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EVALUATION OF HIGH YIELDING TEMPERATE PERENNIAL FORAGES FOR AUGMENTING FORAGE RESOURCES IN LADAKH (INDIA)

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ABSTRACT

The present study was conducted in a community pastureland of Spituk Monastery, Leh (Ladakh) from 2013 to 2015 to evaluate some temperate forage grasses/legumes and their mixtures grown in the interspaces of *Salix* plantation with a spacing of 4 m x 4 m. The experiment comprised of 13 treatments laid out in a randomized block design with each treatment replicated three times using a plot size of 12 m x 12 m. The results revealed that alfalfa had maximum value of sward height (62.5 cm), which was at par with treatment alfalfa grown in mixture with *Dactylis* + tall fescue + sainfoin. However, plant cover was maximum (75.6-85.6%) in mixture treatments as compared to sole grass or legume treatments (20.4-80.6%). Maximum green (9.87 t ha^{-1}) and dry fodder yield (2.68 t ha^{-1}) was observed in *Dactylis* + tall fescue + sainfoin + alfalfa treatment, which was at par with tall fescue + alfalfa treatment. The mean values for plant height, collar diameter, diameter at breast height, number of branches and leaf yield were 1.79 m, 21.2 mm, 16.1 mm, 5.32 and 66.72 dry matter kg ha^{-1}, respectively. The study suggests that tall fescue, *Dactylis*, red clover and sainfoin hold great promise as intercrop in *Salix*-based silvipastoral systems for augmenting the fodder needs in the region.

Keywords: Evaluation, grasses/legumes, Ladakh, *Salix*, silvipasture

INTRODUCTION

In cold arid Ladakh, there is hardly any scope for extending the area under cultivation. The limited land availability makes it further difficult for the farmers to allocate adequate land for fodder cultivation. However, there exists a great scope in the introduction of temperate perennial forage crops in forest plantations in the form of silvipastures and rehabilitation of pasture lands. Silvopasture establishment is one of the sustainable approaches to land-use management where both forage and tree crops combine into an integrated production system to get maximum benefits (Hamilton, 2008). Yield and quality of forage in such systems can be improved by introducing high yielding grass and legume species in appropriate mixtures. The management of these systems presents a crucial challenge regarding the selection of proper grass and legume species as well as the maintenance of optimum balance between the two species in a grass-legume stand. The resource base available with the farming community is limited in Ladakh, the cold arid region of North-Western Himalaya. The area has hardly any scope for extending the area under cultivation. The limited land endowments make it difficult for the farmers to earmark adequate land for fodder and forage cultivation. There is a great scope in introduction of fodder crops as inter-crop in forest plantations which has by and large remained untapped for fodder resource development. This can

be done by adopting silvopastoral systems (SPS), which allows the optimization of forestry and forage production in a compatible way. SPS are agroforestry arrangements that intentionally combine livestock production with rotational grazing using ideal combination of grasses, legumes and trees as a three-dimensional feed source for producing highly nutritious top fodder and forage, fuel wood, timber, and optimizing land productivity, conserving plants, soil and nutrients etc. on sustainable basis on the same unit of land (Yadav *et al.*, 2019). The utilization of these plantations can give a big boost to fodder development in the Trans-Himalayan region of Ladakh.

The Ladakh region has extensive low yielding grasslands which account for 5.76% of the total geographical area (Singh *et al.*, 2018). The area is characterized by very low annual precipitation (22-36 mm mainly in the form of snowfall for 7-8 months and followed by little rainfall for 4-5 months), large variation in diurnal temperature, high wind velocity during afternoon hours, tough and rugged terrain and very low humidity, <50% (Kachroo *et al*., 1977; Humbert-Droz and Dawa, 2004). Forage production potential could be increased by either pasture rehabilitation and rejuvenation or establishment of suitable silvopasture systems in marginal, submarginal and wastelands. The general aim of silvopastoral system is to maximize profitability from a given area of land using combinations of compatible trees and pastures (Peri *et al.*, 2007). Misri (1988) enlisted various important grasses in alpine pastures of Himalaya as *Agrostis*, *Agropyron, Dactylis, Elymus, Festuca, Lolium, Phalaris, Phleum* and *Stipa,* etc. and the major temperate legumes as *Astragalus, Lespedeza, Lotus, Medicago, Melilotus* and *Trifolium.* However, scanty information is available about the systematic studies on pasture production under silvipastoral systems in Ladakh. In view of above, the present study was aimed to evaluate several grasses/legumes and their combinations in a *Salix*-based silvopasture system for augmentation of forage resources.

