distribution and composition are also considered here. Foresters can obtain foliar nutrient values from the forests in focus and use this information to make judgments on the relative nutrient status of forest stands. Soil and foliage samples were collected from 41 different research sites (stands), for the purpose of nutrient evaluation during a period of 3 years from 2005 to 2008. Six nutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sodium) of soil and tissue were assessed. Potassium and sodium (1.58 and 0.7 %) had by far the highest tissue concentrations followed by Ca > Mg > N > P. Four conifer species had higher concentration of nitrogen (1.66-1.97 %) followed by Ca, K, P, Mg and Na while the concentration of these nutrients in soils of moist temperate area differed considerably from that in tissues, i.e. potassium had the higher concentration (1.65-1.79 %) followed by Na, Mg, Ca, N and P.

Introduction

The foliar nutrient analysis is a well established method used to assist diagnosis of mineral requirement in forestry (Driessche, 1974) however, work done in this regard in Pakistan is scanty. The primary objective of this study is to asses the influence of soil and foliar nutrient concentration in the distributions of conifer tree communities in moist temperate areas of northern part of Pakistan. Forest soils influence the vegetation composition of forest, ground cover, rate of tree growth, vigor of natural reproduction and other silviculturally important factors (Bhatnagar, 1965). Physico-chemical characteristics of forest soils vary in space and time because of variation in topography, climate, weathering processes, vegetation cover, microbial activities and also several other biotic and abiotic factors (Paudel and Sah, 2003). Vegetation also plays an important role in soil formation (Chapman and Reiss, 1992). The yearly contribution of surface vegetation to soil, in the form of needles, leaves, cones, pollen, branches and twigs, is substantial as they gradually decompose and becomes a part of the soil (Singh and Bhatnagar, 1997). Thus, the nutrients are returned to the soil and exert a strong feed-back on the ecosystem processes (Pastor *et al.,* 1984). Nutrient supply varies widely among ecosystems (Binkly and Vitousek, 1989), resulting in differences in plant community structure and its production (Ruess and Innis, 1977). The nature of soil profile, pH and nutrient cycling between the soils and trees are the important dimensions to determine the site quality (Sheikh and Kumar, 2010). Thus the vegetation influences the physico-chemical properties of the soil to a great extent, it improves the soil structure, infiltration rate, water holding capacity, hydraulic conductivity and aeration (Ilorkar and Totey, 2001; Kumar *et al*., 2004). To relate vegetation to environmental factors, it is imperative to examine the nutrition status of soils so as to determine the nutrient regime prevailing in the area.

The importance of nutrients in the functioning of ecosystems has been increasingly recognized (Bates, 1971; Auclair, 1979; Duarte, 1990). Such information is potentially useful in guiding forest management decisions ranging from forest health concerns to designing operational fertilization programs. Various techniques have been developed to assay forest nutrient status; the most effective technique involves foliage sampling and analysis (Driessche 1974, Timmer and Stone 1978, Brockley and Sherman 1994). The need to evaluate the requirement of nutrition of particular plant species is increasing day by day. In Pakistan, foresters, silviculturist and ecologists are trying to pay attention to evaluate the nutrition status of selected forests or sites whereas in developed countries one can readily find the critical values of macro and micro elements for most plant species but in Pakistan no such critical values are available.

Ahmed *et al.,* (1990) investigated the variation in the levels of phosphorus, nitrogen, potassium, manganese and zinc in the tissue of five different morphological types of *Juniperus excelsa* in Baluchistan province of Pakistan but did not find any significant differences among the morpho-types for any of the elements tested. Hussain and Badshah (1998) stated that erosion and deforestation had reduced nutrient contents of soil. Similar

results for other mountainous areas have been reported by Shah *et al.*, (1964), Hussain (1969) and Hussain *et al.*, (1995).

Besides these individual studies no extensive investigations have been carried out to examine the status of nutrients in soils and dominant plant species in Pakistani forests. Therefore a detailed study was conducted in moist temperate conifer forests. It is anticipated that the present results might help the professional of forestry to better manage these forests in Pakistan. Researchers have mostly focused on the nutrient levels of plants occurring in small sections of the moist temperate area. However, no comprehensive study has yet been undertaken to cover a broad region such as the entire moist temperate region of Pakistan.

Materials and Methods

Vegetation, tissue and soil sampling: Vegetation of forty one stands was sample by point centre quarter method (Muller-Dombois & Ellenberg, 1974). Importance value of tree species were computed on the basis of which thirteen communities were recognized (Siddiqui, 2011; Siddiqui *et al.*, 2012) following the practice of Brown & Curtis (1952). Essential nutrients (like N, P, K, Ca, Mg and Na) of soils and the tissues of dominating conifer species (*Pinus wallichiana, Abies pindrow, Cedrus deodara, Picea smithiana* and *Taxus fuana*) of 41 stands were analyzed. Soil samples were collected from 41 stands at 5-30 cm depth. From each stand five to six soil samples were randomly collected and pooled them to make a single soil sample. During the collection of the soil it was assured that no litter should be added with soil. Soil samples were stored in labeled polythene bags and brought to the laboratory for analysis. In laboratory the soils were air dried, passed through a 2 mm (10 mesh) sieve size and again stored in clean plastic bottles. Subsequently, these soils were used for different analyses. Tissues from different conifer plants in each stand were collected from randomly selected trees for the analysis of essential elements, stored in labeled polythene bags and brought to laboratory for chemical analysis. Tissues of different conifers were air dried, then crushed by a grinder carefully and stored in clean plastic bottles.

