GRASSLAND PRODUCTIVITY IN THE INDIAN HIMALAYA AND PERFORMANCE OF INTRODUCED TEMPERATE FORAGE SPECIES IN COLD AND SEMI-ARID ENVIRONMENT

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ABSTRACT

Grasslands in the Himalayan ranges, particularly in the middle altitudes, are over-exploited by both sedentary and nomadic flocks. No systematic studies have been made to assess the productivity and carrying capacity of these grasslands so that suitable improvement measures could be adopted. A study conducted in the Shimla district of Himachal Pradesh (HP) at 2092, 2400 and 2895 meters above mean sea level (amsl) and varying soil conditions, showed that protection alone increased dry matter production between 9 and 188% over a three year period and average production in the third year from lower to higher altitude grasslands was 101.1, 27.98 and 31.86 q/ha. The herbage from grassland at 2895 m was nutritionally superior that the others. Carrying capacity on the basis of dry matter intake varied between 0.6 and 2.77 animal units per ha. Productivity and carrying capacity of the grasslands can be increased significantly by application of split doses of N @ 80 kg/ ha. Experiments conducted on the adaptibility of temperate grass/ legume species in the cold, dry areas of the middle Himalayas revealed that Red clover (*Trifolium pratense*), White clover (*T. repens*), Lucerne (*Medicago sativa*) among legumes and Orchard grass (*Dactylis glomerata*), Timothy (*Phleum pratense*) and Wheat grass (*Agropyron* species) among grasses are quire adapted and can be used to increase grassland productivity.

KEYWORDS

Indian Himalaya, grassland productivity, Biotic factor, carrying capacity, *Dactylis glomerata*, dry matter

INTRODUCTION

The Indian Himalaya lies between 27° to 36° north latitude and 74° to 97° east longitude, i.e. from Jammu and Kashmir in the west to Arunachal Pradesh in the east. The Himalaya functions as a great climatic divide and determines the climate of the sub-continent. Altitude-wise the Himalaya can be divided into three sections: (a) the inner or the great Himalaya comprising of the northern-most ranges with an average height of 6,000 m; (b) the middle or lesser Himalaya, an intricate system of mountains and valleys with an average height ranging between 3500 and 5000 m. These ranges have extensive alpine and temperate grasslands and being easily accessible are extremely exploited; (c) the outer Himalaya or the foothills or the Sivaliks as they are commonly called, are entirely made of fluvial deposits.

Excepting the alpine pastures, there are no true grasslands in India. Intermixed with forest vegetation are found at times fairly extensive stretches of grasslands in different altitudes in the Himalayan ranges. Some of these grasslands have existed since the recorded history of pastoralism in India. Examples of such grasslands are "Margs" in Kashmir and "Bughiyals" in Uttar Pradesh. With the increase in population pressure, more and more forests are being felled and these areas are being converted into grasslands.

The middle altitude grasslands of the Himalayan range are the most exploited as these are used by both the sedantary flocks as well as the flocks of nomadic graziers on their way to and from the alpine pastures. No systematic studies have been made on the productivity and carrying capacity of these mid-altitutde grasslands even though estimates of productivity have been made by some workers at one point of time of the year (Dabadghao and Shankarnarayanan, 1973; Singh et al., 1975). Authentic information on the productive capacity of these grasslands and their carrying capacity will enable undertaking improvement measures and their optimum utilisation.

While some work on the adaptibility of the varieties of temperate grasses and legumes bred in Europe, America and New Zealand have been carried out in humid temperate areas of Himachal Pradesh (Ghosh, 1969), no such work appears to have been done in cold cry temperate areas in the Himalaya. Introduction of adapted species in the grasslands in these areas would be a boon to the pastoralists.

