CHARACTERISTICS OF SOIL UNDER CEDRUS DEODARA: AN INTERACTION OF LITTER, HUMUS AND MINERAL SOIL TOWARDS IMPROVEMENT OF SITE-QUALITY.

by

M. N. Malik, M. Jamil-ur-Rehman and M. Hafiz,
Pakistan Forest Institute, Peshawar

Nutrient status of representative soil profile, mineral composition of humus and semidecomposed litter, and levels of mineral elements in the needles of different age crop of *Cedrus deodara* were determined. The findings are tabulated and discussed. The roll of organic matter in the enrichment of soil-site and towards maintenance of nutrient balance is elaborated.

Organic matter in forest soils contributes towards the improvement of site quality. It originates from the disintegrating forest floor debris. comprising leaf fall from main tree species, and decomposing herbaceous and grass vegetation. On decomposition the debris releases a complex mixture of various organic compounds and mineral nutrients. The presence of humus and its interaction with soils mineral constituent distinguishes it both in pedological and ecological characteristics, from other soils. In essence, it is the natural source of maintenance of nutrient level and performs manyfold functions in the overall soil-plant relationships. The humid temperate conditions in some deodar forests usually encourage decomposition of organic matter and release of watersoluble nutrients and various organic colloids.

Deodar is an important timber species of West Pakistan. Its ecological distribution has been studied in the past (3, 4). It occupies soil sites which differ in many edaphic characteristics, including the composition of humus, covering the forest floor or intermixed with the top mineral soil. The rate and extent of trans-migration of humic substances develop characteristic soil profiles. Soil, under certain climatic conditions and vegetative cover, develops profiles particular to that site, while the growth of forest trees is related to the nutrient reserves of various horizons and the physical make-up of the soil. The objective of this study is to ascertain the inter-mixing of vegetation debris with the mineral soil and its influence on the soil fertility potential and, thus, to find out some means of qualitative assessment of site-quality.

MATERIAL AND METHODS.

A particular site was selected on a moderate slope in Compartment 23 of Shaiz forest in Dir Forest Division, and a representative soil rofile was exposed down to its parent material. Besides studying varying physical, pedological and apparent genetical characteristics of soil profile, soil samples were collected from different layers down to a depth of 60". Representative samples, of surface litter and partly decomposed humus were also obtained from the different areas.

Needles of current year growth were also collected from whorls of lateral shoots of seedlings of ages varying from 3 to 22 years. The approximate age of seedlings was accounted for by counting of inter-nodes.

The soil samples were prepared and sieved through 60-mesh sieve for chemical analysis in the laboratory. pH was determined electrometrically in a 1 : 2.5 soil-H_2O suspension. The totaltelemental composition was determined following methods outlined by Jackson (7). Total Fe_2O_3 was determined by 1, 10-phenanthroline method (2).

The humus and litter samples were ashed at 450°C in a muffle furnace, followed by treatment with HF and $HClO_4$ and bringing it in solution in HCI. Samples for analytical work were prepared by dissolving the needle ash in 5 ml. of 6N HCl. The cationic composition was determined following methods given by Jackson (7), and Na and K were determined by Beckman Model B Flame Spectrophotometer.

REVIEW OF LITERATURE.

'Site-quality concept has been quite baffling on account of several variables involved in causing the cumulative effect. Heiberg and White (5) expressed that site represented the sum of many effective conditions, under which the plant or plant community lives. Amongst soil factors, the variables such as available moisture, thickness of solum, depth of A horizon, sub-soil level of nutrients and pH have been considered in quantitative expressions in one form or the other (1). No single soil variable has yet been found which could be used in the rating of site-quality.

Conifers are not exacting in their nutrient requirements, and they require relatively lesser nutrient level (1, 13, 14). Deodar (*Cedrus deodara*) is no exception to this general rule. It can adapt to soil conditions varying consideraply in parent soil-characteristics (4). The composition and constitution of organic matter influences site quality (11). Manil et al (9) found that in phyto-sociological mapping studies, humus formed as a result of composition and constitution of ground flora causes slight differences even between sites classed, otherwise as homologus. Koroleff (8) has described the ill-effect produced by leaf litter. Although it favourably modifies micro-climatic influence' the surface matting caused by undecomposed litter causes hinderence to the seed in reaching the floor resulting, consequently, in failure of germination of seed. Furthermore, such conditions also result in mechanical and physiological injuries to the young germinating seeds which might succeed in reaching the top soil (9, 15).

