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Performance of Deccani ram lambs grazed on stockpiled forage from established silvipasture

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Abstract

A long-term experiment was conducted to assess the performance of stocker ram lambs utilizing stockpiled foliage and forage from established *Leucaena leucocephala*- based silvopastoral system *vis-à-vis* natural pasture. The treatments were: (1) stockpiled foliage and forage in a *L. leucocephala* –based silvipasture (silvipasture) and (2) stockpiled forage in a natural grasslands (natural) consisting primarily *Sehima nervosum, Heteropogon contortus, Dichanthium annulatum and Chrysopogon fulvus.* Deccani ram lambs (36) were allowed to graze in both the treatment pastures from mid September to late March during 2006-09. Each treatment was replicated three times in a completely randomized design. Total forage production, nutrient contents and lambs average daily gain (ADG) was significantly (P<0.01) higher in silvipasture than natural pasture. Silvipasture system (4.11 t/ha) produced more (P<0.01) forage than the natural pasture (1.36 t/ha). When the foliage of *L. leucocephala* was excluded, the silvipasture system still produced higher (P<0.01) crude protein (CP) than natural pasture. Average daily gain (P<0.01) was 87.2 g for the ram lambs in the silvipasture and 59.1 g for the ram lambs in the natural pasture. Lambs weight gain per ha was greater (P<0.01) in the silvipasture than in the natural pasture (236 *vs.* 160 kg) over the grazing season. The study showed that the stockpiled foliage and forage from the silvopastoral system would meet the nutrient requirements of ram lambs even during drier months of the year.

Key words: Agroforestry, Animal nutrition, Growth performance, Ram lambs, Silvipastoral system, Small ruminants, Stockpiled forage

Abbreviations: ADF: Acid detergent fibre; **ADG:** Average daily gain**, ADL:** Acid detergent lignin**, BW:** Body weight**, CP:** Crude protein**, DM:** Dry matter**, NDF:** Neutral detergent fibre

Introduction

Rainfed agro-ecosystems have a distinct place in Indian agriculture, occupying 67% of the cultivated area, contributing 44% of the food grains and supporting 40% of the human and 65% of the livestock population (Venkateswarlu, 2005). Small ruminant (sheep and goat) production systems play a vital role in the sustenance of the livelihoods of rural poor in rainfed agro-ecosystems (Pasha, 2000). During lean periods, shepherds migrate along with their animals in search of fodder. This migration creates social conflicts with local people for available scarce forage resources. To arrest this kind of migration and also to provide quality forage to animals, the establishment of silvopastoral system is one of the best alternatives. Silvipasture systems have been studied, but not extensively for stockpiled forage intended for grazing during late winter (moderately drier months of the year) with *Leucaena leucocephala* in *Cenchrus ciliaris* and *Stylosanthes hamata*-based pasture systems. This study was conducted to determine how a mature silvopasture system compares to a traditional open pasture system in terms of the amount and quality of stockpiled forage available during late winter grazing for stocker lambs and their performance.

Materials and Methods

Experimental site: The experiment was conducted for 4 years (2005-2009) at the Hayatnagar Research Farm, Central Research Institute for Dryland Agriculture (17°27' N latitude and 78°35' E longitude and about 515 m above sea level), Hyderabad, in southern India. The climate is semi-arid with hot summers and mild winters. The mean maximum air temperature during summer (March, April and May) ranges from 35.6 to 38.6°C, whereas in winter (December, January and February) ranges from 13.5 to 16.8°C. Annual long-term rainfall for the site is 746.2 mm, falling predominantly from June to October. The soils are medium-textured, red soil (belong to the order Alfisol, great group- Typic Haplustalf and series Hayathnagar series as per USDA soil classification). The soil pH is neutral to slightly acidic.

Treatments: The treatments were (1) stockpiled foliage and forage in a *L. leucocephala*- based silvipasture (silvipasture) and (2) stockpiled forage in natural grasslands (natural). Each treatment was replicated three times in a completely randomized design. Each treatment utilized three, 0.4- ha pastures (2 treatments x 3 replications= 6 pastures).

Establishment of fodder trees and pastures in silvipasture: The *Leucaena leucocephala* seedlings were planted in rows (alleys) during the monsoon season 1990 and the gap filling was done during 1991 monsoon period. *L. leucocephala* was grown with an alley width of 5 m and within the hedgerows the distance between *L. leucocephala* plants was 2 m. During the initial 2 years (1990-91) pasture (*Cenchrus ciliaris* and *Stylosanthes hamata)* was established in alternate rows between the hedgerows of *L. leucocephala* and left as fallow except harvesting the pasture component in January every year from 1992. During the 2005 monsoon season, all the *L. leucocephala* trees were cut back to 0.5 m from the ground level in the month of May and the perennial *C. ciliaris* was again sown in 0.2 ha of each replication in 0.45 m rows at a seeding rate of 8 kg ha^{-1} and received 40 kg N + 20 kg $P_2O_5^{-1}$ ha. Similarly *S. hamata* was also sown in another 0.2 ha area of each replication (Fig 1) at a seeding rate of 4 kg ha^{-1} and received similar dose of P_2O_5 and half dose of nitrogen.

