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Composition of herbage in *Pinus roxburghii* Sargent stands: basal area and importance value index

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ABSTRACT
In the present study basal area and Importance Value Index (IVI) attributes of herbage were investigated in chir pine (*Pinus roxburghii* Sargent) stands of three different ages and also in open grassland in the sub-tropical region of Himachal Pradesh (India) during growing season (June to September). A higher basal area of the herbage was recorded in open grassland as compared to chir pine stands of different ages. Basal area of the vegetation increased gradually from July onwards and its highest values were recorded in September in all the systems. Amongst the chir pine stands basal area of herbage was recorded highest in tree stand followed by pole and sapling stands. IVI and basal area values of different species revealed that only few species were major contributors to the total basal area values of the vegetation at different times. The differences in the basal area of vegetation in the four systems at a particular time and changes as recorded in the basal area with the sampling time were found to be statistically significant.

Keywords: Chir pine, Grasses, Sedges, Legumes, Non-legumes, Basal area, Stands.

INTODUCTION
Chir pine (*Pinus roxburghii* sargent) is one of the most important conifers of north western Himalaya and is an important timber and resin yielding species. Besides this, chir pine forests provide large stretches of grazing lands and hence people in its zone of occurrence largely depend on them for fodder to feed their livestock. It had been investigated that the pines adversely effect the understorey grasses through release of allelochemicals, increase the acidity of soil and also through interception of solar light and precipitation (Lee and Monsi, 1963, Anderson, 1965, Federer and Tanner, 1966 and Anderson *et al.*, 1969). The needle-fall from chir pine trees varies with the age of trees and average estimation is 4-8t/ha/year (Dass, 1995). Pine needles are normally collected by local population for animal bedding, used as manure after decomposition and is supplied as raw material in the industries for making boards. The herbaceous vegetation in chir pine forests often declines if the needle-litter deposition on forest floor is allowed to carry over beyond 3-4 years. Thus, the present study was undertaken to study structural and functional components of herbaceous vegetation under chir pine trees with the aim of evaluating the adverse effects of chir pine trees on it. The study was restricted to growing season only because the herbage is harvested after mid October usually. Few structural attributes of vegetation of the same experiment like species diversity and density have been presented in Gupta *et al,* (2000) and rest are given below.

MATERIALS AND METHODS
The study was conducted in Solan district of Himachal Pradesh in India which has an undulating mountainous topography. The area is mainly sub-tropical located at 30° 51′ N latitude and 76° 11′ E longitude with an average altitude of 1300 m above msl. Rain is

received both during the rainy (July to mid September) as well as in winter season. 80% of the annual rainfall is received during rainy season only. The soil is broadly categorized as brown-hill podzolic soils.

Three forest stands of chir pine (*P. roxburghii*) viz., sapling stand (S_1), pole stand (S_2) & tree stand (S_3) and an open grassland area (S_0) of 0.1 ha each, having similar soils, slope, aspect and topography, under same location were demarcated for studying the herbage diversity. The silvological characters of these chir pine stands have already been discussed by Gupta *et al.*, (2000). Herbage composition was studied by harvesting vegetation at the ground level from five horizontal-quadrates each of size 50 cm x 50 cm from all the plots at monthly intervals in the rainy season. The vegetation was segregated species wise and the basal area of each species was determined following Phillips (1959) and IVI was computed by following Misra (1968).

RESULTE AND DISCUSSION

The floristic composition of four systems in the present study revealed the presence of eighteen herbage species (nine grasses, four sedges, three legumes and two non-legumes) with little variations in species type among them (Gupta *et al*., 2000). Common species in these systems were: *Heteropogon contortus, Chrysopogon montanus, Apluda mutica, Themeda anathera, Lespideza gerardiana* and *Micromeria biflora* (Table 1).

During the study period, in open grassland, total basal area of vegetation varied from 91.76 cm²/m² to 120.91cm²/m². Grasses showed the highest value of basal area as 106.61cm²/m² and lowest as 65.00 cm²/m². Among the individual grass species *C. montanus* attained the highest basal area (37.0 cm²/m²) in September. Total basal area of sedges, legumes and non-legumes was considerably lower compared to total basal area of grasses in open grassland (Table 1).

In sapling stage (S_1) of chir pine total basal area of grasses ranged from 44.30 cm²/m² to 79.09 cm²/m². Among individual grasses, *T. anathera* and *A. mutica* attained the highest of 28.93 cm²/m² in September. Sedges were intermittently recorded whereas, legumes and non-legumes exhibited considerably lower basal area compared to total basal of grasses (Table 1).