Mineral composition of humus and foliar analysis have been used for site quality rating. Watt and Heinselman (13) have significantly correlated foliar N and P with site quality, for example in case of *P. mariana*; K was found to be inversely proportional to better site quality. It has been inferred that rapid litter decomposition, free movement of enriched water and nearness of mineral sub-soil contribute to higher percentage of N and P in soil, thereby improving its potential fertility in favour of better establishment of young seedlings. For diagnostic purposes of various soil-plant relations, P content in foliage-litter has been found quite useful, but N content did not prove of much value in practice (13); the former nutrient element reflected growth quality and P status of soil accurately at each individual site. Wall (12) found a decreasing site-index with decreasing N and P content of needles. He also found these elements to be very low in soil on poor sites. Plant species, in general, prefer edaphically similar sites irrespective of geographical location. Hohne (6) has found, from a study where N and mineral content of forest ground flora have been related to site, that certain species are selective in their requirements for mineral elements. Close relations between the nutrient content of plant and soil are well known (15, 14). Viro (11), in his studies on evaluation of site fertility concludes that of the two methods of site evaluation, soil analysis and foliar analysis, the former is standard; it is to be supplemented perhaps in exceptional cases with the latter. Seth and Bhatnagar (10) have conducted site studies on *Shorea robusta* and found concentration of N, P, K and Mg, in foliage, rising progressively from site-quality 1 to IV; they also found direct relation of soil's Ca to foliage Ca.

RESULTS AND DISCUSSIONS.

The accumulation of organic matter on the forest floor is quite high. Part of this decomposes and gets mixed with the mineral soil, whereas a considerable proportion remains on the surface in an undecomposed or semi-decomposed condition for longer periods. This phenomena usually depends upon the composition of vegetation and climatic and physiographic factors and, thereby, influences the site-quality through pronounced effects on soil-plant relationships.

The morphological characteristics of soil-profile under study rate it as a site, favouring relatively faster conversion of organic litter to humus. It also suggests free movement and mixing of nutrients in soil thereby improving its nutrient potential. The soil is relatively of fine texture, particularly in the upper horizons and, therefore excessive removal of colloids by leaching is impeded. The orgainic matter incorporated in the first 12″ layer of soil is 1.6 percent to 0.5 percent, which rapidly decreases from B to C horizons. Consequently, the nitrogen of soil is low, ranging from 0.16 percent to 0.13 percent in the upper horizons, decreasing rapidly from 0.05 to 0.03 percent in the rest of the profile. Normally, forest soils are rich in nitrogen, and a 0.2 percent of nitrogen content is considered to be quite adequate for the growth of most tree species (15).

The soil is very deep permitting root penetration down to 76″ depth. The soil possesses high cation exchange capacity. The pH of soil varies from 5.8 to 6.5, suggesting favourable environments for the growth of coniferous vegetation.

The data of chemical analysis of soil profile are given in Table 1. The average potash content of soil is 3.0 percent, with a range of 2.35 to 3.18 percent. The K20 content decreases with increasing depth of profile. The lime content of soil varies considerably throughout the profile. The average CaO content of the soil is 2.07 percent, and it varies from 0.98 percent to 5.32 percent. The MgO content of soil varies from 1.13 to 2.17 percent with an average of 1.87 percent.

The oxides of iron and aluminium are somewhat low in top layer, but increase in B and C horizons. The percentage of Fe_2O_3 varies from 5.96 to 7.95 and that of Al_2O_3 from 21.15 to 16.62. Removal of Fe_2O_3 from A to B horizon is gradual and remarkable. The P_2O_5 increases in the lower horizons of the profile.

The exchangeable nutrients and available P_2O_5 of soil are given in Table 2. The analysis presents water-soluble plus ammonium acetate extractable metallic cations. The K_2O content of the top 6″ soil is 0.047 percent which gradually decreases in the lower horizons to 0.019 percent. The average K_2O is 0.02 percent, which is considered sufficient for the normal tree growth (14). The available CaO and MgO contents are also high to meet the requirements of conifers; these range from 0.57 percent to 0.28 percent and from 0.07 percent to 0.13 percent, respectively. The P_2O_5 content of soil varies considerably. The maximum accumulation has been found in the middle of soil profile, a zone which is also considered to be the zone of maximum root development. The overall P_2O_5 content, necessary to promote normal tree growth, is quite high. A 0.005 percent P_2O_5 in easily available form, is considered sufficient for the normal tree growth (14).