MATERIALS AND METHODS

Study site

The study was conducted in a community pastureland owned by Spituk Monastery in Leh, Ladakh region. District Leh with an area of 45,100 km^2 makes it 2nd largest district in the country after Kutch, Gujarat. The area because of its climatic conditions is classified as cold arid. With a temperature range of -60 to +35°C; the area is subjected to both seasonal and diurnal fluctuation of temperature, which not only affects the plant growth and cropping but also the livelihood options. Annual precipitation is scanty and ranges between 80 to 100 mm; that too mostly in the form of snow during November to March (Wani *et al.*, 2014). Ladakh is situated in the extreme heights of Trans-Himalaya, which lies between 31°44´57" - 32°59´57" N latitude and76°46´29" - 78°41´34" E longitude. It covers an area of more than 65,000 km^2 in the two districts of namely Leh and Kargil. The area is famous for high mountains and glaciers. Topographically, it has very dusty, sandy and barren landscapes, which seem devoid of vegetation at first sight, but it is rich in valuable medicinal herbs, of which many are endemic. In winter, the area remains isolated for more than 6-7 months every year and temperature drop to 30-60°C in some valleys and mountainous locations.

Experimental design

A field experiment on performance of four grasses and five legumes was conducted in a community pastureland owned by Spituk Monastery Spituk, Leh during the period 2012-2015. Forage crops included were grasses: tall fescue (*Festuca arundinaceae*), Praire grass (*Bromus unioloides*), orchard grass (*Dactylis glomerata*) and timothy (*Phleum pratense*) and legumes: red clover (*Trifolium pratense*), sainfoin (*Onobrychisviciifolia*), yellow sweet clover (*Melilotus officinalis)* and alfalfa (*Medicago sativa).* Grass/legume combinations like tall fescue + alfalfa, *Dactylis* + alfalfa, tall fescue + yellow sweet clover, *Dactylis* + yellow sweet clover and orchard grass + tall fescue + alfalfa + sainfoin were also used. The experiment consisted of 13 treatments laid out in a

randomized block design with three replications using a plot size 12 m x 12 m. The sets of *Salix elegans*, procured from the forest department, were planted at a spacing of 4 m x 4 m, accommodating 625 plants ha^{-1}. Sets were planted 60-90 cm deep in crow bar made holes and carefully firmed up during planting. Sowing of the forages was done in the first fortnight of May, 2012. The study site was not previously cultivated. The major flora present in the area were forbs, including *Chenopodium glaucum*, sedges, low yielding grasses (*Poa* spp., *Agropyron* spp., *Bromus* spp., *Alopecurus* spp., *Avenafatua,* etc.) and shrubs like *Hippophae*, *Elaegnus, Ribes,* etc. The soil extended to a depth of 30-60 cm, with texture as sandy loam, average organic carbon content of 0.23-0.54%, alkaline pH (8.14-9.24) and EC of 0.84-0.93. The soils were low in available N, P and K. Uniform dose of N, P_2O_5 and K_2O (80, 40 and 30 kg ha^{-1}, respectively) was applied in May every year to all the treatments. Nitrogen was applied through urea in two split doses as 40 kg at basal and remaining 40 kg at just prior to flowering.

Evaluation of grasses/legumes and Salix

The data pertaining to various growth parameters in grasses/legumes and *Salix* was taken using the small plot observation trial as described by Tarawali *et al*. (1995). Plant cover was estimated as percentage of the ground covered by the species. Sward height was measured as the average height of forage crops in plots of 0.25 m^2 (0.5 m x 0.5 m). Data on growth traits of *Salix*, *viz.*, height of sets, collar diameter (10 cm from the ground), diameter at breast height (1.3 m from ground) and number of branches was taken in last week of September. Collar diameter and diameter at breast height measurements were taken using a digital vernier calliper. *Salix* leaf yield was estimated as dry matter in kg $tree^{-1}$ and multiplied by 625 (number of saplings ha^{-1}) to get dry matter in kg ha^{-1}. At the time of 50% heading of forage, each plot (1 m x 1 m) was harvested using hand sickle and intercrops were separated and weighed to have green forage weight. A 500 g sample of chopped forage was kept in an oven at 65°C till constant dry weight (Ram *et al*., 2006).

