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Hortipastoral systems for ram lamb production in rain fed areas

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ABSTRACT

Three on farm experiments – experiment 1 (E1, 130 days), experiment 2 (E2, 120 days) and experiment 3 (E3, 120 days) were carried to evaluate the performance of Nellore Zodpi ram lambs grazed in established hortipastoral systems (mango and sweet orange orchards of above 5 years old with natural and established pasture of C. ciliaris, S. hamata and with boundary plantation of L. leucocephala) in rainfed areas. The forage and crude protein (CP) yields (t ha^{-1}) were significantly ($P < 0.01$) higher from established pasture than natural pasture in orchards. The established pasture contained medium (C. ciliaris) to high (S. hamata) CP and medium in vitro dry matter degradability (IVDMD), where as the natural pasture contained low CP and medium IVDMD. The lambs with supplementary grazing on established pasture or supplemented with L. leucocephala foliage gained significantly ($P < 0.01$) higher live weight than grazed solely on natural pasture in all the experiments. Similarly higher ($P < 0.01$) average daily gain (ADG) was also observed with supplementary grazing. Income from ram lamb production under hortipastoral systems seems to be quite remunerative in all the experiments. Net gain (\$ ha^{-1}) from the hortipastoral systems ranged from 40.4 to 70.1 through ram lamb production. Further, higher income was observed with supplementary grazing on established pasture or supplementation of L. leucocephala foliage. The present study reveals that the orchards (mango and sweet orange) over 5 years old can be developed as hortipastoral systems with suitable understory grass species and boundary plantation of L leucocephala for higher biomass production. These systems can be efficiently integrated for ram lamb production in rainfed areas. Season plays a lot in availability of nutrients and subsequently the growth of the ram lambs under hortipastoral systems in rainfed areas, hence the lambs could be introduced preferably in the middle of rainy season (September month) for maximum weight gain.

Key words: Hortipastoral system, Ram lamb production, Average Daily Gain (ADG), Net gain and Rain fed areas.

INTRODUCTION

Rainfed agro-ecosystem has 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 [1]. The farming systems in rainfed areas are quite diverse with a variety of crops, cropping systems, horticulture, agroforestry and livestock production. Horticulture and small ruminant (sheep and goat) production systems play a vital role in sustenance of livelihoods of rural poor of rainfed agro-ecosystem [2] in arid and semi-arid regions, where crop production is a risk-prone enterprise due to uncertain rainfall and frequent draughts. In general, farmers develop orchards for fresh fruit production and not considered as grazing resources. However, small ruminants are primarily maintained on natural pasturelands/waste lands with *in situ* grazing and the productivity is constrained by the low quality of native grasses as well as the shortage of good quality forage, especially during the dry season. Hence, it is suggested to develop silvopastoral/hortipastoral systems/models by introducing pasture and foliage component under trees so as to provide nutritious green forage and foliage [3] to small ruminants for getting higher production from unit of land in rainfed areas. Hence, the present on farm study was undertaken to assess the suitability and profitability of hortipastoral systems for ram lambs production.

MATERIALS AND METHODS

Three on farm experiments – experiment 1 (E1, 130 days), experiment 2 (E2, 120 days) and experiment 3 (E3, 120 days) were carried at the hortipastoral systems (E1 and E2 in mango, where as E3 in sweet orange orchards above 5 years old) developed by the farmers in Rangareddy district (located in the central part of the Deccan Plateau and lies between 16° 30' and 18° 20' of North Latitude and 77° 30' and 79° 30' of East Longitudes with 781.5 mm mean annual rainfall) of Andhra Pradesh State in Southern India. Mineral bricks were provided in the grazing area. Sheltering was provided to all the animals during nighttime. Body weights of animals were recorded fortnightly for three consecutive days before allowing for grazing.

