(32,000 cobs/ha), radish (128 q/ha), vegetable brassica (130 q/ha), spinach (40 q/ha) and pumpkin (182 q/ha) (45 cm × 45 cm columns, having pitcher within the columns). Crops were successfully grown under rainfed conditions with two–three additional irrigation as drought prevailed during entire September. Herein, 4000 jute bags were used in one hectare land.

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Grassland productivity during early winter in Ladakh, India

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Agro-pastoralism is the backbone for the sustenance of livelihood of people in semi-arid mountainous deserts of Ladakh, India. Livestock comprising sheep, goat, yak, donkey and horse, play an important role in human survival by providing fuel, transport, wool, milk, organic manure, meat and hide. Deficiency of fodder is the major constraint in livestock production system in this area; hence grassland vegetation available for grazing is important for livestock feeding and nutrition. The present study was aimed to evaluate grassland productivity in different villages of Leh, Ladakh. Productivity of grasslands in the study area ranged from 0.7 to 8.8 q/ha, reflecting low values and wide variability. Nutrient availability in grasses was poor, while fibre content was high. Supplementation of feed, fodder or concentrate ration is therefore essential to meet the nutritional requirements of the livestock largely dependent upon grazing in those grasslands.

Keywords: Agro-pastoralism, early winter, grassland productivity, livestock, nutrient availability.

TOPOGRAPHY of Ladakh, India is characterized by undulating terrain interspersed with rocky hills and elevation ranging from 4500 to 5880 MSL. In addition, due to the extreme cold, aridity, high radiation and strong winds, majority of Ladakh's landscape is more suitable for livestock husbandry than crop cultivation. Therefore, livestock husbandry is the main livelihood of Ladakh with the livestock population nearly 3.3 times the human population[1]. For centuries, agro-pastoralists in Ladakh have produced the finest pashmina wool apart from meat, dairy products and organic fertilizers.

Grazing resources are limited to areas along water bodies like reservoirs, rivulets and rivers. Grass cover along the river bank is the main food source available for livestock in the region. Due to low precipitation, plant productivity is very low[2]. The growing season is confined to short-duration species grown during June to August in summer, and vegetation is characterized by alpine steppe communities with medium to sparse cover (20%); the dominant gross species include *Carex* and *Stipa* grass species. Availability of grass cover has been found to be 40–70% deficient in cold arid regions[1]. Nevertheless, domesticated animals with the exception of donkeys and horses usually spend the summer grazing in high-elevation pastures and small grasslands. Therefore, estimation of grassland productivity and nutritional quality assessment of the available grasses could help evaluate sustainability of livestock in the Ladakh region.

Random samples of vegetation from the grazing areas in the villages of Thang (Sub-division Nubra, Block Turtuk), Hundar (Sub-division Nubra, Block Diskit), Suspol (Sub-division Likir, Block Saspol), Nimoo (Sub-division Likir, Block Nimoo), Likir (Sub-division Likir, Block Nimoo) and Yakma Chuchot (Sub-division Leh, Block Chuchot) in Leh district, Ladakh were collected during October 2019. In each village, 10 quadrants of 1 m each from different grassland sites used for livestock grazing, largely along the river bank or natural water channel side were selected. Samples of the grass cover were clipped 1 cm above the ground from area under the quadrant and stored in brown-paper envelopes. Thereafter, the samples were transported to the ICAR-National

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Table 1. Dry matter availability and nutrient content of grasslands in different villages of Ladakh, India

Parameters	Thang	Hundar	Suspol	Nimoo	Likir	Yakma Chuchot	SEM	*P*-value
Dry matter (q/ha)	7.065^{b}	0.694^{ef}	6.239^{bc}	8.759^{ab}	2.410^{e}	5.898^{bd}	0.061	0.000
Crude protein (kg)	40.1	4.2	38.7	62.2	14.5	32.9		
Nutrient content (%)								
Organic matter (%)	88.20	86.36	87.52	90.98	86.26	86.78	0.084	0.291
Ash (%)	11.80	13.64	12.48	9.02	13.74	13.22	0.084	0.291
Mineral concentration (%)	3.79^{e}	4.00^{de}	5.49^{a}	3.68^{ef}	4.73^{cd}	4.92^{abcd}	0.020	0.001
Crude protein (%)	5.68	6.01	6.21	7.10	6.02	5.58	0.031	0.555
Ether extract (%)	2.18	2.58	2.54	2.54	2.84	2.85	0.010	0.125
Crude fibre (%)	31.56^{bc}	36.01^{b}	29.16^{c}	37.28^{a}	25.20^{e}	31.78^{cd}	0.144	0.015
Nitrogen-free extract (%)	48.76^{b}	41.76^{a}	49.62^{c}	44.06^{ab}	52.21^{d}	46.57^{ab}	0.133	0.037
Fibre constituents (%)								
Neutral detergent fibre (%)	63.39	66.33	62.17	60.32	66.02	56.80	0.172	0.296
Acid detergent fibre (%)	48.94	48.46	53.32	51.52	47.63	48.11	0.130	0.541
Hemicellulose (%)	14.44^{ab}	17.88^{a}	8.87^{b}	8.81^{b}	18.41^{a}	8.70^{b}	0.126	0.001
Lignin (%)	1.66^{c}	5.15^{a}	3.92^{abc}	3.96^{abc}	2.84^{abc}	2.54^{b}	0.035	0.001
Cellulose (%)	47.26	43.32	49.40	47.57	44.77	45.55	0.134	0.606

Figures with different superscripts differ significantly at $P \leq 0.05$.