Management of pasture for stockpiling: From 2006 onwards, *L. leucocephala* trees were pruned to 0.5 m height from the ground each May to induce new shoots which were used as forage. All the pastures were mowed in early April each year to a height of 10 cm. Fertilizer (N + P_2O_5) was applied to all pasture plots including natural (40 kg N + 20 kg $P_2O_5^{-1}$ ha) at the onset of monsoon in late June or early July. All pastures both in Natural and Silvopasture treatments were allowed to grow until grazing began in September.

Grazing management: Prior to the study, all ram lambs (Deccani breed) were drenched for internal parasites and placed on a common pasture near the study area in early September. Lambs stayed on pasture for a week to allow acclimatization to stockpiled foliage and forage. Ram lambs were collectively penned on 15 September (± 2 days), fasted for 16 (± 1) h and then weighed. After measuring initial body weight, lambs were stratified by weight and randomly assigned to treatments. At the start of the experiment, lambs weighed an average of 13.9 0.17 kg with age 114 ± 5.2 days old. Lambs were weighed at fortnightly intervals. Eighteen lambs were assigned for each treatment (6 lambs per replication). Total pasture area in each replication was divided into four paddocks (0.1 ha). The paddocks were rotationally grazed for a period of 3 days throughout the experimental period (180 days) from the middle of September to late March in three consecutive years (2006-09). All animals were allowed to graze from 0800 to 1600 hrs. Mineral bricks were provided in the grazing area. Shelter near the experimental site was provided to all the animals during night time. Body weights of animals were recorded fortnightly for three consecutive times before allowing for grazing.

***Quantification of forage and fodder*:** Botanical composition of natural grassland was determined by the line intercept method (Cainfield, 1941), from 20, 5-m-long transects taken randomly. Five points at 1-m interval were read on each transect and species touching the line were added to the score. The plant composition was calculated from transect data. Forage production in the pasture and silvipastoral systems and natural grassland was estimated by determining within 1x1 m quadrates at monthly intervals. The quadrant were taken at 5 different (four corners and a central) locations in each paddock. Similarly forage production was estimated by pruning five *L. leucocephala* trees in a paddock 0.5 m height above ground level.

***Laboratory and statistical analysis*:** Forage samples (natural grasslands, *C. ciliaris* and *S. hamata*) and *L. leucocephala* foliage were collected at monthly intervals during each season. The samples were initially air-dried and then oven dried at 60 ± 5°C. Dried samples were ground to pass a 2 mm sieve in a Wiley Mill. They were analyzed for crude protein (CP), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) (AOAC, 1995). Data were subjected to analysis of variance according to the procedure described by Wilkinson *et al*. (1996).

Results and Discussion

***Forage composition, fodder availability and quality*:** Natural grassland was dominated by *Sehima nervosum* and co-dominated by *Heteropogon contortus, Dichanthium annulatum* and *Chrysopogon fulvus* and other grasses, legumes and forbs (Table 1). *Sehima-Dichanthium* is the most commonly dominated natural grassland species in peninsular India (Kushwah and Kumar, 2001). Mean forage (forage and foliage or forage only) availability (t ha^{-1}) was greater ($P<0.01$) in silvipasture (4.11± 0.11) than natural (1.36± 0.09). Average forage and foliage production from the silvipasture in the present study were a little higher than those reported by Rai *et al.* (2001) and could be due to favourable rainfall during the study period and also good management.

Table 1. Composition of natural pasture

Species	Composition (%)
Sehima nervosum	21.36
Heteropogon contortus	17.80
Dichanthium annulatum	7.22
Chrysopogon fulvus	6.08
Other grasses[a]	20.06
Legumes[b]	15.42
Forbs[c]	12.06

[a] *Iseilema laxum, I. Indicum, Themeda triandra, Setaria glauca, Aristida reducta, Panicum species* and *Eragrostis* species

[b] *Indigofera linifolia, Indigofera hirsuta, Indigofera cordifolia, Atylosia scarabaeoides, Cassia pimula, Phasedus* species, *Tephrosia* species

[c] *Boraria stricta, Lepidagothis trineris, Trichodesma* species, *Cyprus* species, *Cocorus* species, *Fimbristylis* species