2.1 Establishment of fodder trees and pastures

The *Leucaena leucocephala* seedlings (100 no.) were planted in the monsoon as a boundary plantation in E1 and E2. The perennial *Stylosanthes hamata* was sown in the monsoon at a seeding rate of 4 kg ha^{-1} in E1 (3 ha), E2 (2 ha) and E3 (1 ha) and received 40 kg N + 20 kg P_2O_5 $^{-1}$ ha. The seeding rate of *Cencherus ciliaris* was 8 kg ha^{-1} by hand broadcast and fertilization consisted of 40 kg N + 20 kg P_2O_5 $^{-1}$ in E2 (2 ha) and E3 (1ha). Similarly a combination of alternative rows were established in E 3 (2 ha) with *S. hamata* + *C. ciliaris* and applied fertilizer (40 kg N + 20 kg P_2O_5 $^{-1}$). All the natural and established forage areas, the total pasture area was divided into two paddocks. The paddocks were rotationally grazed for a period of 15 days in all the experiments.

2.2. Animals and feeding

Nellore Zodpi growing ram lambs were chosen as experimental animals as these are the dominant breeds existing with the shepherd farming community in the study area and moreover this is the tallest sheep breed in India. Stocking rate was considered as 2 growing ram lambs per ha area based on the preliminary studies conducted on available herbage in orchards.

2.2.1. Experiment 1 (E1)

One year after establishment of the pastures in orchards, during the late monsoon season (September month), eighteen Nellore Zodpi ram lambs (98 ± 3.6 days old) with mean body weight 9.66 ± 0.15, previously drenched against internal parasites, were randomly divided into three comparable groups (G1, G2 and G3) by body weight (BW: mean ± S.E.= 9.64 ± 0.21, 9.63 ± 0.30 and 9.70 ± 0.35 kg) and introduced in the system. As a control traditional rearing system, the first group (Group G1) was allowed to graze on natural pasture available in the sweet orange orchard (total area of 9 ha) for 8 hrs. This was the rearing system of what exactly local shepherds do for small ruminants. The second group (Group G2) also remained with the G1 but once in the after noon they were separated and allowed to graze for 3 hrs on *S. hamata* established pasture (2 ha) in the orchard. Similarly after grazing on natural pasture the third group (Group G3) was fed separately in the evening with *L. leucocephala* foliage at the rate of 1kg/lamb.

2.2.2. Experiment 2 (E2)

Similarly, in the month of October, twenty four Nellore zodpi ram lambs (104 ± 2.8 days old) with mean body weight 9.69 ± 0.07 were randomly divided into four comparable groups (G1, G2, G3 and G4) by BW (9.76 ± 0.13, 9.74 ± 0.19, 9.62 ± 0.16 and 9.69 ± 0.16 kg). The first group (Group G1) was allowed to graze on natural pasture available in the mango plantations (total area of 12 ha) for 8 hrs as similar in E1. The second (Group G2) and third group (Group G3) also remained with the G1 but once in the after noon they were separated and allowed to graze for 3 hrs on *C. ciliaris* and *S. hamata* established pasture in the orchard (each 2 ha area), respectively. Similarly after grazing on natural pasture the fourth (Group G4) group was fed separately in the evening with *L. leucocephala* foliage at the rate of 1kg/lamb.

2.2.3. Experiment 3 (E3)

Twenty four Nellore zodpi ram lambs (102 ± 3.1 days old) with mean body weight 9.28 ± 0.05 kg, previously drenched against internal parasites, were randomly divided into four comparable groups (G1, G2, G3 and G4) by BW (9.21 ± 0.09, 9.35 ± 0.10, 9.24 ± 0.08 and 9.33 ± 0.13 kg, respectively) and introduced in the system in the month of October. The first group (Group G1) was allowed to graze on natural pasture available in the mango plantations (total area of 12 ha) for 8 hrs as similar in E1. The second (Group G2) and third group (Group G3) were also remained with the G1 but once in the after noon they were separated and allowed to graze for 3 hrs on *C. ciliaris* and *S. hamata* established pasture (each 1 ha area) in the orchard, respectively. Similarly after grazing on natural pasture the fourth group (Group G4) was also allowed to graze on *C. ciliaris* + *S. hamata* established pasture (1 ha) in the orchard, in the after noon for 3 hrs.