The results of chemical analysis of undecomposed litter, partially decompoesd litter and humus samples are presented in Table. 3. The ranges of K_2O and CaO content of litter are 0.23 to 0.28 percent and 2.52 to 2.80 percent, respectively. Similarly, humus and partially decomposed litter also contained considerable amount of nutrients which ultimately return to the soil. The difference in composition of these materials is due to the removal of some watersoluble nutrients and gradual libration of various organic compounds on decomposition by soil micro and macro-organisms.

NUTRIENT COMPOSITION OF DEODAR NEEDLES.

The data of analysis of needle samples are presented in Table 4. The nutrient requirements of young deodar seedlings are low (5). The seedlings can therefcre maintain desired growth rate provided other site variables, such as various edaphic and physiographic factors are favourable. The tree crop' in general, extracts nutrients from deeper layers of soil strata, and helps in improving fertility of site subsequently returning the nutrients to soil's upper layers through seasonal needlefall (9).

From the needles' composition of different age seedlings. given in Table 4, it was found that none of the nutrient elements exhibited correlation with the age of seedlings. The amounts of K_2O CaO MgO, however, appeared increasng with the age of plant.

CONCLUSION.

1. Soil profile, particularly its upper layers, are quite rich in nutrients sufficient for meeting the needs of germinating tree crop.

2. Soil is continuously enriched through libration of elements and organic colloids from the decomposing litter.

3. Mixing of decomposed organic matter with the soil is responsible also for better configuration of soil particles leading to better drainage and creation of suitable conditions for the proper development of plant roots in the middle of the profile.

Deodar seedlings are, in general, low demander of nutrients. This species can, therefore, establish itself on different types of soil. For assessment of site-quality edaphic factor must be taken into account together with climatic, biotic and other physiographic factors.

REFERENCES

1. Forest Soils .. 1966 Foliar analysis (Chemistry). Ext. form Report Forest Timb. Bur. August, 1964.
2. Furman, N. H. .. 1962 Standard Methods of Chemical Analysis D. Van Nostrand Company. Inc, Princeton, N. J.
3. Glover, H. M. 1922 Some factors affecting deodar reproduction. Punjab Forest Conference, Forest Department, Lahore.
4. Gorrie, R. M. .. 1930 The Sutlej Deodar, its Ecology and Timber production. A thesis submitted for the degree of Doctor of Science, Edinburgh University.
5. Heiberg, S. Q. and White, D.P. 1956 A site evaluation concept. Jour. of Forestry 54:7.
6. Hohne, H. .. 1965 The mineral and N content of forest ground flora in relation to site. F. A. 2: 1850.
7. Jackson, M. L. .. 1958 Soil Chemical Analysis. Prentice-Hall, Inc. Englewood Cliffs, N. J. U. S. A.

8.	Koroleff, A. ..	1954	Leaf litter as a killer. Jour. of Forestry 52: 178.
9.	Manil, G., et al. ..	1964	Humus as a site factor in the acidiphilour Beech Forests of Belgium F. A. 25:4566. 1958.
10.	Seth, S. K. and Bhatnagar, H. P.	1960	Inter-relations between mineral constituents of foliage, soil properties, site-quality and regeneration status in some *Shorea robusta* forest. Indian For. 86 (10): 590-601.
11.	Viro, P. J. ..	1940	Evaluation of site fertility. Unosylva 15 (2): 91-7.
12.	Wall, R. F. ..	1955	Site requirements of Lake states trees. Ext. from Rep. Lake States Forestry Exp. Sta. 1963-64.
13.	Watt., R. F., and Heinsclman M. L.	1965	Foliar nitrogen and P. level related to site-quality in a northern Minnisota spruce bog.
14.	Wilde, S. A. ..	1958	Forest soils-their properties and relation to silviculture. The Ronald Press Co., NewYork.
15.	Zahner, R. .	1958	Site-quality relationships of Pine Forests in Southern Arkansas and Northern Louisionia. Forest Science 4: 162.

Table No. 1.

Total Mineral Status of a Representative Soil-Profile under Deodar in Dir Forests