MATERIAL AND METHODS

In Shimla district, three sites at different altitudes were selected for the present studies. The details of the sites are given below:

	Site	Koti	Theog	Narkanda
1.	Altitude (amsl) m (ft)	2092 (6800)	2400 (7800)	2895 (9700)
2.	Aspect	South	South-west	South-east
3.	Slope	less steep	steep (60°)	gentle slope in some areas and steep in others
4.	Soil	sandy loam with with stone & gravel	gravel	sandy (silty) loam with some gravel
5.	Rainfall (mm) (annum)	800-1000	1100-1200	>1400
6.	Snowfall (cm)	50	125-150	>250
7.	Maximum temp. in summer and minimum temp. in winter - maximum/minimum (°C)	36/4	30/-5	26/-10
8.	Growth period	June-Nov.	July-Nov.	July-Oct.
9.	Grass cover	*Chrysopogon Heteropogon*	*Chrysopogon Heteropogon*	*Agrostis, Poa, White Clover, Chrysopogon*

Experimental areas in all the sites are slopy with slope ranging between 20° to 60°. All these areas are open to grazing and have been grazed for decades by unlimited number of cattle, buffalo and sheep throughout the summer months.

Experimental areas were fenced to prevent entry of stray animals and divided into suitable paddocks. Random samples of fresh grass in an area of 1 m^2 were taken from 10 points at Koti and Narkanda and 5 points at Theog every month during the grazing season. These samples were weighed and average production worked out per sq. meter which were converted to per hectare of green matter production. Out of the fresh green matter collected, random samples were drawn for dry matter estimation every month. Drying was done at 100°C + 2°C until constant weight was achieved. Chemical analysis was done as per standard technique.

In order to get an idea of dry matter digestibility of the forages from

different grasslands, two animals were kept in matabolic cages in September-October 1992 and 1993. The intial body weight of sheep was recorded and was given weighted amount of herbage from the grasslands. Samples for estimation of dry matter and other parameters were drawn every day. Similarly, refused herbage was weighed and samples drawn for analysis.

Effect of Nigrogen application on productivity was studied on closed grasslands at Koti and Theog. Six levels of N viz. 0.20, 40, 60, 80 and 100 kg per ha were applied by broadcasting split doses, half at onset of monsoon and second half after one month of first application. The experiement was replicated four times. From the fresh harvests, samples were drawn for determination of dry matter.

Adaptability trials of temperate species were carried out at Kukumseri in Lahaul and Spiti district situated at 2700 m (8775 ft. amsl). The area has a cold semi-arid type climate with fairly heavy snowfall during winter and scanty rainfall (25 cm). The temperature varies from 23°C in summer to -30°C in winter.

The experiements were carried out in randomized block design with three replications in $6m^2$ plots, which received 40 kg N, 40 kg P_2O_5 and 20 kg K_2O, except the legume trial which received only 20 kg N in addition to 60 kg P_2O_5 and 25 kg K_2O. In all cases plant height, fresh and dry matter yields were recorded.

RESULTS AND DISCUSSIONS

Dry matter yield of different grasslands for the grazing period, July to November, are given in Table 1. There was an increase in all the grasslands with the advancement of season, the highest productivity being achieved in Koti and Theog grasslands in August. In Narkanda, which is located at the highest altitude among the study sites, productivity peaked in September. In 1991, however, the highest productivity at Narkanda was achieved in August. There was progressive increase in the yield over the years in all the grasslands which was obviously due to the protection provided. At Koti, which is a south facing site, there was 188% increase in the average production between the first and third years, the final year production being 101.1 q/h. The actual production at Koti in September 1993 was 130 quintals of dry matter per ha. Production increase at Theog and Narkanda sites were 9 and 15% respectively. This may be due to both soil and climatic effects. Soil at Theog is extremely poor and both Theog and Narkanda sites being located at higher altitudes were affected by low temperatures.

Dry matter digestibility was highest at Narkanda even though herbage production was lower than Koti. CP as well as DCP was also highest for Narkanda. This is because the higher altitude grasslands such as Narkanda comprise more of temperate grass species as compared to the other two sites. Narkanda also had some white clover in the herbage whereas the other two sites were devoid of legume component. Nutritional quality of herbage from different grasslands for the year 1992 is given in Table 2.