2.3 Quantification of forage and top fodder

Forage production (t ha^{-1}) from natural pasture and hortipastoral system was calculated by estimating the forage yield by following quadrate method (1 X 1 m area) on the day of initiation and at the end of the project. The quadrates were taken at 5 different (four corners and a central) locations in each paddock.

2.4. Economics calculation

An economical evaluation was also applied to the results in terms of possible prices of live weight and all possible expenses towards the establishment of pastoral system under the orchards in each experiment. Cost of the fertilizers was calculated based on the prevailing market rates ($ 1 and 2 $10kg^{-1}$, respectively for N and P_2O_5 fertilizer). Similarly seed ($ 1 kg^{-1} seed of either *S. hamata* or *C. ciliaris)* and *L. leucocephala* seedlings ($ 1/10 $seedling^{-1}$) cost was also calculated. Live weight cost was calculated as per the prevailing market rates ($ 2 kg^{-1} live weight). No labour expenses were considered in establishment of pasture assuming the same number of labour man days required for clearing the unwanted weeds from the orchards if animals were not allowed for grazing. Further, the farmer 's family members were taken care of grazing, hence no labour expenses were considered in economics calculation.

2.5. Laboratory and statistical analysis

The leafy samples (natural pasture, *C. ciliaris* and *S. hamata*) from each experiment were collected at day 1 and again at the end of the experiment, where as *L. leucocephala* foliage was collected once during the experiment. 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 organic matter (OM) and crude protein (CP) and ether extract (EE) [4] and cell wall constituents [5] and IVDMD [6]. Statistical analysis was carried out by Student *t*-test to compare the means of all the groups by SPSS version 12. The significant difference at $p<0.01$ was considered.

RESULTS

Experiment 1 (E 1)

The forage and protein yields (t ha^{-1}) were significantly ($P < 0.01$) higher from *S. hamata* established pasture than natural pasture. Irrespective of the period, the protein content in the *L. leucocephala* foliage was much higher than in the pasture. The lowest protein content was recorded in *natural pasture*. Although there was higher protein content during the start of experiment for all the forages, the difference was highly significant ($P < 0.01$) in *S. hamata*. NDF and ADF levels were higher in the pasture than in the *L. leucocephala* foliage. NFE was higher and IVDMD was lower ($P < 0.01$) in the natural pasture compared to the *S. hamata* pasture and *L. leucocephala* foliage. Weight gain and ADG were significantly ($P < 0.01$) higher in lambs with supplementary grazing on *S. hamata* (G 2) than other groups. Similarly, net gain ($\$^{-1}$) was significantly ($P < 0.01$) higher from G 2 and lower from G 1.

Experiment 2 (E 2)

The forage yields (t ha^{-1}) were comparable between the established pastures, however CP yield was significantly ($P < 0.01$) higher in *S. hamata*. Irrespective of the period, the protein content in the *L. leucocephala* foliage was much higher than the pasture. The lowest protein content was recorded in natural pasture. *L. leucocephala* foliage had (g kg^{-1}) lower NDF and ADF levels than in the pasture. Established pasture and foliage had lower NFE and higher IVDMD ($P < 0.01$). Weight gain and ADG were significantly ($P < 0.01$) higher in lambs with supplementary grazing. Similarly, net gain (\$ ha^{-1}) was significantly ($P < 0.01$) higher from G 3 followed by G 4, G2 and G 1 group lambs.

Experiment 3 (E 3)

Significantly ($P < 0.01$) higher forage yield (t ha^{-1}) was observed with alternate rows of *C. ciliaris* + *S. hamata* established pasture. Although forage yield was a little low, the protein yield (t ha^{-1}) was significantly higher from *S. hamata* established pasture than *C. ciliaris* + *S. hamata* established pasture. *S. hamata* forage had ($P < 0.01$) higher CP content (g kg^{-1}) and lower fibre fractions. Protein and NFE contents during the start of experiment for all the forages were higher and the differences were significant ($P < 0.05$) in both established and natural pastures where they were lower at the end of experiment. NDF and ADF levels were higher in the pasture than in the *L. leucocephala* foliage. IVDMD was lower ($P < 0.01$) in the natural pasture compared to the established pasture. Weight gain and ADG were comparable among the lambs with supplementary grazing on *C. ciliaris*, *S. hamata* and *C. ciliaris* + *S. hamata* pastures in the afternoon. Similarly, net gain ($ ha^{-1}) was also significantly higher from G 2, G 3 and G 4 compared to G1 group lambs.

