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Effect of Aspect on the Structure of Some Natural Stands of *Cupressus torulosa* in Himalayan Moist Temperate Forest

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The total basal cover was highest (5646.12 $cm^2/100\ m^2$) on the South-East facing slopes, and lowest (1983.30 $cm^2/100m^2$) on the South-West facing slopes. *Cupressus torulosa* was found associated with *Cedrus deodara* on the North (North-East & North West) facing slopes, but on the South (South-East & South-West) facing slopes, the main association was observed with *Pinus wallichiana* and *Rhododendron arboreum*. The chemical analysis of the soil revealed that moderate acidic *p*H, higher amount of organic carbon percentage, phosphate and potash were available on the North-West and South-East facing slopes, resulting into better growth of *C. torulosa* stands, on these aspects.

Key Words: **Aspect, Qualitative, Quantitative, Synthetic, Soil analysis, Structure, Temperate forest**

Introduction

Himalayan moist temperate forests, extend between 1500 and 3150m a.s.l. at different altitudinal gradients. Within one altitude the co-factors like topography, aspect, inclination of slope and soil type affect the forest composition (Bankoti et al. 1986). Although qualitative descriptions of the forest vegetation of the Himalaya are available (Singh & Singh 1986, 1987b, Gaur & Bartwal 1991), some scattered attempts on quantitative examinations have also been made recently (Kalakoti et al. 1986, Tiwari et al. 1989, Adhikari et al. 1991, Sharma & Kumar 1992).

The present analysis includes (i) Phytosociological attributes pertaining to analytical and synthetic characters of *C. torulosa* and associated species, and (ii) Chemical properties of soil at various horizons supporting *C. torulosa* growth. Different faces of the slopes were selected so as to cover whole array of variations and climatic suitability of this type in Himalayan moist temperate forests.

Materials and Methods

Study Sites

The moist temperate forest of Jhandidhar area (alt. 2100-2450m) in the district Pauri Garhwal, representing dense natural *C. torulosa* chunks as 'pure' and 'mixed' forests, were selected for qualitative and quantitative evaluation. Topographical criteria were used as an index in selecting the stands. A total of four aspects, i.e. North-East (NE), North West (NW) South East (SE) and South West (SW) having different microclimates and altitudinal gradients were studied for determining the variations in and suitability to the growth and perpetuaion of the species. The different altitudes have been called 'Zone' for the present purpose.

In the study area, the year is made up of three main seasons: the cool and relatively dry winter (mid-December to mid-March); the warm & dry summer (April to mid-June) and a warm & wet period (mid-June to mid-September) called the monsoon or rainy season. Apart from these main seasons, the traditional periods interconnecting rainy and winter, and winter and summer are referred to as autumn (October-November) and spring (February-March), respectively. The rainy

Table 1 *Composition of tree layer on different aspects of* ***Cupressus torulosa*** *forest*

Aspect and Altitude	Tree species	Freq. (%)	Density (trees/100m^2)	Total basal cover (cm^2/100m^2)	IVI	A/F
NE (2100 m)	*Cupressus torulosa*	100	5.8	3305.08	215.211	0.058
	Cedrus deodara	70	2.0	723.88	84.793	0.041
NW (2325 m)	*Cupressus torulosa*	100	4.8	5477.72	214.660	0.048
	Rhododendron arboreum	30	0.3	45.60	20.633	0.033
	Myrica esculenta	10	0.1	9.25	6.784	0.100
	Cedrus deodara	60	0.9	838.08	57.900	0.025
SE (2450 m)	*Cupressus torulosa*	100	4.7	5646.120	183.611	0.047
	Pinus wallichiana	80	1.9	237.728	58.300	0.029
	Rhododendron arboreum	20	0.9	360.776	24.310	0.225
	Myrica esculenta	10	0.1	9.800	5.342	0.100
	Quercus semecarpifolia	40	0.8	186.420	28.214	0.050
SW (2275 m)	*Cupressus torulosa*	100	5.6	1983.30	160.510	0.056
	Pinus wallichiana	90	2.2	453.84	68.963	0.027
	Rhododendron arboreum	60	1.9	334.90	51.410	0.053
	Quercus semecarpifolia	20	0.2	27.23	9.839	0.050
	Cedrus deodara	20	0.2	10.22	9.233	0.050

Table 2 *Composition of tree species saplings on different aspects of **Cupressus torulosa** forest*