Research Centre on Camel, Bikaner, Rajasthan, India. Samples were oven-dried to record dry-matter availability, ground to pass through 1 mm sieve and analysed for proximate principles[3] and fibre constituents[4]. Data generated were analysed employing analysis of variance technique using SPSS software[5].

Maximum dry-matter availability of 8.759 q/ha was observed in Nimoo followed by 7.065 in Thang, 6.239 in Suspol, 5.898 in Yakma Chuchot, 2.410 in Likir and minimum of 0.694 q/ha in Hundar (Table 1). The grassland of Hundar village was dominated by bushes of seabuckthorn (*Hippophae rhamnoides*), which is primarily a browse species for Bactrian camel (*Camelus bactrianus*). In Africa, it was observed that increase in human and domestic livestock numbers is associated with increase in weed and wood shrub densities resulting in a decrease in grassland productivity[6]. In the present study, major livestock species, including yak, horse, pony, donkey and cattle along with Chanthangi goat were seen grazing in the pasture (Figure 1). Quality of grass cover was observed to differ from one village to another due to predominance of certain grasses in a particular village; this could affect the nutrients availability for livestock grazing in the area. Availability of crude protein was also observed to be higher in the grassland of Nimoo compared to Hundar, as observed for dry-matter availability. This may be due to better moisture conservation and predominance of grasses like *Setaria*, *Kobresia* and *Phragmites australis*, resulting in high leaf-to-stem ratio and thereby higher protein concentration. The peak standing biomass in sledge meadows has been estimated to be 857 kg/ha in Spiti region, Himachal Pradesh[7], which is located south of Ladakh. Dry-matter availability in the present study was high at all sites, except in Hundar; this could be due to predominance of bushes and thereby lower coverage of grasses over the ground.

Figure 1. Animals grazing in the grassland at the foothills of Ladakh, India.

Organic matter and ash content in the browse materials were observed to be similar among different villages. Mineral concentration was observed to be higher in village Suspol which could be due to lower fibre content and lesser drying up of the pasture, as in the case of other grasslands higher drying was recorded. Highest crude protein content was observed in grass cover of Nimoo and lowest in Yakma Chuchot and Thang. Protein content has been reported to decrease with increase in stem fraction and increase in plant maturity[8]. Decrease in protein content reflects the need to supplement concentrates or stored alfalfa roughage which is usually fed only to milch animals. Ether extract content was observed to have similar protein content among different villages, whereas crude fibre content was observed to be lower in herbage of Likir and highest in Hundar. This could be due to the difference in plant species growing in the grasslands, though overall values were high reflecting low palatability of these feed resources during late winter. Neutral detergent and acid detergent values were also reflective of the

fibrous nature of browse resources, as observed in most of the villages under study.

Differences in neutral detergent fibre and acid detergent fibre (ADF) contents and cellulose contents in the browse materials were not observed due to similar nature and hardiness of the collected grasses. However, higher content of ADF revealed that the plant materials were fibrous and hence less digestible for livestock. Grasses were hard to cut, reflecting their fibrous nature and thereby expected to have lower palatability for various livestock species. Differences in hemicellulose and lignin content were observed, which can be attributed to differences in the maturity of plant species in the grasslands. Domesticated species, especially yak, pashmina goat, pony and horse were found to sustain on these grasslands, reflecting their better fibre digesting ability. Under harsh climatic conditions, only those grasses survive which can cope with aridity, extreme diurnal temperature fluctuations, strong winds and abrasion, solifluction at higher altitudes and salinity at lower altitudes, nutrient-poor soils and a short growing season. Under such conditions, productivity is generally low and the vegetation is sparse[9]. Growing season is confined to a short period from June to August in summer, and alpine steppe communities with medium to sparse cover (20%) dominate the vegetation. Dominant grass species like *Carex* and *Stipa* have high fibre content. Cold deserts of the Himalaya have short-lived species, which provide cover for 2–3 months. Grazing resources comprise 14.2% of land in Leh and 16.8% in Kargil district, Ladakh. Lower productivity of grasslands could also be attributed to high grazing pressure during sample collection, as this study was conducted during early winter when the crop residues available in households or fields are minimal.

On the basis of the present study, it can be concluded that grasses in the Ladakh region have high fibre content with poor nutritional value for livestock. Productivity of grasslands differs from one area to another, perhaps due to variation in the natural terrain, soil texture and salinization of the land that also affect the nutritional composition of the grasses.

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Manoeuvring prospective rhizosphere-competent bacteria for invigorating growth in chickpea

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The exploration for beneficial rhizosphere-competent bacteria commenced with screening isolated strains for plant growth-promoting attributes, including secretion of indole-3-acetic acid, gibberellins, 1-aminocyclopropane-1-carboxylic acid deaminase, solubilization of phosphate and zinc. The secretion of flavonoid-like compounds revealed quantitative as well qualitative variability among the isolates as their culture supernatant exhibited several fluorescent compounds on TLC plates with different mobilities. Inoculation of seeds with effective isolates under axenic condition enhanced plant growth and induced flavanoids secretion from roots, although the effect was only quantitative. The prospective bioinoculants exhibited competence in lieu of intrinsic antibiotic resistance, amylase production, biofilm formation, root infectivity, salinity tolerance and exopolysaccharide production. Seed bacterization with potential isolates alone and in consortium with rhizobia stimulated growth of chickpea plants under controlled condition.

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