Cost economics

Cost ($ ha^{-1}) of establishment (seed + fertilizer) of *S. hamata*, *C. ciliaris* and *S. hamata* +*C. ciliaris* pasture was 12, 16 and 14 respectively. Similarly cost ($ /experiment) of establishment of *L. leucocephala* seedlings was 10. Significantly higher income was observed with supplementary grazing on established pasture/foliage under orchards. Further, the net gain ($ ha^{-1}) was significantly higher in E 1 compare to the other experiments (E 2 and E 3).

DISCUSSION AND CONCLUSION

Pasture and CP yield

As evidenced in Table 1, herbage mass available in natural and established pastures were relatively optimum and sufficient throughout all the experiments and did not represent a limit to intake at pasture [7]. A partial exception is natural pasture in all the experiments, run during the last month (towards the end of winter) when pasture availability and growth are usually low. However, the natural pasture in all the experiments can be still regarded as sufficient for ram lambs considering the number of animals grazed per ha. Forage and CP yields were significantly ($P < 0.01$) higher from established pasture especially with leguminous than natural pasture. Higher CP production from established pastoral system vis-à-vis natural pasture has been reported [8]. The forage yields from natural pasture are relatively higher in the present experiment [9]. The lower ($P < 0.01$) pasture and CP yields at the end of experiment in all the experiments could be due to grazing effect in addition to the maturity of the pasture. In general, grazing had a negative effect on forage quality and biomass production [10].

Pasture and foliage quality and degradability

The established forage contained medium (*C. ciliaris*) to high (*S. hamata*) CP and medium IVDMD, where as the natural pasture contained low CP and medium IVDMD indicating the necessity of protein supplementation to the small ruminants grazing on natural pastoral lands for optimum growth in all the experiments. The *L. leucocephala* foliage contained high CP and IVDMD. Grass species had relatively lower forage quality [11]. Considering ICAR [12] the foliage and established forage from the hortipastoral systems meet the nutrient requirements of small ruminants for maintenance and production and protein is not a limiting nutrient for small ruminant production on such composite vegetation. 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 [13].

Lambs performance

The lambs with supplementary grazing on established pasture or supplemented with *L. leucocephala* foliage in addition to grazing on natural pasture, gained significantly ($P < 0.01$) higher live weight than grazed solely on natural pasture. This is because of availability of sufficient quality foliage and forage from the established pastures compared to natural under orchards and increased digestibility of the feed. Supplementation of plant protein sources, which contain medium to high CP levels [14] will alleviate CP deficiency of fibrous feeds, reduce feed retention time and improve feed intake [15]. Further, it has been reported [16] that CP intake was probably more essential for maintenance and production needs of the sheep. Significantly ($P < 0.01$) higher ADG was observed with supplementary grazing on *S. hamata* and *C. ciliaris* + *S. hamata* forage. This could be due to relatively high content of nitrogen and carbohydrate fractions featured by slow-rate of degradation of *S. hamata* forage. Relatively lower ADG observed in the lambs supplemented with *L. leucocephala* foliage than supplementary grazing on *S. hamata* forage although the former had higher CP. The *L. leucocephala* foliage contained phenolics (18.6 g kg^{-1} DM) and tannins (23.5 g kg^{-1} DM) [17] and these antinutritional factors [18] lower feed digestibility [19] and nutrient utilization in ruminants [20]. Further, reported [21] that domestic cattle and sheep (grazers and mixed feeders) may be more susceptible to tannins than browsing ruminants because browsing ruminants may have a higher N retention than grazers. Significantly ($P < 0.01$) higher ADG was observed in E 1 followed by E 2 and E 3. The differences in ADG among the experiments could be due to the differences in availability of pasture interms of quality as the experiments conducted in different periods. Low pasture quality impairs the productivity of ruminant livestock especially when grazing is the main feeding system [22]. Further, it could be due to decreased intake rate of forage for lambs with changing maturity from the vegetative to reproductive stage and that affects the availability of nutrients in forage [13]. Higher ADG in E 1 could be due to marked increase in availability of feed resources in rainy season [23] as the experiment initiated during the middle of rainy season (September month).

