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Evaluation of Crop – livestock silvipastoral farming system for dryland farmers of Western zone of Tamil Nadu

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Abstract
In a small scale resource-poor farm, modest addition in productivity is no longer sufficient to justify the production enterprise of limited resources. Integrated farming systems with different enterprises pave the way for realizing increased productivity, profitability and sustainability in small farms. Based on this, on farm field experiments were conducted in three farmer's fields at dryland tracts of Tirupur district for a period of two years to evaluate sustainable silvipastoral farming system. Treatments were five silvipastoral systems *viz., Acacia leucophloea* + *Cenchrus ciliaris, Acacia leucophloea* + *Cenchrus ciliaris* + *Stylosanthes hamata, Acacia leucophloea* + *Cenchrus setigerus* + *Stylosanthes hamata, Acacia leucophloea* + fodder sorghum + *Pillipesara* and *Acacia leucophloea* + *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara.* One unit of Mecheri sheep of five ewes and one ram and two buffaloes were maintained in each location. Observations on system productivity, profitability, employment and energy budgeting were assessed. *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* system with sheep and buffalo components resulted in higher system productivity of 67660 kg as *Cenchrus* equivalent yield with higher net return of Rs. 32485/ha/year and benefit cost ratio of 2.58. Similarly, the same system gave higher employment and output energy (261900 MJ) with an energy efficiency of 49.9 per cent.

Keywords: Silvipastoral farming system, dryland, energy budgeting, system productivity, physical indicators

Introduction
An ever-increasing population put forths enormous demands on land resources. This is particularly acute in India, which has only 2.4 per cent of the world's geographical area but supports over 16 per cent of the world's population. Availability of quality fodder to the animals is the major impediment in scientific management of animals because India, having only 2.4% of the world's geographical area sustains 11% of the world's livestock population. It accounts for 55% of the world's buffalo population, 20% of the goat population and 16% of the cattle population. This has put unbearable burden on our natural vegetation (Nithya, 2020) [8]. The grazing activity is mainly dependent on the availability of the grazing resources from pastures and other grazing lands viz. forests, miscellaneous tree crops and groves, cultivable wastelands and fallow land. Such lands are about 40% of the total geographical area of the country. Vast area in the country (about 157 million ha) is classified under various types of degraded land where one or more limiting factors render the cultivation of crops economically unviable. The grazing intensity in the country is as high as 12.6 adult cattle units (ACU)/ha as against 0.8 ACU/ha in developed countries (Sankaran, 2020) [12]. Small ruminant farming heavily depends on traditional feeding methods including most common grazing lands (Ramana *et al.,* 2000) [10].
Area under permanent pastures and grazing lands comprises a mere 3.3% of the total area, and has been declining steadily. The forest cover is to the tune of 21.54% of which more than 85% are protected and these lands used to be a major grazing area for livestock rearing communities (Roy *et al.,* 2019) [11]. Sheep and goat keeping is an important livelihood activity for a large

proportion of India's rural poor. Statistics revealed that in India 71 per cent of cattle, 63 per cent of buffaloes, 66 per cent of small ruminants, 70 per cent of pigs and 74 per cent of poultry are owned by resource-poor small, marginal farmers and landless labourers (Saravana Kumar and Sivakumar, 2011) [13]. Silvipasture is a system of integrating trees/shrubs with pasture has promise as an efficient system for higher and sustained availability of forage production and other secondary products like firewood, minor timber etc. Complementarity between tree and grass species grown in association is essential for the establishment and sustainability of silvipastoral systems on degraded marginal lands. Perennial grasses grown in such systems ensure rapid ground cover to check soil erosion and conserve moisture, besides providing fodder or industrial raw material for meeting the livelihood requirements of resource poor farmers (Kenneth J. Moore *et al.,* 2015) [6].

In Tamil Nadu, area under permanent pastures and other grazing land is 0.11 lakh ha and fodder crops raised under dry land condition covers an area of 1.57 lakh ha (Velayudham, 2011) [16]. Among the 32 districts of Tamil Nadu, Tirupur, Namakal and Salem occupy 72.5 per cent of pasture area and hence considered as pasture hub of Tamil Nadu. Small ruminants are primarily maintained on natural pasturelands with *insitu* 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. Silvipasture is another traditional land use system used for grazing livestock. Existing silvipastoral system is not able to provide nutritious and off-season fodder to animals. In this context, the study was taken to evaluate the improved silvipastoral farming system under dry land eco-system of Tamil Nadu.

Materials and Methods

A two-year on-farm field experiment was conducted to assess the performance of improved silvipastoral farming system under dryland tracts of Tamil Nadu.