Statistical analysis

The pooled data was subjected to analysis of variance and LSD ($P \leq 0.05$) was used to compare means among various treatment combinations following Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The results revealed that tall fescue, *Dactylis,* sainfoin and red clover performed reasonably well under cold arid conditions of Ladakh (Table 1). However, the performance of timothy and Praire grass was not optimum. The mixtures of tall fescue and *Dactylis* with alfalfa, sweet clover and sainfoin performed even better in terms of forage yield. Alfalfa recorded maximum value of sward height (62.5 cm), which was at par when alfalfa was grown in mixture with *Dactylis*, tall fescue and sainfoin. However, plant cover percentage was maximum (75.6-85.6%) in mixture treatments as compared to sole grass or legume treatments (20.4-80.6%). Sward canopy cover can be a consequence of not only the competence of plants to acquire and utilize available resources, but also the ability to occupy limited space (Dong *et al*., 2005). Germination/emergence is a critical time in plant development to acquire space, with plants that emerge first in the field gaining a competitive advantage (Bond and Grundy, 2001). Maximum green (9.87 t ha^{-1}) and dry fodder yield (2.68 t ha^{-1}) was observed in *Dactylis* + tall fescue + sainfoin + alfalfa treatment, which was statistically at par with the treatment tall fescue + alfalfa. Mixtures have been reported to be superior to single grass or legume stands (Gokkus *et al*., 1999) due to utilization of symbiotically fixed nitrogen, more enhanced interception of light (Hay and Walker, 1989) and efficient utilization of space (Ahmad *et al*., 2018a). The average green and dry forage production in the pastures of Ladakh has been estimated as 8.84 and 2.35 t ha^{-1}, respectively (IGFRI, 2012). Tewari *et al*. (2016)

Table 1: Evaluation of grasses/legumes at Leh, Ladakh (pooled data, 2013-2015)

Treatments	Sward height (cm)	Plant cover (%)	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})
Orchard grass	55.2	60.5	8.36	2.26
Tall fescue	58.5	65.4	8.65	2.34
Praire grass	38.6	40.2	4.85	1.31
Timothy	27.8	30.5	3.24	0.87
Red clover	40.2	48.8	7.16	1.93
Sainfoin	55.6	68.2	7.86	2.12
Yellow sweet clover	44.4	66.8	6.56	1.77
Alfalfa	62.5	80.6	9.85	2.66
Tall fescue + alfalfa	56.4	85.5	9.76	2.64
Tall fescue + sweet clover	54.4	77.6	8.68	2.34
Orchard grass + alfalfa	61.5	82.4	9.45	2.55
Orchard grass + sweet clover	50.5	75.4	7.26	1.96
Orchard grass + tall fescue + alfalfa + sainfoin	61.6	85.6	9.87	2.68
S.E.m±	0.42	0.56	0.67	0.26
$CD_{0.05}$	1.29	1.73	2.02	0.55

have reported that the yield of alfalfa varies from place to place; however, on an average it produces 6.0-7.0 t green fodder (2-3 t dry fodder) with 12.5-23.9% crude protein and grain yield of 0.15-0.20 t ha^{-1}. However, the values of growth and yield parameters of all the forages were comparatively lesser in this Trans-Himalayan region as compared to the other temperate areas (Ahmad *et al.,* 2018a) because of the harsh climate, aridity, short growing season and less fertile soil conditions (Kachroo *et al.,* 1997; Raj and Sharma, 2013). Ahmad *et al.* (2018b) have also reported that cultivation of annual/perennial grasses and legumes that can prove remunerative in the Himalayan region include *Avena sativa*, *Medicago sativa*, *Dactylis glomerata, Festuca arundinacea, Phalaris aquatica, Phalaris tuberosa, Festuca rubra, Lolium perenne, Trifolium pratense, Onobrychis viciifolia,* etc.