Carrying Capacity

The carrying capacity of grasslands was computed on the basis of dry matter production per hectare and dry matter intake per sheep per day. The results for the years 1992 and 1993 are given in Table 3. While dry matter production was highest at Koti, dry matter intake was highest at Narkanda. Carrying capacity on the basis of animal units (5 sheep unit = 1 animal unit) was lowest for Theog grasslands (0.6) and highest for Koti (2.77) in 1992. The carrying capacity of Narkanda grasslands was more or less the same in both years, i.e. 1.03 and 1.06.

Carrying Capacity Under Cut and Carry System

Many hill grasslands at these altitudes are not grazed. The grass is allowed to grow and harvesting is done once in October/November as per requirement. The carrying capacity of these grasslands was also computed under cut and carry system.

It was estimated that the average requirement of dry grass per animal unit ranged between 12-15 kg per day or 54.75 quintal per year. However, the dependence of animals for fodder available from the grasslands is only for about 200 days thus requiring 30 quintals per annum. For the rest of 165 days, herbage is made available from other sources.

Thus, on the basis of dry matter production from different grasslands, the carrying capacity can be computed as follows.

Carrying capacity under cut and carry system (animal units)

	Koti		Theog		Narkanda	
	1992	1993	1992	1993	1992	1993
Stall fed for 365 days	0.71	1.27	0.43	0.28	0.46	0.50
Stall fed for 200 days	1.30	2.32	0.78	0.57	0.85	0.92

Effect of Nitrogen Fertilizer on Grasslands

Result of fertilizer application trial is given in Figure 1. Significant differences were observed in different doses of fertilizer application at both sites. At Koti, highest yield of 171.87 quintal per ha was observed at 80 kg N per ha against 97.5 quintal per ha for the control plot. The rest of the doses were at par with each other. At Theog, although the overall production was low, application of 80 kg N per ha differed significantly from all other doses of application but was at par with 40 kg N.

Performance of Temperate Species in Cold Semi-arid Environment

Experiment I: Seven grasses and four legumes were tested. Only one cutting was taken during first year and three cuts during the second year. Figure 2 gives the dry matter yields of different species. Except for smooth brome (*Bromus inermis*), *B. wildenowii* and *Melitotus* species, all others performed well in dry semi-arid climate. Dry matter yields of the legume, Red clover, was higher than the most productive grass, wheat grass (*Agropyron* sp. local) and the introduced species, Tall fescue.

Experiment II: Orchard grass has been found to be one of the most productive grasses in humid temperate areas in the hills. Sixteen strains were evaluated. The dry matter yields of the cultivars are given in Figure 3. Cv-Sumex gave the highest dm. yield of 9.19 t/ha followed by strain No. 15125 and Germinal and these significantly out-yielded the check. Dry matter yield of Sumex in 1991 was 14.56 tonnes/ha which was highest among all the Cvs. tested.

Experiment III: A trial with eleven varieties of Rye grass (*Lolium perenne*) of U.K., Europe and New Zealand origin gave dry matter yields between 1.8 t/ha to 4.53 t/ha. During the second year there was little or no vegetative growth and as such the experiement was discontinued. On the other hand, Timothy (**Experiment IV**) in a test with eight strains, fared better under these harsh conditions. Dry matter yield varied between 3.83 t/ha to 6.78 t/ha and the strains Clair and Itaska gave stable performance over the three year test period (Figure 4).

Experiment V: Lucerne (*Medicago sativa*) is a versatile legume used both in the tropical plains and the temperate hill regions. Ten cultivars

bred in different parts of India and in use in the plains were sown in lines 25 cm apart. Three cuts were taken in the first year, 5 in the second, and 3 during the third season. While all the varieties were statistically at par, Cvs. Anand 4 and RLS 88 gave slightly higher yield than the check LL com 3 (Figure 5). Lucerne showed very good growth and provided 3-5 cuts as compared to 2 cuts obtained in the grasses tested. The dry matter yield of 9-11 t/ha was higher than 7-9 t/ha obtained in the most productive grass, *Dactylis glomerata*.