Soil and tissue analysis: The soils and plant tissue were extracted in accordance with Moore and Chapman (1986). Micro Kjeldahl method was used for analysis of soil N (Horneck and Miller, 1998) while the method outlined by Tan (1996) was used for the analysis of soluble phosphorus. Calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were determined using Atomic absorption Spectrophotometer (Pie-Unicam) after preparing the samples as described in Moore and Chapman (1986).

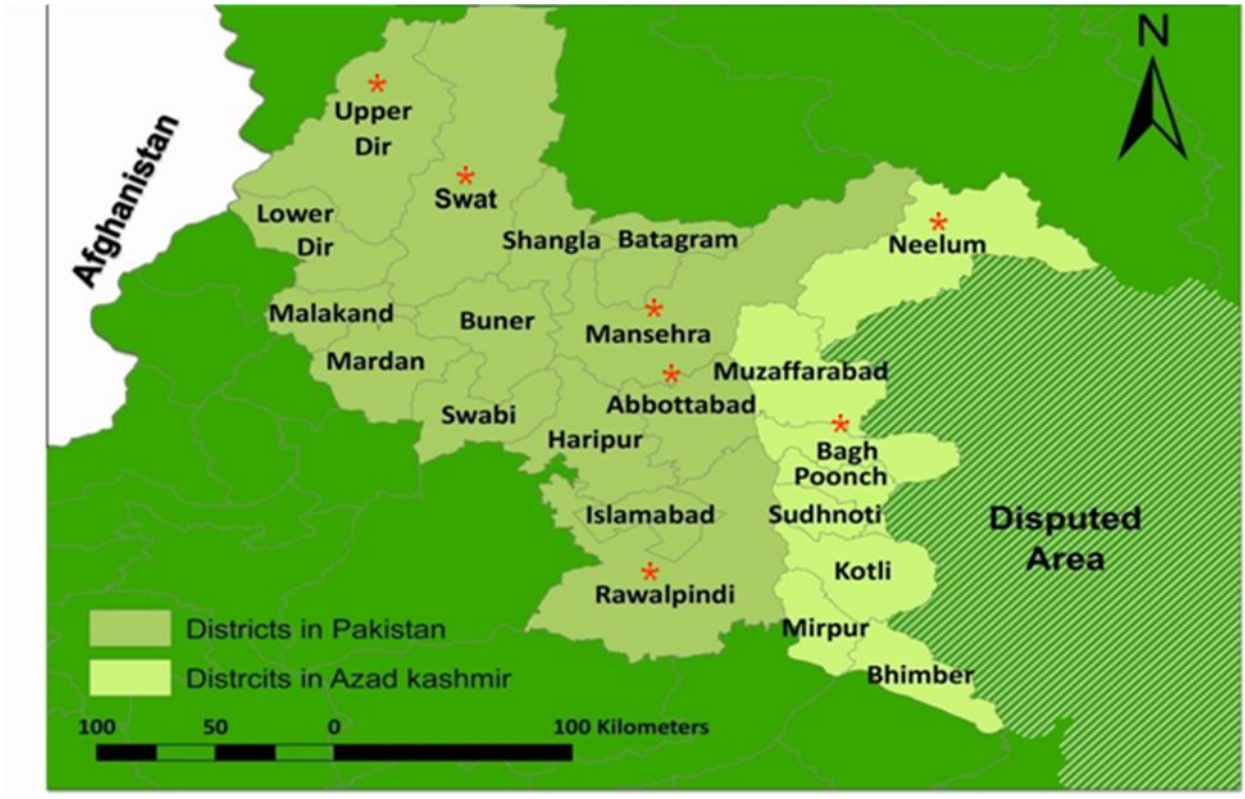

Fig.1. Study area map. * showing the district where sampling was conducted.

Table 1. Main locations, sampling sites, elevation and slope angle of each forest (site) and importance value of each tree species from 41 stands of moist temperate areas of Himalayan and Hindukush region of Pakistan.