Aspect and Altitude	Tree species	Freq. (%)	Density (trees/100m^2)	Total basal cover (cm^2/100m^2)	IVI	A/F
NE (2100m)	*Cupressus torulosa*	100	4.9	125.15	220.470	0.049
	Cedrus deodara	60	1.1	38.85	79.536	0.030
NW (2325 m)	*Cupressus torulosa*	20	0.2	1.20	14.870	0.050
	Rhododendron arboreum	30	0.6	8.03	34.685	0.067
	Myrica esculenta	100	3.1	73.10	184-219	0.031
	Cedrus deodara	10	0.1	3.53	10.310	0.100
	Pinus wallichiana	20	0.3	7.08	22.744	0.075
	Quercus semecarpifolia	30	0.5	8.56	33.131	0.055
SE (2450 m)	*Cupressus torulosa*	30	0.4	12.81	31.060	0.044
	Pinus wallichiana	100	2.9	119.28	178.117	0.029
	Rhododendron arboreum	60	1.6	47.80	90.790	0.044
SW (2275 m)	*Cupressus torulosa*	60	1.4	56.13	84.128	0.038
	Pinus wallichiana	100	3.0	101.64	157.268	0.030
	Rhododendron arboreum	10	0.2	6.42	11.808	0.200
	Quercus semecarpifolia	40	0.5	21.72	39.378	0.031
	Cedrus deodara	10	0.1	1.57	7.299	0.100

season accounts for about three-quarters of the annual rainfall, which during the study period (1994-95) ranged between 1045 and 1075 mm. The mean annual temperature ranged from 14.19°C (minimum) to 20.76°C (maximum) and the atmospheric humidity from 53% (May) to 92% (August). The average meterological data of the study sites for each month have been presented in figure 1.

Methods

The vegetation was qualitatively and quantitatively analysed for frequency, density and abundance following (Curtis & McIntosh 1950). The relative values of frequency, density and dominance were determined as per Philips (1959). These values were summed up to represent IVI (Importance value index) of individual species (Curtis 1959). The ratio of 'abundance-to-frequency' for different species was calculated to elicit the distributional patterns, which indicated regular (< 0.025), random (0.025–0.05) and contagious (> 0.05) distribution patterns (Curtis & Cottam 1956). The 'abundance-to-frequency ratio, density/ha, total basal cover/ha and IVI were estimated quantitatively for all the four aspects separately. These aspects were also analysed phytosociologically. This was done through random quadrat sampling, using ten, 10 x 10m quadrats each.

The circumference at breast height (cbh. 1.37 m above the ground) of all trees in each quadrat was recorded individually by species. Individuals of tree species with 10-30 cm cbh were recorded as saplings, which were also accounted as such for basal area estimation.

The species richness, concentration of dominance, diversity and equitability of species on different aspects were considered for detailed analysis. The species richness was calculated as per .lh 13 Whittaker (1972).

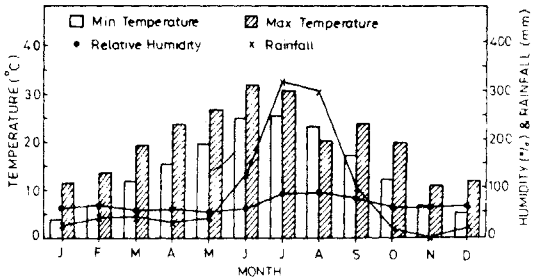

Figure 1

The concentration of dominance was calculated by Simpson's Index (Simpsn 1949). Density of saplings was considered as the regeneration potential of the species. The General Diversity ($\bar{H}$) was computed by using Shannon-Wiener Information Index (1963). The logarithm to the base 2 was used for the expression of diversity in the units of bits per individuals.

The soil characteristics were analysed by collecting three samples for each aspect, vertically down the earth sequentially; surface (0-10 cm), middle (11-20 cm) and lower (21-30 cm) levels. The air-dried replicates were then analysed for organic carbon

Table 3 *Species richness, concentration of dominance, species diversity and equitability in* ***Cupressus torulosa*** *forest on different aspects*

Form	Aspect	Species richness	Concentration of dominance	Diversity Index ($\bar{H}$)	Equitability (Ec)
	North- East	2	0.6188	0.8211	4.326
	North- West	4	0.6439	0.8752	2.379
Tree	South- East	5	0.3852	1.7074	2.990
	South- West	5	0.3913	1.6275	3.455
	North- East	2	0.7007	0.6869	3.082
Sapling	North- West	6	0.4500	1.6881	4.024
	South- East	5	0.4638	1.2695	3.487
	South- West	5	0.4138	1.5813	3.385

percentage, available P and K (as per Jackson 1962) and *p*H (Misra (1968).

Results and Discussion

In Himalaya, the North-East aspects are considered as moister and cooler due to shorter insolation periods in a day as compared to the South-West aspects, which perceive longer insolation periods, and therefore, are treated as drier and hotter.
Similarly, at the higher altitudes due to lower atmospheric pressure the condensation and precipitation rates are higher, which are normally believed to support higher heterogeneity of vegetation. The gentle slopes are assumed to retain more soil moisture contents with comparatively more water deposits as contrast to steeper slopes, where subsequent run-off is more.