CONCLUSION

It is evident that carrying capacity of the grasslands in the mid-altitudes in the Himalaya is low, the primary reason being their excessive exploitation by unlimited number of herbivores throughout the growing season. It is also evident that these grasslands can recoup remarkably once the biotic factor, i.e. in the grazing animal is removed and the grasslands protected, the rate of recovery depending on the soil and climatic factors. Increased production ranging from 9% to 188% was achieved by protection alone in three years. The nutritional quality of the herbage from the higher altitude grasslands is superior to that of the lower altitude, which comprise mainly of tropical and sub-tropical species and are devoid of legume component. Carrying capacities of these grasslands can be increased further by split application of 80 kg/N/ha.

Lucerne, Red clover, White clover among legumes and Orchard grass, Timothy, Tall fescue and *Agropyron* sp. among grasses are quite adapted to the cold, dry conditions of Lahaul and Spiti and can be used in the grasslands to increase productivity significantly. There is a need to test more *Agropyron* sp. and varieties, particularly those bred and used in Canada and the northern United States.

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Table 1
Dry matter yields of different grasslands (q/ha)

Month	1991			1992			1993		
	K	T	N	K	T	N	K	T	N
July	-	28.0	29.0	90.0	33.5	27.8	96.7	33.0	28.6
August	-	30.0	32.0	118.0	36.5	30.0	112.0	36.4	31.04
September	-	31.0	30.0	110.0	27.6	37.1	130.0	20.5	37.8
October	-	23.5	26.5	92.7	23.2	33.0	83.0	24.4	34.0
November	35.0	11.2	19.8	39.0	23.58	25.8	69.8	15.58	27.87
Av.	35.0	24.7	27.5	89.9	28.87	30.87	101.1	27.98	31.86

K = Koti; T = Theog; N = Narkanda

Table 2
Nutritional evaluation of herbage of different grasslands (1992)

Parameter	Koti	Theog	Narkanda
A. Digestibility (%)			
Dry matter	64.51	68.92	69.35
Crude protein	49.52	50.67	54.24
Ether extract	50.12	52.45	54.50
Crude fibre	61.14	62.42	62.56
Digestible crude protein	2.78	4.43	4.82
Total digestible nutrients	54.95	56.58	58.94
B. Nitrogen free extract	63.45	64.51	65.84
C. Intake			
Dry matter (kg/day/sheep)	1.25	1.04	1.35
D.C.P. (g/sheep/day)	34.7	46.0	65.0
T.D.N. (g/sheep/day)	686.8	588.4	795.6

Table 3
Dry matter production, intake and carrying capacity of grasslands

	Koti		Theog		Narkanda	
	1992	1993	1992	1993	1992	1993
Dry matter yield (q/ha)	39.0	69.8	23.58	15.58	25.50	27.87
Dry matter intake (kg/sheep/day)	1.25	1.38	1.04	1.40	1.35	1.44
Carrying capacity (sheep/ha)	8.55	13.87	6.22	3.04	5.18	5.30
Carrying capacity (animal unit/ha)	1.71	2.77	1.24	0.60	1.03	1.06

Figure 1
Effect of N. Fertilizer on Yield

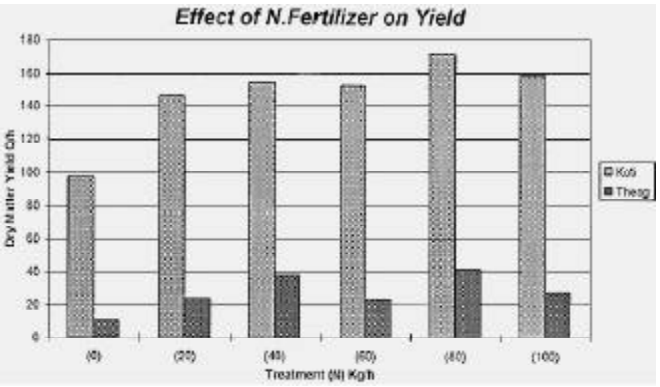
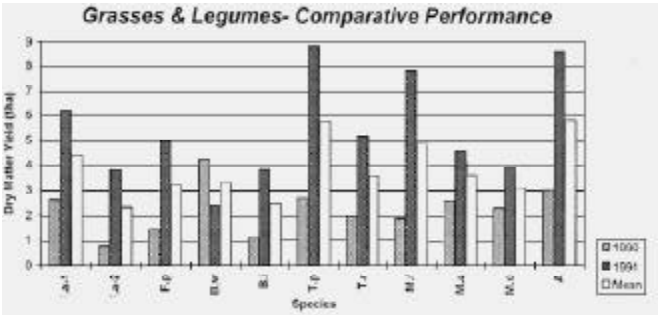