The established forage contained medium (*C. ciliaris*) to high (*S. hamata*) CP and medium ADL, whereas the natural pasture contained medium CP and high ADL (Table 2). The lower ($P < 0.01$) pasture quality at the end of the experiment could be due to the changes as a result of maturity from the vegetative to reproductive stage (Gong *et al.*, 1996). These changes were more severe in natural than established pasture. Crude protein availability (t ha^{-1} on DM basis) was highest (Table 3) from silvipasture (0.68) compared to natural pasture (0.05). *L. leucocephala* is one of the potential leguminous tree in terms of nutritive value of pruned foliage for top forage production under silvipasture (Ramana *et al.,* 2000; Kanani *et al.,* 2006). When the foliage of *L. leucocephala* was excluded, the silvipasture treatment still produced higher ($P<0.01$) forage and crude protein than natural.

***Animal Productivity*:** Weight gain was significantly ($P<0.01$) higher in animals grazed in silvipasture (Table 4) than natural in all the years. Similarly, mean average daily gain (ADG) was also significantly ($P<0.01$) higher in ram lambs grazed in silvipasture. Low pasture quality impairs the productivity of ruminant livestock especially when grazing is the main feeding system (Devendra and Burns, 1983; Pamo *et al.*, 2001). Protein may be the limiting nutrient in many forages, particularly in the tropics, and protein availability declines in plant leaves as they mature. Obtaining adequate nitrogen-containing compounds is a greater constraint for animals than is obtaining energy-producing compounds when grazing. Throughout the experiment, body weight gained by the lambs in silvipasture was significantly higher ($P < 0.01$) than that gained by the lambs in natural pasture. Body weight changes of sheep and goats that foraged in tropical deciduous woodland would be positively correlated with their dietary CP levels and this could be the reason for higher weight gain in silvipasture lambs (Kronberg and Malechek, 1997). Differences in weight gain of lambs between the two groups (silvipasture and natural) were not significant during first 6 weeks of grazing (late rainy season), but weight gain became significantly ($P<0.01$) higher for the lambs in silvipasture as the dry season started in the middle of November. The lambs in silvipasture gained 134.5% more weight than those in natural during the dry season (December to March), while the difference in weight gain was only 2.7% in the late rainy season (October to November). A similar trend was observed in ADG of lambs. CP intake was probably more essential for growth requirements of the lambs and results in body weight changes (Kronberg and Malechek, 1997).

There was a difference between total weight gain per ha ($P<0.01$). Total weight gain per ha for lambs in the silvipasture was 236 kg, while the lambs in the natural pasture gained 160 kg. The reason for total gain per ha difference was due to the availability of quality feed (Table 3). Protein intake in the form of *S. hamata* and *L. leucocephala* fodder synchronized with roughage intake resulted in better nutrient availability for optimum rumen fermentation and microbial growth, which in turn improved intake and nutrient digestibility in animals grazed in silvopasture. Lower weight gain of lambs on natural pasture was the cumulative effect of low feed availability and digestible nutrient intake associated with inhibited microbial growth and fibrolysis. The DM and CP available from silvopasture components were little higher when compared to the other tropical grasses (FAO, 2000).

The study showed that the stockpiled foliage and forage from the silvopasture meets the nutrient requirements of ram lambs even during drier months of the year and fattening of ram lambs will be possible under rainfed conditions. Thus this system provides an option for livelihood improvement of small ruminant rearing communities. However, some initial support in the form of government policies may be needed for meeting the tree establishment related expenditure.