Main Location, Sites and Stand No.		Species Name	Importance Value	Elevation of stand (m)	Slope of stand (º)
A- Dir upper , Malakand Division					
1	Kumrat	*Pinus wallichiana*	58	2400	5
		Cedrus deodara	28		
		Populus pamirica	11		
		Abies pindrow	3		
2	Panahkot	*Pinus wallichiana*	59	2200	40
		Cedrus deodara	41		
B- Swat , District					
3	Malam Jabba 1	*Abies pindrow*	90	2600	34
		Picea smithiana	10		
4	Malam Jabba 2	*Pinus wallichiana*	96	2350	30
		Abies pindrow	4		
5	Miandam	*Abies pindrow*	65	2600	49
		Pinus wallichiana	35		
C-Azad Kashmir					
6	Keran, Nellam valley	*Cedrus deodara*	60	1960	30
		Pinus wallichiana	40		
7	Chikar	*Pinus wallichiana*	100	1930	28
8	Suddhan Gali 1 Dist. Bagh	*Abies pindrow*	44	2450	22
		Pinus wallichiana	40		
		Cedrus deodara	16		
9	Suddhan Gali 2	*Abies pindrow*	79	2500	32
		Pinus wallichiana	17		
		Cedrus deodara	4		
10	Suddhan Gali 3	*Pinus wallichiana*	83	2420	38
		Abies pindrow	17		
D-Rawalpindi Division, Murree Hills					
11	Ghora Gali	*Pinus wallichiana*	89	2100	29
		Pyrus pashia	5		
		Taxus fuana	3		
		Quercus incana	3		
12	Patriata Top 1	*Cedrus deodara*	78	2300	40
		Pinus wallichiana	22		
13	Patriata Top 2	*Pinus wallichiana*	100	2300	25
14	Patriata Top 3	*Pinus wallichiana*	91	2000	39
		Albizia chinensis	9		
15	Kashmir Point	*Abies pindrow*	56	2500	39
		Pinus wallichiana	26		
		Juglans regia	13		
		Cedrus deodara	5		
E- Abbot Abad , District Hazara					
16	Ghora Dhaka 1	*Abies pindrow*	89	2500	36
		Taxus fuana	7		
		Pinus wallichiana	2		
		Cedrus deodara	2		
17	Ghora Dhaka 2	*Abies pindrow*	57	2500	32
		Pinus wallichiana	39		
		Taxus fuana	4		
18	Ghora Dhaka 3	*Pinus wallichiana*	87	2800	40
		Abies pindrow	13		
19	Ghora Dhaka 4	*Abies pindrow*	60	2800	40
		Pinus wallichiana	35		

Main Location, Sites and Stand No.		Species Name	Importance Value	Elevation of stand (m)	Slope of stand (º)
		Taxus fuana	5		
20	Ghora Dhaka 5	*Abies pindrow*	55	2600	37
		Pinus wallichiana	17		
		Cedrus deodara	15		
		Juglans regia	13		
21	Khera Gali	*Cedrus deodara*	57	2730	42
		Pinus wallichiana	30		
		Abies pindrow	13		
22	Changla Gali 1	*Abies pindrow*	64	2650	47
		Pinus wallichiana	20		
		Taxus fuana	14		
		Juglans regia	2		
23	Changla Gali 2	*Pinus wallichiana*	57	2670	35
		Abies pindrow	40		
		Taxus fuana	3		
24	Kuzah Gali 1	*Cedrus deodara*	76	2560	5
		Abies pindrow	21		
		Pinus wallichiana	3		
25	Kuzah Gali 2	*Abies pindrow*	57	2560	28
		Pinus wallichiana	26		
		Cedrus deodara	17		
26	Nathia Gali 1	*Pinus wallichiana*	55	2640	35
		Abies pindrow	45		
27	Nathia Gali 2	*Abies pindrow*	91	2630	33
		Pinus wallichiana	9		
28	Thandyani 1	*Pinus wallichiana*	81	2320	31
		Cedrus deodara	19		
29	Thandyani 2	*Cedrus deodara*	65	2300	38
		Pinus wallichiana	35		
F- Kaghan valley, District Mansehra					
30	Paye, Shogran	*Pinus wallichiana*	58	3100	38
		Picea smithiana	29		
		Abies pindrow	13		
31	Sri, Shogran	*Picea smithiana*	68	2900	39
		Abies pindrow	32		
32	Shogran 1	*Pinus wallichiana*	65	2400	27
		Abies pindrow	35		
33	Shogran 2	*Cedrus deodara*	82	2400	23
		Pinus wallichiana	10		
		Abies pindrow	8		
34	Shogran 3	*Cedrus deodara*	91	2500	33
		Picea smithiana	5		
		Abies pindrow	4		
35	Paras	*Cedrus deodara*	76	1600	20
		Juglans regia	9		
		Pinus wallichiana	5		
		Quercus ilex	5		
		Quercus incana	5		
36	Khanian	*Cedrus deodara*	83	2000	35
		Pinus wallichiana	17		
37	Shinu 1	*Cedrus deodara*	67	1900	39
		Pinus wallichiana	33		
38	Shinu 2	*Cedrus deodara*	100	1650	43
39	Naran river belt 1	*Pinus wallichiana*	69	2500	5
		Picea smithiana	14		
		Cedrus deodara	10		