In pole stand (S_2) of chir pine, total basal area of ranged from 67.48 cm²/m² to 90.91 cm²/m². Among individual grasses *T. anathera* attained the highest (42.20 cm²/m²). Similar to other systems, sedges, legumes and non-legumes exhibited comparatively lower basal area (0.32 to 8.35 cm²/m²) than grasses (Table 1).

In tree stand of chir pine (S_3), grasses were the main contributors to the total basal area of the vegetation. The total basal area of grasses ranged from 54.09 9 cm²/m² to 96.70 cm²/m². *T. anathera* contributed the highest (45.75 cm²/m²) basal area. Legumes, non-legumes and sedges had minor contribution to the total basal area of the vegetation compared to grasses (Table 1).

Increase in basal area of vegetation under all the four systems with the growing season till September conforms to the findings of Singh and Yadava (1974), Kapoor (1987), Gupta (1987), Trivedi (1994), Dalai (1996), and Guleria *et al*., (1999) for similar monsoonal grasslands of India. Increments in basal area in successive months in all the systems were statistically significant (Table 2). Likewise, increases in basal area during successive months in each system were also significant (Table 2).

Table 2. Variations in basal area (cm²/m²) of the vegetation under four different systems and date of sampling.

System	June (M1)	July (M2)	August (M3)	September (M4)	Mean
Open grassland (So)	91.76	108.72	113.08	120.91	108.62
Sapling stand (S1)	51.50	67.62	68.40	83.32	67.71
Pole stand (S2)	76.50	83.18	92.44	98.51	87.66
Tree stand (S3)	56.08	67.64	88.74	108.72	80.30
Mean	68.96	81.79	90.67	102.87	

	S. E.	C.D. 0.05
Systems (S0, S1, S2 & S3)	1.63	3.69
Months (M1, M2, M3 & M4)	2.10	4.75
Systems x Months	98.22	284.74

Table 1. Monthly variations in basal area (cm2/m2) of different species under four production systems (S0, S1, S2 and S3) during study period.

	June (M1)				July (M2)				August (M3)				September (M4)			
Name of the species	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
GRASSES																
Chrysopogon montanus Keen ex. Trin	17.80	6.16	-	12.00	36.28	15.08	6.00	6.30	19.88	15.48	10.44	5.20	37.00	8.32	12.30	8.70
Heteropogon contortus (L.) P. Beauv.	6.08	3.80	3.28	5.85	5.60	6.92	7.96	7.50	11.28	5.52	3.72	1.68	7.14	4.20	5.36	4.50
Themeda anathera (Keen) Hack	5.92	16.20	41.84	25.56	10.00	22.56	31.00	15.00	15.40	30.76	40.44	42.80	12.10	28.93	42.20	45.75
Panicum maximum Jacq.	10.88	12.00	11.36	10.20	15.36	11.28	15.88	12.56	18.66	5.84	17.04	6.50	13.87	25.12	20.45	10.20
Panicum villosum Laek. Een. ex. Trin.	17.60	4.36	-	3.48	16.12	9.78	11.80	10.28	19.76	3.08	8.00	9.80	14.50	3.50	7.20	12.80
Cymbopogon martnii (Roxb.) Wats	6.72	-	-	-	5.80	-	-	-	12.00	-	-	-	7.90	-	-	-
Apluda mutica (L.)	-	-	-	-	0.44	-	-	-	0.80	1.04	0.52	2.80	1.00	2.00	0.30	5.75
Imperata cylinderica (L.) P. Beauv.	-	1.68	6.12	-	5.08	-	-	-	-	2.04	3.04	5.76	8.00	7.00	3.10	9.00
Urochloa panicoides P. Beauv	-	-	4.88	-	3.08	-	-	-	4.08	-	-	-	5.10	-	-	-
Total	65.00	44.30	67.48	54.09	97.76	65.62	72.64	51.64	101.86	63.76	83.20	74.54	106.61	79.07	90.91	96.70
SEDGES																
Cyperus rotundus (L.)	7.36	-	4.66	-	-	-	-	-	-	-	1.92	-	-	-	2.60	-
Cyperus aristatus (Rottb.)	7.96	-	-	-	-	-	1.00	-	-	-	-	3.60	-	-	-	6.20
Carex wallichiana Prescott.	1.40	0.64	-	-	-	-	0.87	2.92	-	-	-	-	-	-	-	-
Fimbristylis rigidula (Nees)	-	1.84	-	-	-	-	-	-	-	-	3.88	-	-	-	2.18	4.25
Total	16.72	2.48	4.66	-	-	-	1.87	2.92	-	-	5.80	3.60	-	-	4.78	10.45
LEGUMES																
Lespedza gerardiana Garh.	5.92	4.72	2.04	2.00	-	2.00	-	-	0.82	1.84	2.92	7.72	-	2.00	1.82	1.00
Desmodium trifolium D.C.	4.12	-	-	-	-	-	8.35	2.80	-	-	-	-	-	-	-	-
Rhyncosia himalensis Benth.	-	-	-	-	-	-	-	5.28	-	-	-	-	-	-	-	-
Total	10.04	4.72	2.04	2.00	-	2.00	8.35	8.08	0.82	1.84	2.92	7.72	-	2.00	1.82	1.00
NON - LEGUMES																
Micromeria biflora Benth.	-	-	2.32	-	9.68	-	0.32	5.00	10.40	2.80	0.52	2.88	12.05	2.25	1.00	-
Plectranthus gerardiana Benth.	-	-		-	1.28	-	-	-	-	-	-	-	2.25	-	-	0.57
Total	-	-	2.32	-	10.96	-	0.32	5.00	10.40	2.80	0.52	2.88	14.30	2.25	1.00	0.57
Grand Total	91.76	51.50	76.50	56.09	108.72	67.62	83.18	67.64	113.08	68.40	92.44	88.74	120.91	83.32	98.51	108.72

Comparing four systems, in general, during different sampling months highest basal area values were recorded in open grassland (S_0) followed by pole stand (S_2), tree stand (S_3) and sapling stand (S_1), respectively. Thus, it evinced that when pine trees grow from sapling stage to the pole or tree stages their influence on basal area of undergrowth diminishes. However, when compared with open grassland the low values of basal area of understorey vegetation in chirpine stands show adverse effect of overgrowing trees.

Density, canopy structure, amount of litter fall and toxicity caused by litter disintegration has direct and indirect influence on the functioning of ground flora (Singh and Lal, 1969, Guevara *et al*., 1992 and Grouzis and Akpo, 1998). Differences in behavior of understorey vegetation in three chir pine based systems (S_1 - S_3) can also be related to differences in silvological characters of trees in them (Gupta *et al*., 2000).

In tree stand, higher increment in basal area of vegetation in subsequent months and highest basal area value of herbage vegetation by the end of growing season as compared to pole stand or sapling stand can be related to 71.3% and 66.4% solar interception by the trees in pole stand and sapling stand, respectively, whereas, the solar interception in tree stand was just 49.8%.

Perhaps drastic reduction of solar influx under mature trees might have affected the growth of understorey herbage The higher total basal area values of the vegetation in the initial months (June to August) in pole stand as compared to tree stand was due to initial higher basal area of vegetation in pole stand than tree stand at the beginning of the season (Table 1).

Among different plant species recorded in the present study sites, the contribution of few species like, *C. montanus*, *H. contortus*, *T. anathera* and *p. maximum* to the total basal area value of the vegetation was considerably higher (>60%) which is a manifestation of their better adaptability to the prevailing environment, Characteristically higher basal area of few species in a community has also been reported by Sajwan *et al*., (1980), Singh *et al*., (1985), Chaturvedi *et al*., (1988) and Guleria *et al*., (1999).

IVI of grasses was higher as compared to sedges, legumes and non-legumes in all the systems during different months (Table 3). In open grassland, total IVI values contributed by grasses in different sampling months ranged from 230.16 to 287.16.

C. montanus attained highest IVI values in all sampling months thus showed dominance over other grass species. The IVI of sedges, legumes and non-legumes was, however, lower than grasses (Table 3). In the chir pine based systems (S_1 - S_3), almost similar results were recorded, IVI of grasses varied from 291.39 to 223.94 and like wise the IVI of sedges, legumes and non-legumes was compareatively lower (Table 3). However, among grasses, instead of *C. montanus* highest value of IVI was recorded for *T. anathera*, showing its dominance over other grass species. The results confirm that pine trees have their influence on dominance of species in a plant community.

Compared to the present study, Melkania and Tandon (1983) have reported *H. contortus*; Chaturvedi *et al*. (1988) reported *Anthraxon lancifolius* and Dalai (1996) reported *C. montanus* as the dominant grass species under chir pine forests. Such difference in the type of dominant species under chir pine can be related to difference in micro-environment. Perceptible variations in basal area and IVI among different species in the present study are the manifestations of their ecological amplitude and their interrelationships with ambient environment and associate species. Similar findings were reported by Dalai (1996), Guleria *et al*., (1999) and Dutt (1999).

Thus, from this study it can be inferred that suitable management practices need to be developed to minimize the adverse effects of chirpine on structural attributes of understorey vegetation like, basal area and IVI, which are more pronounced in young trees.

CONCLUSION

It can be concluded from the present study that pine trees adversely effect the basal area development of understorey herbage. These effects are more pronounced in sapling and pole stands as compared to tree stand. Not only that, the chirpine trees also altered the dominance of species in the understorey plant community.

Table 3. Monthly variations in Importance Value Index (IVI) of different species under four production systems (S_0, S_1, S_2 and S_3) during study period.

	June (M1)				July (M2)				August (M3)				September (M4)			
Name of the species	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
GRASSES																
Chrysopogon montanus Keen ex. Trin.	59.25	45.60	-	71.69	54.63	49.68	32.20	22.96	70.30	38.33	17.78	24.75	54.62	71.25	21.81	23.20
Heteropogon contortus (L.) P. Beauv.	26.70	34.73	34.46	45.68	33.72	24.36	69.46	38.75	20.25	33.75	34.42	21.69	32.20	31.70	35.42	26.15
Themeda anathera (Keen) Hack	39.58	91.90	58.11	102.12	47.41	107.91	89.45	82.75	18.25	125.26	84.35	95.55	45.00	77.50	80.00	60.01
*Panicum maximum*P.Beau.	50.51	42.97	40.86	32.73	44.05	55.92	48.53	50.87	41.69	31.69	48.34	63.37	48.40	40.18	51.37	29.24
Panicum villosum Laek. Een. ex. Trin.	31.17	28.44	-	39.17	51.40	39.70	26.28	39.50	44.63	23.50	32.39	28.96	25.40	22.72	25.20	50.87
Cymbopogon martnii (Roxb.) Wats.	22.95	-	-	-	21.42	-	-	-	34.69	-	-	-	28.18	-	-	-
Apluda mutica (L.)	-	-	-	-	16.60	-	-	-	9.65	18.20	9.92	12.30	16.40	5.89	13.72	14.40
Imperata cylinderica (L.) P. Beauv.	-	16.28	40.00	-	10.71	-	-	-	-	12.71	33.20	14.57	17.06	17.21	24.36	20.10
Urochloa panicoides P. Beauv	-	-	50.51	-	7.72	-	-	-	18.16	-	-	-	16.00	-	-	-
Total	230.16	259.92	223.94	291.39	287.16	277.57	265.92	234.87	267.62	283.44	260.40	261.19	283.26	266.45	251.88	233.97
SEDGES																
Cyperus rotundus (L.)	18.34	-	58.34	-	-	-	-	-	-	-	6.97	-	-	-	20.15	-
Cyperus aristatus (Rottb.)	26.77	-	-	-	-	-	8.40	-	-	-	-	9.35	-	-	-	12.35
Carex wallichiana Prescott.	3.85	14.65	-	-	-	-	7.45	1.48	-	-	-	-	-	-	-	-
Fimbristylis rigidula (Nees)	-	9.23	-	-	-	-	-	-	-	-	10.00	-	-	-	12.00	11.78
Total	48.96	23.88	58.34	-	-	-	15.85	1.48	-	-	16.97	9.35	-	-	32.15	24.13
LEGUMES																
Lespedza gerardiana Garh.	12.13	16.19	9.23	8.60	-	22.42	-	0.82	13.35	10.00	12.30	18.12	-	14.34	8.50	29.40
Desmodium trifolium D.C.	9.04	-	-	-	-	-	15.05	23.16	-	-	-	-	-	-	-	-
Rhyncosia himalensis Benth.	-	-	-	-	-	-	-	32.33	-	-	-	-	-	-	-	-
Total	21.17	16.19	9.23	8.60	-	22.42	15.05	55.49	13.35	10.00	12.30	18.12	-	14.34	8.50	29.40
NON - LEGUMES																
Micromeria biflora Benth.	-	-	8.49	-	9.65	-	4.19	8.21	19.02	6.55	10.32	11.35	12.39	19.20	7.47	-
Plectranthus gerardiana Benth.	-	-	-	-	3.20	-	-	-	-	-	-	-	4.35	-	-	0.57
Total	-	-	8.49	-	12.85	-	4.19	8.21	19.02	6.55	10.32	11.35	16.74	19.20	7.47	0.57

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