Figure 2
Grasses & Legumes - Comparative Performance



Notes			
F.a	Festuca arundinacea	T.r	Trifolium repens
F.p	Festuca pratense	M.f	Medicago falcata
B.w	Bromus wildenowii	M.a	Melilotus alba
B.i	Bromus inermis	M.o	Melilotus officinalis
T.p	Trifolium pratense	A	Agropyron spp.

Figure 3
Dactylis Glomerata - Strain Evaluation

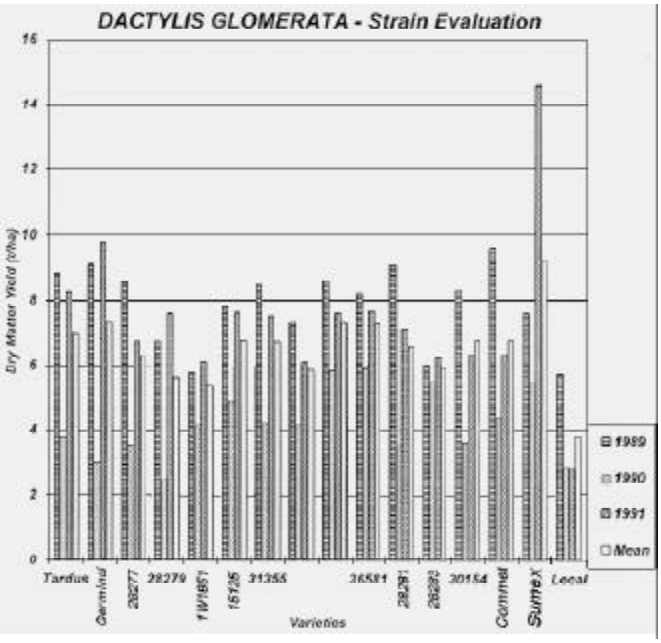


Figure 4
Phleum Pratense - Strain Evaluation

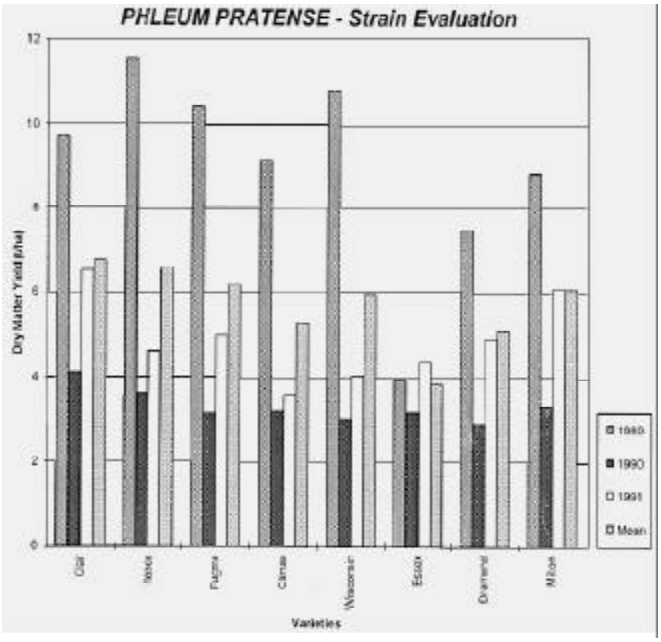


Figure 5
Medicago Sativa - Strain Evaluation