Main Location, Sites and Stand No.		Species Name	Importance Value	Elevation of stand (m)	Slope of stand (º)
		Populus alba	5		
		Abies pindrow	2		
40	Naran river belt 2	*Cedrus deodara*	100	2500	5
41	Lalazar, Naran	*Abies pindrow*	100	3000	45

Authority of species: *Pinus wallichiana* A.B.Jackson, *Abies pindrow* Royle, *Cedrus deodara* (Roxb.) G. Donf., *Picea smithiana* (Wall.) Boiss., *Taxus fuana* Nan Li & R.R. Mill, *Juglans regia* L. *Quercus incana* Roxb, *Quercus ilex* Griff., Itin., *Albizia chinensis* (Osbeck) Merrill, *Pyrus pashia* Ham ex D. Don, *Populus pamirica* Komarov *and Populus alba* L.

Results and Discussion

Fig. 1 shows the main locations, close to the sampling sites. Importance value of each tree species, their main locations, sampling sites, elevation and slope angle of each forest (site) are presented in Table 1. Phytosociological attributes of each species were calculated. On the basis of highest importance value 13 communities were formulated (Table 2). Soil and tissue nutrients of each community were investigated and resulting values are presented in Table 3 & 4 respectively. Foliar nutrient concentration of Angiospermic broad leaf species were not analyzed because of their low abundance in these forests. Among conifers *Pinus wallichiana*, *Cedrus deodara* and *Abies pindrow* were the most widely distributed species while *Picea smithiana* and *Taxus fuana* were recorded from a few stands but the nutrients of all five species were evaluated to explore their role in the abundance, distribution and composition of forests.

Table 2. Communities, stand numbers, elevation (range) and slope angle (range) of thirteen communities of moist temperate areas of southern Himalayan and Hindukush region of Pakistan.

Serial No.	Community	Stand No.	Elevation Range (m)	Slope range in (o)
1	*Pinus wallichiana* (Pure)	7,13	1930-2230	25-28
2	*Cedrus deodara* (Pure)	38,40	2500-2650	0-43
3	*Abies pindrow* (Pure)	41	3,000	45
4	*Pinus wallichiana / Picea smithiana*	30,39	2500-3100	5-38
5	*Pinus wallichiana / Albizia chinensis*	14	2,000	39
6	*Pinus wallichiana / Pyrus pashia*	11	2,100	29
7	*Cedrus deodara / Pinus wallichiana*	6,12,21,29,33,36,37	1900-2730	23-42
	Pinus wallichiana / Cedrus deodara	1,2,28	2200--2400	5-40
8	*Cedrus deodara / Picea smithiana*	34	2500	33
9	*Cedrus deodara / Abies pindrow*	24	2560	5
10	*Cedrus deodara / Juglans regia*	35	1,600	20
11	*Abies pindrow / Pinus wallichiana*	5,8,9,15,17, 19,20,22,25,27	2450-2650	22-49
	Pinus wallichiana / Abies pindrow	4,10,18,23,26,32,	2350-2800	27-40
12	*Abies pindrow / Picea smithiana*	3	2600	34
	Picea smithiana / Abies pindrow	31	2900	36
13	*Abies pindrow / Taxus fuana*	16	2500	28

Note: Authorities of tree species, main location and sites of stands refer to Table 1.

Table 3. Soil nutrients distribution in thirteen communities of moist temperate areas of Himalayan and Hindukush region of Pakistan.

Community	N	P	K	Ca	Mg	Na
1.	0.455±0.105	0.2575±0.082	1.16±0.2	0.6±0.18	0.48±0.02	0.44±0.09
2.	0.155±0.005	0.3±0.04	1.46±0.01	0.53±0.29	0.62±0.06	0.91±0.07
3.	0.61	0.27	0.84	1.56	0.75	0.45
4.	0.48±0.03	0.34±0.02	2.075±0.425	0.62±0.06	0.445±0.095	1.025±0.175
5.	0.17	0.25	1.07	1.16	0.54	0.15
6.	0.17	0.27	0.52	0.264	0.46	0.25
7.	0.457±0.139	0.288±0.049	1.674±0.145	0.3806±0.091	0.59±0.058	0.857±0.145
8.	0.24	0.25	0.95	0.98	0.54	1.24
9.	0.24	0.43	1.91	0.89	0.16	0.36
10.	0.29	0.16	2.1	0.48	0.7	0.65
11.	0.417±0.079	0.263±0.024	1.689±0.161	0.483±0.081	0.533±0.049	0.515±0.046
12.	0.35±0.17	0.285±0.025	1.575±0.175	0.44±0.12	0.35±0.13	0.4±0.05
13.	0.34	0.32	2.06	0.68	0.72	0.54

Table 4. Foliar nutrients distribution in thirteen communities of moist temperate areas of Himalayan and Hindukush range of Pakistan.