The highest density of *C. torulosa* forest (5.8 trees/100m^2) was observed on the NE (Cooler) aspect and at the lowest zone (2100 m), where it was found associated with *Cedrus deodara* only. The lowest density (4.7 trees/100m^2) of *C. torulosa* was recorded on the SE face of highest zone (2450 m), where it was accompanied by *Pinus wallichiana, Rhododendron arboreum, Myrica esculenta* and *Quercus semecarpifolia* (table 1), which is supported by the fact that

Table 4 *Chemical characters of soil on different aspects of **Cupressus torulosa** forest*

Aspect/horizon	Soil *p*H	Organic Carbon	Phosphate (p,kg ha^{-1})	Potash (k, kg, ha^{-1}
NE				
Horizon A	5.9	2.66	11.03	160
Horizon B	59	2.49	11.43	96
Horizon C	6.0	1.76	12.02	80
NW				
Horizon A	4.9	2.70	19.70	116
Horizon B	5.0	2.40	17.74	168
Horizon C	43	2.70	13.59	108
SE				
Horizon A	4.9	2.70	19.70	200
Horizon B	4.3	2.25	17.74	144
Horizon C	4.5	2.55	17.73	104
SW				
Horizon A	4.3	2.10	17.74	104
Horizon B	3.9	1.80	26.20	94
Horizon C	4.3	2.55	9.85	108

higher altitude promotes heterogeneity. The distributional pattern of *C. torulosa* was random on NW and SE aspects (moderate temperature), whereas, it was contagious on NE (Cooler) and SW (hotter) aspects. It was interesting to note that the associated species in the *C. torulosa* forest have also shown random distribution on NE and SW aspects and contagious pattern on NW and SE aspects (table 1), which has clearly reflected that *C. torulosa* prefers moderate environmental conditions in terms of growth in maximum TBC.

The maximum density (4.9 saplings/100 m^2), TBC (125.15 $cm^2/100m^2$) and IVI (220.47) of *C. torulosa* saplings was observed, on a gentle slope $(20)^o$ of NE aspect, which provided suitable moister conditions and also favoured regeneration. Less surface litter on the SW aspect with comparatively steeper slopes (35^o-40^o) indicates less ground flora, but the regeneration of *C. torulosa* and *P. wallichiana* on this aspect was fairly good (table 2).

The total basal cover of *C. torulosa* was maximum on the SE aspect (5646.12 $cm^2/100m^2$) at an altitude of 2450 m, and minimum (1983.30$cm^2/100m^2$) at an altitude of 2275 m on SW aspect. Kusumlata and Bisht (1991) have also recently worked on the quantitative analysis and regeneration potential of some moist temperate forests in Garhwal Himalaya and reported that the total tree basal cover of *C. torulosa* in Teka forest area was 5320.48 $cm^2/100m^2$ on SE aspect (altitude 1800 m), which is in consonance with the results of SE aspect of present study.

The synthetic characters of the tree layer of various stands had shown that southern aspects were more species-rich, whereas northern aspects were higher in concentration of dominance (NE 0.6188 and NW 0.6439) but indicated lower diversity Indices (NE 0.8211 and NW 0.3752). However, NE aspects had indicated higher equitability of the species (4.326). As contrast, the synthetic characters of sapling layers did not reflect any fixed trend (table 3).

Soil Analysis

The nature of the soil profile, soil *p*H and the nutrient cycling between the soil and trees are important dimensions in determining the quality of the site (Jha & Dimri 1991). In the Himalayan moist temperate forest of *C. torulosa* in Jhandidhar area the *p*H of the soil ranged from 3.9 (Horizon B of SW aspect) to 6.0 (Horizon C of NE aspect), clearly indicating that the soil in these forests was acidic in nature and there was much variation in the *p*H values of different aspects (table 4). The NE aspect, in general, reflected the less acidic soil in moisture and cooler environmental conditions, resulting into less diversity of the species on this aspect. The other three aspects having moderate range of *p*H values and moderate to hot environmental regimes comparatively have resulted into higher diversity (tables 1 & 3). The higher organic carbon percentage in the various horizons of NW and SE aspects was the outcome of occurrence of more forest floor creepers and climbers, and species in the form of trees, bushes and saplings. As a matter of fact these higher values have given rise to the higher basal area of *C. torulosa* and other species on this aspect (tables 1, 2 & 3). The lower phosphate contents on the NE aspect have given birth to proportionately less number of species of trees and saplings (tables 1, 2 & 4). The higher potash values have given birth to higher basal area and higher number of individuals on the SE and NW aspects, respectively.

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