The data pertaining to the effect of various forage intercrops and their combinations have been presented in Table 2. The data revealed non-significant variations in plant height, collar diameter, diameter at breast height, number of branches and leaf yield, with mean values of 1.79 m, 21.2 mm, 16.1 mm, 5.32 and 66.72 dry matter kg ha^{-1}, respectively. The lower values might be attributed to the establishment phase of the silvipasture system. Sharma, *et al*. (2017) observed 2.75 m and 15.66 mm, average height and collar diameter, respectively, of various willow clones. However, it is hypothesised that with the age of the system the growth and yield from *Salix* tends to increase and there shall be some positive effect of forage intercrops, especially legumes on the productivity of *Salix*. Willows have been lopped for firewood and fodder at intervals of 2-3 years in cold-arid deserts. The trees attain a height of 5 m in around 10 years (Dhiman, 2014).

The general aim of forage-based agroforestry systems is to maximize profitability from a given area of land using combinations of compatible forest/fruit trees and pastures. Perennial grasses and legumes grown in such systems ensure rapid ground cover not only to check soil erosion and conserve moisture, but also provide fodder for livestock (Peri *et al.*, 2007). However, further research is needed to evaluate these forages over longer periods using several agronomic interventions (optimum seeding rates, time and method of sowing/planting, nutrient, weed and cutting management, etc.) for enhanced forage yield and quality. Of the various tree species, *Salix* spp. represents majority of the total area under plantations in Ladakh, and is currently one of the most widely used afforestation trees in this region. However, plantation densities or number of trees ha^{-1} are often very high, the aim being to maximize wood production in terms of volume ha^{-1}. We advocate that these *Salix* based silvipastoral systems should be established at a spacing of 4 m x 4 m

Table 2: Effect of forage crops on growth characteristics of *Salix* (pooled data 2013-2015)

Treatments	Plant height (m)	Collar diameter (mm)	Diameter at breast height (mm)	No. of branches	*Salix*dry leaf yield (kg ha^{-1})
Orchard grass + *Salix*	1.82	19.4	15.5	5.5	67.5
Tall fescue + *Salix*	1.74	20.8	15.2	5.2	65.4
Praire grass + *Salix*	1.84	19.8	14.9	5.0	66.2
Timothy + *Salix*	1.65	20.2	15.1	5.2	67.4
Red clover + *Salix*	1.76	21.4	16.4	5.3	67.2
Sainfoin + *Salix*	1.68	22.1	16.2	5.1	66.4
Yellow sweet clover + *Salix*	1.92	21.2	15.4	5.6	66.8
Alfalfa + *Salix*	2.20	21.5	16.6	5.4	66.2
Tall fescue + alfalfa + *Salix*	1.92	20.4	15.4	5.3	65.9
Tall fescue + sweet clover + *Salix*	1.86	22.8	16.8	5.1	67.6
Orchard grass + alfalfa + *Salix*	1.68	21.8	16.5	5.5	67.8
Orchard grass + sweet clover + *Salix*	1.75	22.2	18.2	5.6	66.5
Orchard grass + tall fescue + alfalfa + sainfoin + *Salix*	1.82	22.4	16.6	5.4	66.4
Mean	1.79	21.2	16.1	5.32	66.72
S.E.m±	0.08	1.1	0.9	0.20	0.73
$CD_{0.05}$	ns	Ns	ns	ns	ns
CV (%)	4.47	4.96	5.75	3.69	1.10

so that forage crops could be grown easily in the interspaces for augmentation of fodder in the region.

Conclusions: High yielding temperate perennial grasses: *Festuca arundinaceae* (tall fescue), *Dactylis glomerata* (orchard grass), legumes: *Trifolium pretense* (red clover), *Onobrychis viciifolia* (sainfoin) and *Melilotus officinalis* (yellow sweet clover) and their mixtures hold a lot of promise and could be exploited for pasture rehabilitation and establishment of silvipastures in the cold arid region of Ladakh. However, long term multi-location testing and evaluation of these forages in agroforestry systems using location specific agronomic/silvicultural interventions should be carried out for increased productivity and adaptability.

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