Community	Species	N	P	K	Ca	Mg	Na
1	*Pinus wallichiana*	2.375±0.175	0.35±0.07	0.465±0.045	0.74±0.22	0.185±0.025	0.1895±0.071
2	*Cedrus deodara*	1.495±0.045	0.81±0.01	1.98±0.42	1.315±0.085	1.25±0.15	1.45±0.35
3	*Abies pindrow*	1.4	0.52	0.45	2.1	0.78	0.18
4	*Pinus wallichiana*	1.585±0.715	0.785±0.035	0.57±0.23	0.804±0.054	0.435±0.015	0.35±0.1
	Picea smithiana	1.605±1.345	0.535±0.305	0.595±0.255	1.755±0.015	1.165±0.635	0.225±0.015
	*Abies pindrow**	1.86±1.54	0.635±0.185	1.07±0.45	1.22±0.58	0.66±0.14	0.505±0.345
	*Cedrus deodara**	2.45	0.7	1.98	1.2	1.6	0.6
5	*Pinus wallichiana*	1.95	0.85	0.63	0.62	0.51	0.15
6	*Pinus wallichiana*	1.6	0.65	0.51	0.43	0.13	0.12
7	*Cedrus deodara*	1.386±0.231	0.476±0.056	1.853±0.16	1.209±0.136	0.778±0.148	0.687±0.081
	Pinus wallichiana	2.189±0.257	0.651±0.069	0.624±0.035	0.808±0.088	0.310±0.038	0.301±0.026
	*Abies pindrow**	0.78±0.166	0.537±0.152	1.413±0.398	1.187±0.174	0.663±0.173	0.61±0.122
8	*Cedrus deodara*	1.85	0.65	1.8	0.52	0.65	0.89
	Picea smithiana	3.24	0.89	0.85	1.52	0.65	0.34
	*Abies pindrow**	0.54	0.45	0.72	1.45	0.87	0.18
9	*Cedrus deodara*	1.4	0.75	2.1	0.85	0.45	0.43
	Abies pindrow	1.8	0.17	2.3	2.4	0.62	0.54
	*Pinus wallichiana**	0.35	0.56	0.81	1.2	0.31	0.27
10	*Cedrus deodara*	0.65	0.65	2.3	1.21	0.87	0.65
	Pinus wallichiana	2.8	0.72	0.52	0.54	0.21	0.29
11	*Abies pindrow*	0.883±0.146	0.428±0.052	1.216±0.153	1.064±0.087	0.444±0.066	0.589±0.054
	Pinus wallichiana	1.953±0.272	0.672±0.057	0.699±0.03	0.85±0.129	0.368±0.069	0.30±0.031
	*Cedrus deodara**	0.816±0.199	0.69±0.048	0.944±0.247	1.296±0.08	0.44±0.071	0.61±0.075
	*Taxus fuana**	1.523±0.135	0.43±0.043	1.282±0.145	0.707±0.029	0.733±0.083	0.257±0.033
12	*Abies pindrow*	0.92±0.28	0.685±0.155	1.79±1.06	0.885±0.095	0.66±0.03	0.43±0.25
	Picea smithiana	1.95±1.6	0.57±0.05	0.74±0.05	1.56±0.09	0.89±0.31	0.18±0.03
13	*Abies pindrow*	2.5	0.98	0.52	0.9	0.85	0.62
	Taxus fuana	1.8	0.59	0.56	0.52	0.13	0.14
	*Pinus wallichiana**	1.21	0.65	0.42	1.8	0.46	0.16
	*Cedrus deodara**	1.05	0.18	0.63	0.78	0.48	0.66

Note: * are associated or those species having the importance value less than co-dominant.
Authorities of species are shown in Table 1.

On the basis of importance value and the floristic composition of stands following thirteen communities including three monospecific forests were recognized. Communities were named on the basis of first two dominant species (Brown and Curtis, 1952). Two floristically similar species even with different rank at different stands are considered as belonging to same community types, since due to a long history of disturbance and cutting of trees in these forests it is not possible to relate numerical values in their natural state of abundance.

(1) *Pinus wallichiana* (monospecific)
(2) *Cedrus deodara* (monospecific)
(3) *Abies pindrow* (monospecific)
(4) *P. wallichiana-Picea smithiana* community
(5) *P. wallichiana-Albizia chinensis* community
(6) *P. wallichiana-Pyrus pashia* community
(7) *Cedrus deodara -P. wallichiana community*
(8) *Cedrus deodara-Picea smithiana* community
(9) *Cedrus deodara-Abies pindrow* community
(10) *Cedrus deodara-Juglans regia* community
(11) *Abies pindrow-P. wallichiana* community
(12) *Abies pindrow –Picea smithiana* community
(13) *Abies pindrow –Taxus fuana* community

(1) Monospecific *Pinus wallichiana* forest: At two different locations (stand 7 and 13) *Pinus wallichiana* is recorded as the sole dominating species. These sampling stands were located at the elevation of 1930 m and 2230 m with 25^o to 28^o moderate slopes respectively. Among all nutrients total nitrogen was recorded in higher amount (2.375±0.175 %) followed by calcium (0.74±0.22 %), potassium (0.465±0.045 %), phosphorus (0.35±0.07 %), sodium (0.1895±0.071) and magnesium (0.185±0.025) whereas in the soil of this community has high level of potassium (1.16±0.2 %), followed by calcium (0.6±0.18 %), magnesium (0.48±0.02 %), nitrogen (0.455±0.105 %), sodium (0.44±0.09 %) and phosphorus (0.2575±0.082 %) which do not show any particular trend in the distribution of nutrients in the soil and tissue.