Table 3. Nutrient content and *invitro* DM degradability (IVDMD) of *L. leucocephala* foliage

Parameter (g kg^{-1} DM)	*L. leucocephala* foliage	
	E1	E2
OM	913.2	917.1
CP	216.2	215.8
EE	39.2	38.9
NDF	298.4	303.0
ADF	167.1	162.8
NFE	449.8	448.7
IVDMD	679.4	676.9

**Values are mean of six samples*

Table 4. Effect of supplementary grazing on weight gain (kg) and net gain ($) in experiments 1, 2 and 3 (E1, E2 and E3)

Particulars	E1			E2				E3			
	G1	G2	G3	G1	G2	G3	G4	G1	G2	G3	G4
Initial weight (kg)	9.6 ± 0.21	9.6 ± 0.30	9.7 ± 0.35	9.7 ± 0.13	9.7 ± 0.19	9.6 ± 0.16	9.6 ± 0.16	9.2 ± 0.09	9.3 ± 0.13	9.2 ± 0.08	9.3 ± 0.10
Final weight (kg)	22.3 ± 0.27	26.9 ± 0.29	24.2 ± 0.32	18.9 ± 0.37	21.2 ± 0.37	23.6 ± 0.423	22.0 ± 0.27	18.3 ± 0.35	21.0 ± 0.52	21.2 ± 0.39	21.4 ± 0.48
Weight gain/animal (kg)	12.7^c ± 0.30	17.3^a ± 0.39	14.5^b ± 0.44	9.2^c ± 0.40	11.5^b ± 0.44	14.0^a ± 0.34	12.4^b ± 0.35	9.1^b ± 0.40	11.7^a ± 0.55	12.0^a ± 0.34	12.1^a ± 0.41
ADG (g)	97.7^c ± 2.34	133.1^a ± 2.97	111.5^b ± 3.17	76.7^d ± 3.35	95.8^c ± 3.44	116.7^a ± 2.87	103.3^b ± 2.94	75.8^b ± 3.37	97.5^a ± 4.56	100.0^a ± 2.82	100.8^a ± 3.43
Additional cost /animal ($)*	-	3.4	2.9	-	3.4	4.6	2.9	-	3.0	4.0	3.5
Value of weight gain/animal ($)	28.2	38.4	32.2	20.4	25.6	31.1	27.6	20.2	26.0	26.7	26.9
Net gain/animal ($)	28.2	35.0	29.3	20.4	22.2	26.5	24.7	20.2	23.0	22.7	23.4
Net gain ha^{-1} ($)	56.4^c	70.1^a	58.6^b	40.9^d	44.3^c	53.0^a	49.3^b	40.4^b	46.0^a	45.3^a	46.8^a

** Expenditure towards establishment of supplementary grazing resources like cost of seed and fertilizer*
** Means with different superscripts in same parameter in a row in an experiment are differ significantly (P < 0.01)*

Table 1. Natural and established pasture yields (t DM ha^{-1}) in different hortipastoral systems

