MEAN ANNUAL INCREMENT IN THE FORESTS OF GARHWAL HIMALAYAS RELATED WITH SOIL AND GROUND LITTER PROPERTIES

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Introduction

Site factors are important determinants of forest productivity within a climatic region and physiographic stratum with soil being the major site component. Ralston (1964) and Carmean (1975) while reviewing research in North America on soil factors vis-a-vis site productivity concluded that the factors responsible for controlling the productivity of forests were the moisture, nutrients and aeration, and when other site factors kept uniform then soil nutrient level is more important (Moller, 1974; Pritchett and Gooding, 1975; Waring, 1973). The character of the forest floor, influencing many soil properties was also reported to be connected with the growth and development of forest stands since controls properties of organic matter which in turn regulate the regeneration of trees (Mathur and Bhatnagar, 1964). George (1977) and Negi (1984) studied the forest productivity vis-a-vis soil nutrients in the tropical and man-made forests but no such work is reported for the forests of the temperate regions particularly Garhwal Himalayas which are otherwise very important from management point of view. The present study which deals with the mean annual increment in these forests of deodar, chir and oak forests as related with soil properties and litter composition is an endevour in this direction.

Site

The area under investigation lies in the Dhanaulti Block of Mussoorie Forest Division (U.P.) at an elevation ranging about 2000 m to 2750 m above m s.l. The average rainfall of the area is 254 cm with maximum 75 21 cm (August) and minimum 0.41 cm (November). The mean maximum and minimum temperature for the hottest month are 30°C and 16°C and for the coldest month 9 4°C and 3 8°C respectively. The other site features, already described earlier by Singhal and Soni (1989) have been presented in brief in Table 1.

Experimental

Eight sites, representing the deodar (*Cedrus deodara*), chir (*Pinus roxburghii*) and oak (*Quercus leucotrichophora*) vegetational types were selected for the study. In each study site woody species were enumerated by the methods of Khan and Gupta (1960) and soil samples collected from the representative profiles. The collection of samples were done before the onset of monsoon. The soil samples so collected were analyesed as per the methods of Piper (1950) and Jackson (1967) for different characteristics. The

Table 1

General description of the sites

Forest Type	Locality	Altitude (m)	Slope		Soil depth	Predominant lithology
			Shape	Degree (%)		
Cedrus deodara	Dhanaulti 3 A	2310	Convex	45	Deep	Phylites, Shales and Sandstone
C. deodara	Dhanaulti 1 A	2375	Convex	30	Deep	Phylites, Shales and Sandstone
C. deodara	Dhanaulti 2 A	2325	Convex	45	Deep	Phylites, Shales and Sandstone
C. deodara	Dhanaulti 6 A	2300	Convex	25	Deep	Phylites, Shales and Sandstone
Quercus leucotrichophora	Dhanaulti 5 A	2000	Convex	40	Deep	Quartzites and Slates
Pinus roxburghii	Sorh 9 A	2225	Convex	30	Very Deep	Quartzites and Slates
Q. leucotrichophora	Than 3	2350	Convex	30	Deep	Quartzites and Slates
Q. floribunda	Dhanaulti 1 B	2350	Convex	50	Very Deep	Quartzites and Slates

Mean Annual Increment (M.A.I) of various species was calculated using field and volume tables available for this purpose.

Results and Discussion

It can be seen from Table 2 that the density of these forests varies between 1.9 to 6.4 trees 100 m^2, total basal cover varies between 160.87 to 9257.52 cm^{-2} 100^2 and mean basal cover between 280.31 to 3627.94 cm^2 $tree^{-1}$ (Singhal and Soni, 1989).

As can be seen from Table 3, that the nutrient status in the litter varies from species to species depending upon their total dry weight contents and other characteristics. The litter under deodar is richer in Ca, Mg, N, P and K contents in comparison to chir and oak may be due to their older age as also reported by Kaul *et al.* (1979) for the sal forests of Dehra Dun area.