(2) Monospecific *Cedrus deodara* forest: In Kaghan valley (stand 38 and 40) deodar is recorded as a sole dominating species. These stands were located at the elevation of 1650 m and 2500 m with flat ridge top to 43^o steep slopes. The nutrient status of foliage showed that potassium has high value (1.98±0.42 %) as compared to other elements whose concentrations were: total nitrogen (1.495±0.045 %), sodium (1.45±0.35 %), calcium (1.315±0.085 %), magnesium (1.25±0.15 %) and phosphorus (0.81±0.01 %) while in the soil of this community potassium has higher amount (1.25±0.15 %) as in tissue, showing better agreement of the availability and supply mechanism. Other soil nutrients were recorded in following quantities: sodium (0.91±0.07 %), magnesium (0.62±0.06 %), calcium (0.53±0.29 %), phosphorus (0.3±0.04 %) and nitrogen (0.155±0.005 %).

(3) Monospecific *Abies pindrow* forest : Closed canopy pure stand of *Abies pindrow* was found at only one location at Kaghan valley (stand 41) at the elevation of 3000m on 45^o steep slope. Needles of *Abies pindrow* exhibited higher amount of calcium (2.1 %) followed by nitrogen (1.4 %), magnesium (0.78 %), phosphorus (0.52 %), potassium (0.45 %) and sodium (0.18 %). The soil of this forest type also showed higher amount of calcium (1.56 %), followed by potassium (0.84%), magnesium (0.75 %), nitrogen (0.61%), sodium (0.45%) and phosphorus (0.27%). The soil nutrients of this community did not show good correspondence with the tissue nutrients.

(4) *Pinus wallichiana-Picea smithiana* community: This community was recorded at two different locations i.e. Paye, Shogran (stand 30) and Naran 1 (stand 39), situated at Kaghan valley. Both the stands were occurred on gentle (5^o) to extremely steep slopes (38^o) at 2500 to 3100 m elevation respectively. *Pinus wallichiana* and *Picea smithiana* are the main component of this community but the nutrient status showed different status of dominance. *Cedrus deodara* which is associated species of this community but attained highest amount of total nitrogen (2.45%), potassium (1.98%), magnesium (1.6%) and sodium (0.6%) as compare to dominant species. The dominant species *Pinus wallichiana* attained the highest amount of phosphorus (0.785±0.035%) while the co-dominant species *Picea smithiana* showed highest amount of calcium (1.755±0.015%) indicating the different requirements of nutrients for their growth.

(5) *Pinus wallichiana- Albizia chinensis* Community: This community was recorded at Patriata 3 (stand 14) sampling site lies on 39^o slope on 2200m elevation. *Pinus wallichiana* showed 91% importance value while associated broad leaved angiospermic species *Albizia chinensis* had only 9% importance value. Foliar nutrient concentration of *P. wallichiana* showed highest value of total nitrogen (1.95%) followed by phosphorus (0.85%), potassium (0.63%), calcium (0.62%), magnesium (0.51%) and sodium (0.15%) respectively. The soil of this community exhibited high level of calcium (1.16%) followed by potassium (1.07%), magnesium (0.54%), phosphorus (0.25%), nitrogen (0.17%) and sodium (0.15%). Plant tissue nutrients did not show any correspondence with soil nutrients.

(6) ***Pinus wallichiana- Pyrus pashia*** **Community**: This community supported by the Ghora Gali (Murree, stand 11) sampling locality, lies on 29º moderate slope at 2100 m elevation. *Pinus wallichiana* showed 89% importance value while an associated broad leaved species *Pyrus pashia* was present with 5% importance value. *Taxus fuana* and *Quercus incana* also showed their presence in this stand with 3% importance value each. Among the tissue nutrients of *Pinus wallichiana* total nitrogen attained maximum level (1.6%) while P, K, Ca, Mg and sodium attained following concentrations: 0.65%, 0.51%, 0.43%, 0.13% and 0.12% respectively. Soil of this forest showed highest level of potassium (0.52%) and magnesium attained 0.46%, phosphorus 0.27%, calcium 0.264%, sodium 0.25% and nitrogen 0.17%. Nutrients of other species were not estimated due to their low importance value.