Field location

Based on the survey, three farmers were selected for carrying out the field experiment. The experiments were conducted in farmer's field at Kilankattuvalasu, Kangeyam (location I), Pulliampatti, Mulanur (location II) and Kambaliampatti, Mulanur (location III) villages in Tiruppur district. The farms are situated at 11^o North latitude and 77^o East longitude and at an altitude of 427 m above the MSL. The normal climatic conditions of Tiruppur district (mean of 50 years) receives a mean annual rainfall of 650 mm in 37.5 rainy days, of which the Winter, Summer, South West and North East Monsoon records 16.09, 106.93, 267.19 and 259.56 mm respectively. The annual mean maximum temperature various from 30^0 to 38^0 C, while the mean minimum temperature varies from 19^0 C to 26^0 C. The district receives maximum amount of rain during the North East Monsoon followed by South West Monsoon (June - September).

Treatment details

Treatments consisted of five different silvipastoral farming systems viz., *Acacia leucophloea* + *Cenchrus ciliaris* (SFS_1), *Acacia leucophloea* + *Cenchrus ciliaris* + *Stylosanthes* (SFS_2), *Acacia leucophloea* + *Cenchrus setigerus* + *Stylosanthes hamata* (SFS_3), *Acacia leucophloea* + fodder sorghum + *Pillipesara*(SFS_4) *and Acacia leucophloea* + *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara*(SFS_5) each in 0.20 ha area. Six Mecheri sheep (5 ewes + 1 ram) and two buffaloes of local breed formed the animal component in the farming system experiment.

Sheep and Buffalo productivity and economics

The growth rate was recorded at monthly interval and expressed in kg/ month. The productivity of sheep was accounted by sale of lambs. Live body weight gain of sheep was observed in different silvipastoral system. The body weight of the sheep was recorded at the beginning of the experiment and once in a month throughout the year.

The buffalo milk yield was recorded daily in litres /day and expressed as litres/ month.

System analysis

The results on the physical indicators *viz.,* system productivity, profitability, employment and energy budgeting were presented as mean over three locations.

Productivity in terms of green and dry fodder equivalent yields of fodder crops were recorded and expressed as t/ ha. Economic Parameters like cost of cultivation, gross return, net return and benefit cost ratio were worked out and expressed in Rs/ha. The cost of sheep was included in the total cost during first year. Gross return was calculated based on the productivity of sheep, buffalo and manure. Net return was calculated by deducting the cost of cultivation from gross return. Benefit cost ratio was worked out for each treatment by dividing the gross return by cost of cultivation.

Number of labourers engaged per operation for different activities were recorded and given in man days/ha/year. Energy budgeting was done in terms of total energy input and total energy output for each component and combined for the silvipastoral farming system as a whole. Cultural energy utilized through inputs and energy produced as products by each crop were worked out and expressed in MJ. Energy efficiency was worked out taking into account the input and output energy for each treatment adopting the method given by Dazhong and Pimetal (1984) [1].

Results and Discussion

Evaluation of silvipastoral farming system

In an area of one hectare, highest system productivity of 73,500 kg and 61,820 kg was registered in *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *pillipesara* along with sheep (5+1) and buffalo (2 No.'s) during first year and second year, respectively. Among the different components, forage crops included in the silvipastoral farming system is the base activity. Contribution of forage crops to the total productivity was higher (25.5 per cent) during 2010-11 whereas the contribution to the total productivity was less (18.2 per cent) during first year in *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara.* The reason attributed to the decreased productivity during first year may be due to lower rainfall. Though there was decreased productivity of crops, it was well compensated by the inclusion of sheep and buffalo, the system productivity was increased during first year than second year, due to the increased contribution from the buffalo unit (Table 1). Among the silvipastoral farming systems, highest productivity of forage crops was recorded in *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* due to the inclusion of legume crop along with grass and cereal in the system might have contributed for increased fodder yield. This was in line with the findings of Esther Shekinah (2002) [3].

A unit comprising of six sheep were maintained in the silvipastoral farming system. The contribution of the sheep to the silvipastoral farming system in terms of productivity and profitability was found to increase over years. Productivity of sheep was higher during second year, as a result of increased number of lambs. The improved silvipastoral farming system with *Cenchrus setigerus, Stylosanthes hamata,* fodder sorghum and *Pillipesara* had visible advantage over sole sorghum in supplying green and dry fodder for sheep. This might have supplied sufficient nutritional requirement for sheep which in turn reflected on the productivity of sheep. During summer, sheep were managed with preserved hay from sorghum. Mishra *et al.* (1997) [7] reported that comparative nutrient utilization pattern in sheep concluded that *cenchrus* based diets can be fed to sheeps for maintenance. During off season, *Acacia* pods were used as feed along with sorghum hay for sheep and buffalo. Average of 5 kg of dried *Acacia* pods tree^{-1} was obtained from *Acacia* trees every year. This might have supplied nutrient rich fodder to the livestock components during off season which in turn was reflected in system productivity (Hart, 1987) [5].

Higher net return (Rs. 32,485) was recorded in *Cenchrus setigerus* + *Stylosanthes hamata* & Fodder sorghum + *Pillipesara* with sheep and buffalo. Higher productivity from diversified crops and milk yield from buffalo could contribute to increased net return in the above silvipastoral farming system. