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COMPOSITION OF HERBAGE IN THREE DIFFERENT *PINUS ROXBURGHII* STANDS AND AN OPEN GRASSLAND: SPECIES DIVERSITY AND DENSITY

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GUPTA, B., CHAUHAN, P. S. & DASS, B. 2000. Composition of herbage in three different *Pinus roxburghii* stands and an open grassland: species diversity and density. A study was conducted to investigate the structural differences in vegetation under three different chir pine (*Pinus roxburghii*) stands of three ages and an open grassland in the sub-tropical region of Himachal Pradesh in India. In all, eighteen herbage species (nine grasses, four sedges, three legumes and two non-legumes) were recorded in the four systems. Minor differences in the floristic composition of the vegetation were recorded in the four systems in the different sampling months. However, the herbage diversity and richness were higher in the open grassland as compared to the three chir pine based systems. Maximum density (tillers m^{-2}) of the vegetation was recorded in July and thereafter it declined gradually in the subsequent months in all the systems. Highest density was recorded in the sapling stand of the chir pine as compared to the other three systems during the period from July to September. The differences in the density of vegetation in the four systems during different sampling months and changes in the density of vegetation in the subsequent months in all the systems were statistically significant.

Key words: Chir pine - grasses - sedges - legumes - non-legumes

GUPTA, B., CHAUHAN, P. S. & DASS, B. 2000. Kandungan daun herba dalam tiga dirian *Pinus roxburghii* yang berbeza dan padang ragut terbuka: kepelbagaian dan kepadatan spesies. Kajian dijalankan untuk memeriksa perbezaan struktur dalam tumbuh-tumbuhan di bawah tiga dirian chir pine (*Pinus roxburghii*) yang berbeza dalam tiga umur dan sebuah padang ragut terbuka di kawasan subtropika di Himachal Pradesh, India. Dalam kesemuanya, 18 spesies daun herba (sembilan rumput, empat rusiga, tiga kekacang dan dua bukan-kekacang) dicatatkan dalam empat sistem. Perbezaan yang kecil dalam kandungan flora bagi tumbuhan-tumbuhan dicatatkan dalam empat sistem pada bulan pensampelan yang berbeza. Bagaimanapun, kepelbagaian dan kekayaan daun herba adalah tinggi di padang ragut terbuka jika dibandingkan dengan tiga sistem yang berasaskan chir pine. Kepadatan maksimum (anak pokok m^{-2}) bagi tumbuh-tumbuhan dicatatkan pada bulan Julai dan selepas itu ia merosot secara beransur-ansur pada bulan-bulan berikutnya dalam kesemua sistem. Kepadatan tertinggi dicatatkan dalam dirian anak pokok chir pine berbanding dengan tiga sistem lagi pada tempoh Julai hingga September. Perbezaan kepadatan tumbuh-tumbuhan dalam empat sistem pada musim pensampelan yang berbeza dan perubahan kepadatan tumbuh-tumbuhan pada bulan-bulan yang berikutnya dalam kesemua sistem adalah berbeza secara statistik.

Introduction

In Himachal Pradesh, a northwestern part of India, many poor farmers depend on livestock for subsistence income. More than 80% of the livestock is dependent on natural grazing lands, viz. grasslands, pastures, meadows and forests for their forage requirement.

Pinus roxburghii Sarg. (chir pine) forests of the mid-hills of Himachal Pradesh are an important part of the economy of farming people. Apart from providing good timber and resin, chir pine forests are also an important source of grazing by livestock. Though there is a close linkage between human beings and chir pine through livestock rearing, man seems to have ignored the extreme importance of such lands. The forests need to be saved from overgrazing and managed to optimise understorey production. Reports have shown that herbage production tends to be low under chir pine on account of radiation interception and release of allelochemicals from the pine needles (Lee & Monsi 1963, Anderson 1965, Federer & Tanner 1966, Anderson *et al.* 1969). Thus, the present study was undertaken to analyse the structural behaviour of the vegetation under chir pine trees of different ages during the growing season. The herbage is generally harvested by the farmers after September for hay.

Material and methods

The study was conducted at Solan district of Himachal Pradesh in India. The whole district is mountainous in nature having rolling and undulating topography. The area is sub-tropical located at 30° 51' N and 76° 11' E with an altitude of 1300 m. Rain is received both during the rainy as well as in the winter seasons but around 80% of the annual rainfall is received during the rainy season only. The soil is broadly categorised as brown-hill podzolic.

Three forest stands of chir pine (*Pinus roxburghii*), viz. sapling stand (S_1), pole stand (S_2), and tree stand (S_3), and an open grassland area (S_0) of 0.1 ha each, having similar soils, slope, aspect, topography, management and situated at the same location were demarcated for studying the herbage diversity. The silvological characters of the chir pine stands are given in Table 1. Crown area of the trees was measured by taking the horizontal distance from the trunk towards the periphery in four directions. Average radius was worked out and crown area was calculated. Solar radiation reaching the herbage layer under trees was calculated by recording the solar influx by two digital lux meters simultaneously under and outside the tree canopy. It was recorded at fortnightly intervals throughout the study period and average values were calculated. Pine needle litter was estimated by collecting leaf litter at fortnightly intervals from 12 quadrats of size 1 × 1m in each chir pine plot from February-end to June-end.

Table 1. Silvological characteristics of chir pine stands

Parameter	Sapling stand (S_1)	Pole stand (S_2)	Tree stand (S_3)
Tree density (No. of trees ha^{-1})	6800	750	250
Average height of tree (m)	1.3	7.5	18.9
dbh (cm)	5.3*	15.1	40.6
Crown cover per tree (m^2)	5.6	20.1	50.2
Relative light intensity (%)	33.6	28.7	50.2
Needle-leaf litter (kg ha^{-1})	4173.2	6285.8	7566.6

* = collar diameter.

Table 2. Monthly variations in density (No. of tillers m^{-2}) of herbaceous vegetation under four production systems (S_0, S_1, S_2 and S_3) from June to September 1994

	June (M_1)				July (M_2)				August (M_3)				September (M_4)			
Name of species	S_0	S_1	S_2	S_3	S_0	S_1	S_2	S_3	S_0	S_1	S_2	S_3	S_0	S_1	S_2	S_3
GRASSES																
Chrysopogon montanus	490.3	219.3	–	420.2	540.0	359.2	134.7	381.00	775.8	544.1	104.7	264.0	820.0	232.4	104.6	112.2
Heteropogon contortus	171.6	44.0	144.6	304.3	290.9	292.1	276.0	292.9	378.2	239.0	135.5	117.6	110.0	90.5	196.0	125.0
Themeda anathera	318.7	552.3	486.7	610.2	854.2	340.0	755.2	580.0	430.8	672.5	850.2	644.7	112.2	950.6	466.7	725.0
Panicum maximum	368.0	162.0	334.5	328.3	360.6	465.0	243.7	444.6	380.8	281.3	202.5	227.6	610.7	450.2	320.4	320.2
Panicum villosum	248.0	102.0	–	189.2	410.6	358.8	205.3	395.2	370.4	229.2	130.0	376.0	592.4	170.0	136.0	540.7
Cymbopogon martnii	52.5	–	–	–	70.0	–	–	–	231.4	–	–	–	69.8	–	–	–
Apluda mutica	–	–	–	–	62.7	–	–	–	56.0	36.0	20.0	92.7	20.0	32.0	48.0	86.5
Imperata cylindrica	–	90.0	168.0	–	92.3	–	–	–	–	80.0	102.2	154.2	28.3	70.3	162.5	92.4
Urochloa panicoides	–	–	172.0	–	42.2	–	–	–	56.0	–	–	–	11.8	–	–	–
Total	1649.4	1169.6	1305.7	1852.2	2723.5	1815.1	1614.9	2093.7	2689.4	2062.1	1545.1	1876.8	2375.1	1996.0	1434.1	2002.0
SEDGES																
Cyperus rotundus	80.0	–	160.1	–	–	–	–	–	–	–	85.0	–	–	–	91.5	–
Cyperus aristatus	162.0	–	–	–	–	–	54.3	–	–	–	–	102.0	–	–	–	75.0
Carex wallichiana	48.0	32.0	–	–	–	–	69.7	71.0	–	–	–	–	–	–	–	–
Fimbristylis rigidula	–	48.0	–	–	–	–	–	–	–	–	94.1	–	–	–	48.1	52.2
Total	290.0	80.0	160.1	–	–	–	124.0	71.0	–	–	179.1	102.0	–	–	139.6	127.2
LEGUMES																
Lespedza gerardiana	68.0	68.0	80.0	64.8	–	240.1	–	–	43.2	38.0	38.4	289.0	–	34.6	24.4	92.4
Desmodium trifolium	36.0	–	–	–	–	–	70.1	73.0	–	–	–	–	–	–	–	–
Rhyncosia himalensis	–	–	–	–	–	–	–	132.3	–	–	–	–	–	–	–	–
Total	104.0	68.0	80.0	64.8	–	240.1	70.1	205.3	43.2	38.0	38.4	289.0	–	34.6	24.4	92.4
NON - LEGUMES																
Micromeria biflora	–	–	77.0	–	43.2	–	62.1	125.3	164.7	20.0	39.6	47.1	125.0	45.4	27.5	–
Plectranthus gerardiana	–	–	–	–	56.5	–	–	–	–	–	–	–	52.2	–	–	69.5
Total	–	–	77.0	–	99.7	–	62.1	125.3	164.7	20.0	39.6	47.1	177.2	45.4	27.5	69.5
Grand total	2043.4	1317.6	1622.8	1917.0	2823.2	2055.2	1871.1	2495.3	2897.3	2140.1	1802.2	2314.9	2552.3	2076.0	1625.6	2291.1

Herbage composition was studied by harvesting the vegetation at ground level from five horizontal quadrats each of size 50 × 50 cm from all the plots at monthly intervals in the rainy season. Herbage diversity index was calculated by using the formula given by Margalef (1968). Density (number of tillers m^{-2}) of the different species was calculated by counting the number of tillers of each species in each sampling quadrat.

Results and discussion

Phytosociological study revealed that eighteen herbage species (nine grasses, four sedges, three legumes and two non-legumes) were present in all the plots (Table 2). The study showed little variation in floristic composition of herbaceous vegetation under the four herbage production systems (S_0, S_1, S_2 and S_3). Whatever difference in species composition recorded among the four plots can be related to difference in their micro-habitat consequent to the difference in leaf-litter deposition and solar radiation interception (Table 1) resulting in difference in soil and air temperature and thereby different germination and growth rates of various species. Park *et al.* (1986) reported the reduction in tillers m^{-2} if the shade level is more than 25%. Besides this, yearly variations in organic components as well as mineral status of litter may result in variation of species number as reported by Berg and Staaf (1981). Release of allelochemicals from leaves as contended by Melkania (1982) and Modgil and Kapil (1990) and Johnson (1995) can also be related to difference in species composition among the four plots.

In the open grassland, the average values of species diversity and richness were worked out to be 0.95 and 11 respectively, whereas for the sapling stand the values were 0.80 and 9, for the pole stand they were 0.86 and 10, and for the tree stand the values were 0.85 and 9 respectively (Table 3). Thus, the study showed that open grassland ecosystem can be regarded as more diversified than chir pine based grasslands. Similar observations have been reported by Singh *et al.* (1985) in their study on herbage diversity under chir pine systems as compared to open grassland. They attributed it to strong interspecific tree-grass interactions especially for interception of solar influx and tree density. Anderson (1965) and Anderson *et al.* (1969) contended that herb layer is more responsive to differences in throughfall precipitation determined by canopy opening than to difference in light. Consequences of allelochemicals released from the leaves of chir pine trees (Lee & Monsi 1963, Modgil & Kapil 1990) can also be reflected in the low herbage diversity and richness under chir pine.

Table 3. Monthly variations in species diversity under four production systems (S_0, S_1, S_2 & S_3) during the study period

Month	Species diversity				Richness			
	S_0	S_1	S_2	S_3	S_0	S_1	S_2	S_3
June	0.96	0.85	0.82	0.70	11	9	8	6
July	0.93	0.71	0.80	0.84	11	9	11	10
September	0.97	0.85	0.92	0.98	11	9	11	11
Average	0.95	0.80	0.86	0.85	11	9	10	9

S_0 = open grassland, S_1 = sapling stand, S_2 = pole stand, S_3 = tree stand.

The data recorded for density of grasses, sedges, legumes and non-legumes indicate that the last three categories were absent in a few samplings during the study period. Different species attained maximum values at different times. Also, their densities varied with the plots. In all the plots herbage density increased gradually from June onwards and achieved maximum density by the end of July and/or August (Table 2) and showed strong dependence on the rainfall pattern. In this region rain starts from June-end, increases gradually in intensity, reaching a peak around mid-August, and terminates by September-end. Strong dependence of the vegetation on rainfall pattern has also been reported by many scientists for the monsoonal grasslands of India (Singh & Yadava 1974, Bawa 1986, Kapoor 1987, Gupta 1987).

In the open grassland (Table 2) the total density of grasses varied from 1649.4 to 2723.5 m^{-2}. Among the individual grasses, *Themeda anathera* attained the highest density (854.2) in July whereas the lowest value (11.8) was recorded for *Urochloa panicoides* in September. Sedges were recorded in June only. *Cyperus aristatus* attained the highest density of 162.0 and *Carex wallichiana* showed the lowest density of 48.0 m^{-2}. The total density of legumes varied between 43.2 and 104.0 m^{-2}. Their density values remained higher in the beginning and decreased gradually with the advancement of the growing season. The total density of non-legumes varied from 99.6 to 177.2 m^{-2}. Among them *Micromeria biflora* exhibited higher values as compared to other non-legumes, and its density values varied from 43.2 (July) to 164.7 m^{-2} (August).

Variation in density of different grasses in the three plots under chir pine did not reveal any pattern. It varied from 1169.6 to 2093.7 m^{-2}. Among different grasses, *Chrysopogon montanus, Heteropogon contortus, Themeda anathera* and *Panicum maximum* contributed greatly to the total density of grasses. Individually, maximum density was recorded for *Themeda anathera* as 950.6 m^{-2} (S_1) and minimum 20.0 m^{-2} for *Apluda mutica* in September (S_2). Sedges, legumes and non-legumes were not recorded in some sampling months. Their contribution to the total density of vegetation was markedly less as compared to grasses.

The density of the herbage vegetation in the open grassland attained higher values as compared to the values recorded under pine trees. Singh *et al.* (1985) have also reported similar findings under chir pine. Among the three types of chir pine stands, the density of the herbage vegetation was highest in the tree stand followed by the sapling stand and pole stand (Table 4). This reveals that, although the presence of

Table 4. Variations in vegetation density under four different systems and dates of sampling

System	June (M_1)	July (M_2)	August (M_3)	September (M_4)	Mean
Open grassland (S_0)	2043.40	2823.06	2897.33	2552.26	2579.01
Sapling stand (S_1)	1317.60	2055.16	2140.10	2075.95	1897.20
Pole stand (S_2)	1622.78	1871.07	1802.21	1625.64	1730.43
Tree stand (S_3)	1916.96	2495.16	2314.88	2291.10	2254.53
Mean	1725.19	2311.11	2288.63	2136.24	

	S. E.	$C.D._{0.05}$
Systems (S_0, S_1, S_2 & S_3)	69.45	141.30
Months (M_1, M_2, M_3, M_4)	69.45	141.30
Systems × Months	98.22	284.74

pine trees in grasslands has an adverse effect on the density of herbage, this effect differs with the growth stages of the pine trees. The density of herbage decreases more in the sapling and pole stands as compared to the tree stand which can be attributed to different solar influx interception. Solar interception in the sapling and pole stands was 66.4 and 71.3% respectively, whereas in the tree stand it was as low as 49.8% (Table 1). Further, it showed that herbage cover is more responsive to light interception than to the amount of litterfall since the amount of litterfall was more in the tree stand than in the pole or sapling stand.

The present study thus emphasises that suitable tending management techniques need to be developed to minimise the reduction in herbage diversity and density under chirpine trees at sapling and pole stages.

Conclusion

The present study conducted to assess the effects of *Pinus roxburghii* (chir pine) trees on understorey vegetation revealed that chir pine affects herbage diversity, richness and density of vegetation. These effects are more pronounced in the sapling and pole stages of chir pine.

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