Parameter	E1		E2			E3			
	Natural pasture	*S. hamata*	Natural pasture	*S. hamata*	*C. ciliaris*	Natural pasture	*S. hamata*	*C. ciliaris*	*S. hamata + C. ciliaris*
	DM yield (t ha^{-1})								
D^{1}	$1.26^{a} \pm 0.08$	$3.21^{a} \pm 0.05$	$1.29^{a} \pm 0.11$	$3.30^{a} \pm 0.07$	$2.96^{a} \pm 0.06$	$1.36^{a} \pm 0.09$	$3.46^{a} \pm 0.09$	$3.02^{a} \pm 0.08$	$3.51^{a} \pm 0.05$
D^{e}	$0.91^{b} \pm 0.08$	$2.08^{b} \pm 0.07$	$0.84^{b} \pm 0.09$	$2.06^{b} \pm 0.11$	$2.18^{b} \pm 0.07$	$0.86^{b} \pm 0.05$	$1.94^{b} \pm 0.10$	$1.80^{b} \pm 0.07$	$2.32^{b} \pm 0.09$
	CP yield (t ha^{-1})								
D^{1}	$0.05^{a} \pm 0.00$	$0.55^{a} \pm 0.02$	$0.05^{a} \pm 0.00$	$0.56^{a} \pm 0.01$	$0.22^{a} \pm 0.01$	$0.05^{a} \pm 0.00$	$0.58^{a} \pm 0.02$	$0.22^{a} \pm 0.01$	$0.40^{a} \pm 0.01$
D^{e}	$0.03^{b} \pm 0.00$	$0.36^{b} \pm 0.01$	$0.03^{b} \pm 0.00$	$0.35^{b} \pm 0.01$	$0.16^{b} \pm 0.01$	$0.03^{b} \pm 0.00$	$0.32^{b} \pm 0.01$	$0.13^{b} \pm 0.01$	$0.27^{b} \pm 0.01$

D^{1} *= day 1 of the experiment*
D^{e} *= at the end of experiment*
** Means with different superscripts in same parameter in a column are differ significantly (P < 0.01)*

Table 2. Nutrient content and *invitro* DM degradability (IVDMD) of pasture

Parameter (g kg^{-1} DM)	Natural						*S. hamata*						*C. ciliaris*			
	E1		E2		E3		E1		E2		E3		E2		E3	
	d1	de	d1	de	d1	de	d1	de	d1	de	d1	de	d1	de	d1	de
OM	943.8	931.1	932.1	912.4	920.3	896.1	958.4	932.1	950.4	938.2	960.1	941.6	947.2	922.0	930.1	912.4
CP	36.4	34.3	35.4	33.9	35.1	30.1	172.2	151.0	169.8	155.4	162.4	150.7	72.8	57.6	73.4	58.4
EE	22.3	19.7	22.1	19.0	21.9	18.4	24.6	19.9	25.1	20.7	24.8	20.1	20.4	16.7	20.6	17.1
NDF	712.2	724.6	711.2	720.0	721.4	720.4	664.2	688.2	669.2	674.2	668.3	678.3	711.1	732.2	720.8	724.8
ADF	508.1	511.2	504.0	516.2	520.7	517.6	453.2	472.6	450.0	468.7	446.2	457.8	470.3	492.4	462.4	472.6
NFE	504.6	480.3	507.4	472.1	498.3	460.7	462.8	431.9	453.7	435.1	460.1	437.9	510.7	474.1	499.8	481.2
IVDMD	454.7	431.2	457.9	426.5	449.8	420.7	543.1	509.2	544.3	514.8	538.7	511.7	501.4	470.3	512.4	482.2

**Values are mean of twelve samples*
^{d1}day 1 of the experiment; ^{de} at the end of experiment

Income
Income from ram lamb production under hortipastoral systems seems to be quite remunerative in all the experiments. Further, higher net gain ($ ha^{-1}) with supplementary grazing on established pasture or supplementation of *L leucocephala* foliage from orchards could be due to faster growth rate and higher ADG as the nutrients availability may not be a problem.

The present study reveals that orchards (mango and sweet orange) over 5 years old can be developed as hortipastoral systems with suitable understory grass species and boundary plantation of *L leucocephala* for higher biomass and subsequently higher income through ram lamb production. Season plays a lot in availability of nutrients and subsequently the growth of the ram lambs under hortipastoral systems, hence the lambs could be introduced preferably in the middle of rainy season (September month) for maximum ADG in rainfed areas.

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