(7) ***Cedrus deodara- Pinus wallichiana*** **Community***:* This is the second most common community in the surveyed area, recorded at ten different locations from 1900 m to 2730 m elevation on moderate ridge top to very steep (45^{o}) slopes. At many places the canopy was closed and most common aspect was south facing exposure. On the basis of importance value, at some locations, this community may be designated as *Pinus wallichiana* – Cedrus community such as stands 1, 2 and 28. In stand 1, at Kumrat a broad leaved species *Populus pamirica* was designated as a third dominant and a few trees of *Abies pindrow* were also recorded. Among six essential nutrients *Cedrus deodara* attained the highest levels of K (1.853±0.16%), Ca (1.209±0.136%), Mg (0.778±0.148%) and Na (0.687±0.081%) while *Pinus wallichiana* attained the highest level of total N (2.189±0.257%) and P (0.651±0.069%). *Abies pindrow* tissue did not attain the higher level of any nutrients than the two dominant species. The soil nutrients are comparatively lesser than those of tissue i.e. N (0.457±0.139%), P (0.288±0.049%), K (1.674±0.145%), Ca (0.3806±0.091%), Mg (0.59±0.058%) and Na (0.857±0.145%).

(8) ***Cedrus deodara – Picea smithiana*** **community:** This community was recorded from only one location (Shogran, Kaghan valley in Stand 34) on South facing steep slope (33º) on 2500 m elevation. *Picea smithiana* had 5% of the total importance value. At this location *Abies pindrow* was also associated with similar quantity but lower basal area. In this forest type *Cedrus deodara* was dominant with 91 % of total importance value but it attained the high concentration of only potassium (1.8%) and sodium (0.89%) while the associated species *Picea smithiana* attained the higher level of three elements i.e. total nitrogen (3.24%), phosphorus (0.98%) and calcium (1.52%), which shows that tissue concentration is not related to dominance of species. Notably magnesium concentration of *Abies pindrow* tissue was high (0.87%).

(9) ***Cedrus deodara – Abies pindrow*** **community:** This community was recorded at Kuzah Gali (stand 24) on moderate ridge top slope at 2560m elevation. Importance value of *Cedrus deodara* was 76 % and it attained the highest level of only phosphorus (0.75%). This community was co-dominated by *Abies pindrow* that attained the highest value of nitrogen (1.8%), potassium (2.3%), calcium (2.4%), magnesium (0.62%) and sodium (0.54%). *Pinus wallichiana* was also associated in this forest with low importance value but did not attain the highest level of any element. These two species had importance values of 21 and 3 %. Soil nutrients of this forest were comparatively lower than those of tissue. Nitrogen attained 0.24%, phosphorus 0.43%, potassium 1.91%, calcium 0.89%, magnesium 0.16% and sodium 0.36% which seem to uncorrelated with tissue nutrients.

(10) ***Cedrus deodara-Juglans regia*** **community:** This community was located on lowest elevation in study area (1600m) on gentle slope 20º at Paras, Kaghan valley (stand 35). Co-dominant angiospermic tree species occupied only 9% of the total importance value. Dominant conifer species *Cedrus deodara* occupied 76% importance value with the highest value of four nutrients i.e. K (2.3%), Ca (1.21%), Mg (0.87%) and Na (0.65%). *Pinus wallichiana*, Quercus ilex and *Quercus incana* were the associates of this forest type. *Pinus wallichiana* which was the second dominant species of this forest but attained the highest value (N, 2.8% & P, 0.72%) of two elements compared to that of the dominant species. Potassium concentration of the soil of this forest was high (2.1%) while the concentrations of other elements were: N (0.29%), P (0.16%), Ca (0.48%), Mg (0.7%) and Na (0.65%).

(11) ***Abies pindrow- Pinus wallichiana*** **Community:** This type of community is the most widely distributed type in the sampling site, recorded at sixteen different locations from 2350 m to 2800m elevation on moderate (22^o) to very steep (49^o) slopes. On the basis of greater importance value, at some locations, this community may be designated as *Pinus wallichiana- Abies pindrow* community. Along with *P. wallichiana* and *Abies pindrow*, some other conifer species (*Cedrus deodara* and *Taxus fuana*) and broad leaf species (Juglans regia) were found as third or fourth dominant species in some stands. The foliar nutrient concentrations of dominant and associated species did not disclose any particular trend in the distribution and dominance of species. Highest concentrations of five elements were recorded from associated species. Phosphorus (0.69±0.048%), calcium (1.296±0.08%) and sodium (0.61±0.075%) of *Cedrus deodara* were recorded in higher amounts while potassium (1.282±0.145%) and magnesium (0.733±0.083%) of *Taxus fuana* were estimated in greater quantity. On the other hand, the dominant species *Abies pindrow* did not attain the highest amount of any element while the other dominant species *Pinus wallichiana* attained the highest amount of only one element (nitrogen 1.953±0.272%). Soil nutrient concentrations of this forest were: N (0.417±0.079%), P (0.263±0.024%), K (1.689±0.161%), Ca (0.483±0.081%), Mg (0.533±0.049%) and Na (0.515±0.046%). The plant tissue concentrations did not match with the soil nutrient concentration.