The values of productivity, expressed in terms of mean annual timber increment has also been found to depend largely on the status of total organic matter in soil and on those factors which influence the input of organic matter and rate of its decomposition

Table 2

Quantitative characters of tree species

Name of species	Frequency	Density Tree/100m²	Abundance 100⁻²m	Mean basal cover cm² Tree⁻¹	Total basal cover cm²/100m²
Site-1					
Cedrus deodara	100	3.30	2.30	763.69	1756.49
Deutzia staminea	20	0.30	1.50	480.64	144.19
Quercus floribunda	40	0.60	1.50	153.80	92.28
		4.20			1992.96
Site-2					
Cedrus deodara	100	6.40	6.40	1446.49	9257.52
Site-3					
Cedrus deodara	80	1.20	1.50	2791.64	3349.97
Quercus floribunda	40	0.50	1.25	229.91	114.95
Mechilus odoratissima	50	0.50	1.00	30.29	15.14
Rhododendron arboreum	30	0 30	1.00	576.10	172 83
		2 50			1652.65
Site-4					
Cedrus deodara	100	4.20	4.20	1243.00	5220.58
Site-5					
Pinus roxburghii	40	0.50	1.25	1860.77	930.39
Q. leucotrichophora	100	1.40	1.40	303.86	425.41
					1355.80
Site-6					
Pinus roxburghii	100	3.30	3.30	280.31	925.03
Site-7					
Q. leucotrichophora	90	1.20	1.30	77.35	92.83
Q. floribunda	30	0.30	1.00	121.69	36.51
Rhododendron arboreum	40	0 40	1 00	50.71	20.29
Lyonia ovalifolia	20	0.30	1.50	31 00	9.30
Cotoneaster bacillares	20	0 20	1 00	9.70	1.94
		2.40			160.87
Site-8					
Q. leucotrichophora	60	0.90	1.50	329.74	296.76
Q. floribunda	100	0.40	1.40	145.61	203.85
Rhododendron arboreum	70	0.90	1.29	101.50	91.35
Lyonia ovalifolia	30	0 40	1.38	70 10	28 04
Aesculus indica	20	0 20	1.00	112.37	22.47
		3.80			642.47

Table 3

Nutrient content in the litter samples under different forest covers and their relationship with the soil nutrient and M A I.

Vegetation	Ca (%)	Mg (%)	N (%)	P (%)	K (%)	C % of soil	pH	Moisture (%)	Mean annual increment (m^3/ha/yr)	Texture
Cedrus deodara	1.18	0.16	1.52	0.12	0.52	6 8	6.2	8.2	5.38	Silty
-do-	1.16	0.14	1.45	0.10	0.68	5.9	5.9	8.1	5.10	Silty loam
-do-	1.14	0.11	1.36	0.08	0.62	6 0	6.0	6 7	5.10	Silty clay loam
-do-	1.15	0.13	1.88	0 09	0 65	6.9	6.8	4.5	5 60	Silty
Pinus roxburghii	0.16	0.03	0.16	0 02	0.06	5.0	5.3	4.4	2 45	Silty loam
-do-	0.12	0 01	0.13	0 01	0.03	5.4	5.4	3.0	3.87	Silty loam
Quercus leucotrichophora	0.17	0.03	0.18	0.03	0.06	5.2	5.2	9.9	2.59	Silty
-do-	0.19	0.04	0.19	0.04	0 07	5.3	5.4	7.5	2.98	Silty clay loam

in soils. It is seen that the productivity of particular stand is related with its soil organic matter content. It increases with an increase in the content of soil organic matter as appeared in its correlationship with the deodar stands showing better productivity (r=0.59) as compared to chir (r=057) and oak (r=0.56). Productivity levels of these forest stands seem to be related with the relative degree of podzolisation of their soils as reported earlier by Singh and Singhal (1976) for similar soils.

It was interesting to see that the contents of micro-nutrients in the soil differ according to the type of vegetation under which these soils have developed and the mode of their accumulation. Their status is also dependent on the status of soil organic matter and the productivity of the forests. The soils under deodar have higher content of Mn, Zn, Cu, Fe as compared to chir and oak. Higher contents of these micro-nutrients in the illuviated horizons as compared to other horizons shows migration of micro-nutrients with the clay and humus. However, when the status of these micro-nutrients is examined, keeping in view the mean increment levels of the individual forest stands it is seen that the micro-nutrients such as Mn, Co and Cu have a greater relationship with the productivity than the other elements under study. In deodar stands where values of M.A.I. are higher as compared to chir and oak the contents of all the micro-nutrients are also high whereas other stands have ralatively less values. This is quite in agreement with the findings of Kaul *et al.* (1979).