Table 2. Chemical composition of forage* at different intervals

Month	DM	CP	Ash	NDF	ADF	ADL
	g kg $^{-1}$ DM					
	Natural pasture					
September	309.9±0.68	52.5±0.73	57.5±1.00	717.1±0.57	511.3± 0.38	134.8±1.00
October	367.9±0.40	54.7±0.36	62.9±0.75	719.7±0.55	509.3± 0.56	135.8±0.75
November	413.5±0.40	52.9±0.51	68.4±0.67	718.9±0.40	513.4± 0.48	140.8±0.67
December	477.4±0.46	47.3±0.55	70.9±0.61	724.9±0.61	515.2± 0.78	142.3±0.61
January	545.2±0.54	42.7±0.54	78.3±0.73	723.4±0.76	521.1± 0.33	144.8±0.73
February	590.0±0.41	39.5±0.39	82.2±1.03	732.7±0.65	519.8± 0.41	156.0±0.92
March	644.5±0.50	34.8±0.37	87.6±0.68	733.2±0.51	520.4± 0.53	165.0±0.78
S. hamata	Silvopasture					
September	362.2±0.52	163.0±0.93	45.6±1.03	664.5±0.62	443.9±0.51	103.5±1.08
October	377.7±0.48	167.1±0.56	47.4±0.38	667.0±0.31	443.6±0.32	107.0±0.33
November	393.5±0.32	164.9±0.53	51.5±0.42	666.7±0.48	447.3±0.66	115.0±0.86
December	423.9±0.76	159.3±0.32	52.9±0.76	672.5±0.34	449.5±0.82	118.8±0.57
January	458.1±0.54	154.1±0.62	53.8±0.52	671.0±0.88	458.0±0.46	125.7±0.28
February	540.8±0.58	151.7±0.28	54.4±0.86	678.9±0.96	459.8±0.55	138.9±1.12
March	590.9±0.70	154.3±0.71	61.2±0.79	676.6±0.24	464.4±0.30	146.7±0.41
C. ciliaris						
September	355.2±0.39	69.2±0.46	64.6±1.01	718.3±0.55	466.9±0.38	102.2±1.01
October	363.1±0.44	68.8±0.39	66.7±0.63	720.5±0.35	468.0±0.49	106.4±0.63
November	398.0±0.58	65.1±0.64	67.4±1.06	719.4±0.36	470.6±0.29	109.5±1.06
December	433.6±0.43	59.4±0.36	71.0±0.60	723.0±0.34	469.5±0.78	114.6±0.60
January	471.1±0.32	54.1±0.76	74.3±0.70	723.4±0.33	472.6±0.33	117.3±0.70
February	526.8±0.41	56.1±0.59	77.4±0.86	727.1±0.66	470.1±0.70	122.6±0.98
March	600.5±0.42	59.5±0.53	86.2±0.44	726.6±0.32	471.8±0.42	131.2±0.44
L. leucocephala						
September	342.9±0.61	214.5±0.50	84.8±0.76	302.2±0.47	172.9±0.30	78.3±0.76
October	352.4±0.32	218.8±0.55	86.6±0.53	305.9±0.39	172.0±0.81	79.9±0.53
November	361.4±0.60	218.0±0.48	87.7±0.64	307.1±0.38	176.2±0.41	83.3±0.64
December	368.8±0.86	215.9±0.47	87.2±0.79	313.7±0.56	176.9±0.61	85.9±0.79
January	383.5±3.29	214.5±0.79	87.7±0.56	316.3±0.47	179.9±0.46	91.5±0.56
February	393.3±5.16	216.4±0.73	87.2±0.82	324.3±0.52	177.7±0.70	95.2±0.82
March	436.7±1.71	215.8±0.71	91.3±0.51	326.2±0.33	177.3±0.41	101.9±0.53

*mean of 9 values

Table 3: Average dry matter (DM) and crude protein (CP) yields from natural and silvipastoral systems

System	September	October	November	December	January	February	March
	DM (t ha^{-1})						
Natural pasture	1.36±0.09	1.32±0.03	1.25±0.03	1.16±0.03	1.11±0.04	1.02±0.02	0.86±0.05
Silvipasture	4.11±0.11	3.92±0.03	3.58±0.06	3.28±0.05	3.00±0.04	2.81±0.05	2.28±0.06
	CP (t ha^{-1})						
Natural pasture	0.05±0.00	0.05±0.00	0.04±0.00	0.04±0.00	0.04±0.00	0.03±0.00	0.03±0.00
Silvipasture	0.68±0.04	0.65±0.03	0.60±0.04	0.54±0.04	0.49±0.03	0.42±0.03	0.33±0.01

Table 4. Performance of Deccani ram lambs

Months	Live weight (kg)					
	2006		2007		2008	
	silvipasture	natural	silvipasture	natural	silvipasture	natural
September	13.9 ±0.11	13.9±0.13	13.9±0.14	13.9±0.12	13.9±0.15	13.9±0.13
October	16.5±0.19	16.3±0.21	16.4±0.10	16.2±0.17	16.6±0.11	16.4±0.17
November	19.3±0.16	18.9±0.14	19.4±0.13	18.8±0.22	19.5±0.16	19.0±0.20
December	22.6±0.17	20.7±0.17	22.4±0.08	20.8±0.13	22.5±0.10	20.6±0.12
January	24.8±0.13	22.2±0.11	24.9±0.09	22.3±0.10	25.0±0.13	22.2±0.15
February	28.3±0.16	23.8±0.12	28.4±0.17	23.6±0.11	28.5±0.18	24.1±0.11
March	29.7±0.09	24.4±0.07	29.5±0.10	24.3±0.08	29.6±0.09	24.9±0.09
	Weight gain (kg)					
	15.8±0.13	10.5±0.16	15.6±0.18	10.4±0.12	15.7±0.18	11.0±0.16
	Average daily gain (ADG) (g head^{-1})					
	87.8±5.06	58.3±4.95	86.7±5.12	57.8±6.22	87.2±5.86	61.1±6.35

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