Depth (inches)	PH (1:2.5)	Percentage of Total								
		Na_20	K_20	Ca0	Mg0	Fe_20_3	Al_20_3	P_20_5	Organic Matter	N
0—6 ..	6.50	2.94	3.18	3.22	2.00	5.96	19.46	0.42	1.60	0.16
6—12 ..	6.45	3.72	3.18	1.26	1.13	6.87	21.15	0.23	0.50	0.13
12—18 ..	6.40	4.03	3.18	..	2.02	7.32	20.30	0.34	0.17	0.05
18—24 ..	6.30	3.10	3.18	1.26	1.98	7.38	20.30	0.44	0.12	0.08
24—30 ..	6.15	2.60	3.06	5.32	1.71	7.21	18.61	0.32	0.07	0.03
30—36 ..	6.05	2.79	3.18	1.12	2.17	7.32	20.30	0.29	0.38	0.04
36—40 ..	5.90	2.94	2.82	0.98	2.04	7.55	19.46	0.61	0.12	0.05
40 46 ..	5.80	3.41	3.53	1.54	1.91	7.83	16.92	0.57	0.27	0.03
46—50 ..	5.80	3.87	2.82	3.22	2.17	7.95	16.92	0.57	0.29	0.03
50—56 ..	6.05	2.17	2.35	1.54	1.49	7.66	17.76	0.44	0.25	0.03
56—60 .	5.90	3.72	2.59	1.26	1.95	7.66	17.76	0.46	.	0.03
Average	6.12	3.21	3.00	2.07	1.87	7.34	18.99	0.43	0.37	0.06

Table No. 2.

Exchangeable Mineral Status of a Representative soil Profile.

Depth (inches)		Percentage of Exchangeable Cations				pH-3 Extractable
		Na_2O	K_2O	CaO	MgO	P_2O_5
0—6	..	0.022	0.047	0.57	0.07	0.026
6—12	..	0.026	0.034	0.47	..	0.042
12—18	..	0.022	0.032	0.38	0.08	0.043
18—24	..	0.030	0.026	0.45	0.09	0.057
24—30	..	0.030	0.026	0.33	0.13	0.040
30—36	..	0.034	0.026	0.38	0.07	0.037
36—40	..	0.030	0.024	0.39	0.10	0.041
40—46	..	0.032	0.024	0.38	0.10	0.032
46—50	..	0.042	0.024	0.28	0.05	0.032
50—56	..	0.034	0.020	0.30	0.11	0.032
56—60	..	0.037	0.019	0.30	0.08	0.017
Average :	..	0.0308	0.027	0.385	0.089	0.036

Table No. 3.

Mineral Nutrient Composition of organic Litter and Humus.

Sieral No.	Plant Material	Na_2O	K_2O	CaO	MgO	Fe_2O_3	P_2O_5	N
1.	Undecomposed litter ..	0.037	0.282	2.80	..	3.43	..	..
2.	Undecomposed litter of profile site ..	0.050	0.235	2.52	..	3.14	..	..
3.	Partially Decomposed litter ..	0.604	0.942	1.82	1.30	8.28	0.091	0.136
4.	Partially Decomposed litter of profile site ..	0.710	1.224	1.12	0.78	..	0.114	0.110
5.	Decomposed litter ..	1.140	1.884	0.78	0.26	8.32	0.125	0.150
6.	Decomposed litter of profile site ..	1.550	2.355	0.44	0.26	9.57	0.114	0.130
7.	Humus ..	0.600	0.918	1.26	1.04	2.57	0.137	0.150
8.	Humus infilterated soil ..	1.500	2.001	0.56	0.26	..	0.103	0.140

Table No. 4.
Mineral Composition of Needles of Deodar Seedlings.

Age of seedling (years)	Height (inches)	Percentage of Total							
		Na_20	K_20	Ca0	Mg0	P_20_5	Fe_20_3	N	Ash
3.	10	0.148	0.480	1.140	0.70	0.311	0.057	0.352	4.59
4.	18	0.110	0.621	0.671	0.70	0.443	0.039	0.423	4.02
5.	24	0.111	0.791	0.897	0.50	0.297	0.046	0.329	5.97
6.	30	0.136	0.725	0.729	0.60	0.274	0.046	0.564	4.62
7.	21	0.099	0.706	0.532	0.45	0.368	0.070	0.540	4.19
9.	48	0.155	0.518	0.729	0.65	0.400	0.070	0.399	4.23
11.	72	.0117	0.574	0.729	0.70	0.300	0.096	0.352	4.29
12.	66	0.155	0.508	0.701	0.50	0.300	..	0.446	4.77
13.	66	0.093	0.649	0.532	0.50	0.286	0.100	0.470	3.88
14.	72	0.099	0.518	0.729	0.80	..	..	0.423	4.21
15.	78	0.114	1.177	1.610	1.20	0.492	..	0.588	7.30
20.	132	..	..	..	1.10	0.303	0.070	..	4.46
22.	156	0.110	1.413	1.260	0.70	0.457	0.050	0 .440	6.24
	Average :	1.120	0.723	0.776	0.70	0.344	0.064	0.444	4.83