Table 4

Study of the soils

Profile	Depth (cm)	Vegetation	Total Mn m.e. %	Total Zu m.e. %	Total Cu m.e. %	Total Fe m.e. %	Total Ca m.e %	Total Mg m.e. %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I	0—18	*Cedrus deodara*	6 8876	0.3519	0.0942	8.2700	6.40	2.0079
	18—70		5.293	0 3672	0.0942	7.1600	9.20	1.1246
	70—120		4.4240	0.2601	0.0942	4.9225	2.80	1.3250
II	0—11	-do-	5.6827	0.2754	0.1099	4 8330	0.40	2.3200
	11—36		4 2635	0.3213	0.0942	7.7865	1.20	0.8497
	36—60		4.9090	0.0459	0.0471	2.2375	4.00	0.9163
	60—91		3 9930	0.2754	0.0942	6.1135	1.90	0.9163
	91—150		2.1054	0 2295	0.0942	2.2375	1.40	0.9330
III	0—14	-do-	8.8080	0.3519	0.1099	2.5955	3 60	1.6120
	14—50		8.7120	0.4131	0.1413	4.4750	4.40	0.7497
	50—90		7.2600	0 4590	0.1099	3.0430	3.60	1.2620
	90—132		9.0750	0.5208	0.1413	6 2650	2 00	1.0579
	132—176		6.9790	0.5202	0.1413	6.9810	2.00	1.3078
IV	0—9	-do-	*8.9860*	*0.3213*	*0.1099*	*8 5025*	*11.20*	1.2580
	9—22		7.6160	0.2601	0 1570	7.7865	1.20	1.1745
	22—42		5.2460	0.2295	0.1413	3.1325	0.80	1.1745
	42—62		6.1500	0.3060	0.1570	6.2700	0.80	1.0550
	62—105		5.9790	0.2448	0.1413	6.5335	3.20	1.4450
	105—135		5.3724	0.1377	0.0471	4.6540	3.20	1.2650
V	0—13	*Pinus roxburghii*	5.0820	0.2907	0.0942	7.0257	2.00	0.8747
	13—50		5.1183	0.0913	0.0471	6.4165	2.00	0 6851
	50—92		5.2635	0.4896	0.0942	7.1600	1.20	0.7747
	92—125		5.4450	0.3366	0.1099	4.1170	0.80	0.8497
	125—160		5.8080	0.3213	0.0942	4.3855	0.80	0.8497

(*Contd* ..)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VI	0−6	*Pinus roxburghii*	2.0328	0.1683	0.0942	4.5645	2.00	0.8663
	6−60		2.5410	0.2448	0.1099	7.3390	0.80	0.7914
	60 −103		2.7951	0.2295	0.1099	6 9810	0.40	0.7914
	103−147		2.3396	0.2448	0.1099	6.9810	0.40	0.8747
	147 −180		2.1747	0.3213	0.1413	5.5490	0 40	0.7664
VII	0—7	*Quercus*	3.3396	0.2448	0.0942	7.7365	4.40	0.8663
	7—24	*leucotrichophora*	2 9403	0.2831	0.0942	6.2650	2.40	0.7914
	24—57		1.5246	0.2831	0.1099	3.1325	1.20	0.5408
	57—92		1.7424	0.3213	0.1099	3.5352	0.80	0.4498
	92—195		0.9438	0.1530	0.1099	4 4750	0.40	0.3415
VIII	0—17	-do-	4 1745	0.2601	0.1099	5.4595	3.20	0.7914
	17—57		4.1745	0 3060	0.1099	2.9535	1.60	0.6831
	57—92		4.2471	0 3519	0.0942	3.5800	1.60	0.8247
	92—185		4.0820	0 2907	0.1099	2.3270	2.40	0.9663

SUMMARY

Elemental composition of the litter under deodar, chir and oak forests of Mussoorie Himalayas were characterised with soil properties and mean annual increments of the species. The study revealed that the forests undrr deodar had higher M.A.I. associated with higher content of Mn, Zn, Mg, Cu and Fe in their soils in comparison to the forests under chir and oak.

गढ़वाल हिमालयी भाग के वनों की माध्य वार्षिक सवृद्धि का वहाँ की मृदा और भूमि पर पड़े पर्णास्तरण से सम्बन्ध

आर०एम० सिंघल व एस० सोनी

सारांश

मसूरी के हिमालयी भाग में हो रहे देवदार, बाँज और चीड़ के वनों की मूल तत्व रचना की विशिष्टताओं का संवन्ध वहां की मृदा विशेषताओं तथा उन वृक्ष जातियों की माध्य वार्षिक संवृद्धि के साथ जोड़ा गया है। अध्ययन से पता चला है कि देवदार वनों की माध्य वार्षिक संवृद्धि अधिक है जो चीड़ और बाँज के मुकाबले में उन वनों की मृदा में मैंगेनीज, जस्ता, मैगनीशियम, ताँबा और लोहा अधिक मात्रा में रहने से संवन्धित है।

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