(12) ***Abies pindrow – Picea smithiana*** **community:** This community was found on two different locations of study area with overlapping conditions. Malam Jabba (stand 3) sampling site was located on West facing steep slope (34^o) at 2600m elevation showed Abies – Picea community whereas Sri, Shogran (stand 31), North facing steep slope (36^o) on 2900m elevation showed Picea-Abies community. Importance value of *Abies pindrow* in Malam Jabba was 90% whereas in Sri, it was 32%. Foliar nutrient concentration of Abies – Picea was also similar i.e. three elements of each species were recorded in higher quantity. Phosphorus (0.685±0.155%), potassium (1.79±1.06%) and sodium (0.43±0.25%) of *Abies pindrow* while nitrogen (1.95±1.6%), calcium (1.56±0.09%) and magnesium (0.89±0.31%) of *Picea smithiana* were estimated in higher quantity. The concentration of soil nutrients of this forest reveals that potassium occupied highest level (1.575±0.175%) while nitrogen (0.35±0.17%), phosphorus (0.285±0.025%), calcium (0.44±0.12%), magnesium (0.35±0.13%) and sodium (0.4±0.05%) attained comparatively lower values.

(13) ***Abies pindrow – Taxus fuana*** **community:** This community was found only at Ghora Dhaka 1 (stand 16) sampling site, located on North-East facing moderately steep slope (28^o) on 2500m elevation. *Abies pindrow* showed high (89%) importance value. *Taxus fuana* occurred with only 7 percent importance value as a co-dominant. *Pinus wallichiana* and *Cedrus deodara* occurred in this stand with low importance values. The dominant species *Abies pindrow* attained the highest levels of nitrogen (2.5%), phosphorus (0.98%) and magnesium (0.85%) while the calcium (1.8%) of *Pinus wallichiana* and potassium (0.63%) and sodium (0.66%) of *Cedrus deodara* attain the highest values. Second dominant species *Taxus fuana* did not attained highest value of any element. Soil of this forest showed the concentration of nitrogen (0.34%), phosphorus (0.32%), potassium (2.06%), calcium (0.68%), magnesium (0.72%) and sodium (0.54%).

Summary of overall nutrients in conifer species: Highest total nitrogen concentration (3.24%) was recorded from the needles of *Picea smithiana* (community 8) whereas its lowest amount (0.35%) was recorded from the tissues of *Pinus wallichiana* from community 9. The highest (0.48±0.03) and lowest (0.155±0.005) amount of total nitrogen was recorded from the soils of community 4 and 2 respectively. Highest phosphorus concentration (0.98%) was recorded from the tissues of *Abies pindrow* (community 13) and highest potassium and calcium concentration (2.1% & 0.85%) were also recorded from the tissues of same species (community 9). Maximum concentration of magnesium and sodium (1.25±0.15% & 1.45±0.35%) were recorded from the tissues of *Cedrus deodara* (community 2). Lowest amount of potassium, calcium and sodium (0.42, 0.43 & 0.12%) were recorded from the tissues of *Pinus wallichiana* (community 13, 6 & 6 respectively). Lowest amount of phosphorus (0.17%) was recorded from the tissues of *Abies pindrow* while minimum concentration of magnesium (0.13%) was recorded from the tissues of *Taxus fauna* from the communities of nine and six respectively. As far as soil nutrients are concern highest concentration of phosphorus, potassium and sodium (0.34±0.02%, 2.075±0.425% & 1.025±0.175%) were recorded from community 4 while highest content of calcium and magnesium (0.62±0.06% & 0.445±0.095%) were recorded from community 3. The lowest amount of soil nutrients were recorded from different communities which are as follows: phosphorus (0.16%) community 10, potassium (0.52%) community 6, calcium (0.44±0.12%) community 12, magnesium (0.16%) and sodium (0.15%) community 5.

When plants accumulate higher amount of nutrients for their physiological activities, growth and fruit production is expected to be high. The plant nutrient level can exceed that of soil. The nutrient regime of soils of pine forests is often low (Kumar *et al.*, 2004; Sheikh & Kumar, 2010). Present study also indicated the same trend, as lower amount of nutrients are recorded in the soils of the studied forests. In Pakistani forests little work is carried out to examine the nutrient requirement of conifer forests in natural condition. Therefore, it is still a

question whether these low amounts of essential nutrients are capable of supporting these conifer forests and their regeneration. Low amount of soil nutrients may also be due to overgrazing, cutting of foliage, branches and whole trees for the purpose of fuel. Therefore, it is hard to find any significant relation between the soil and foliar nutrients in these forests. However, critical amounts of essential nutrients required by different conifer species need further investigation. The current study only indicated the present status of essential nutrients in the soil and the levels of nutrients in the foliage of the dominant conifer species. On an overall basis in the forests investigated, there seems to be no marked correspondence between tissue nutrient concentration and soil nutrient contents.

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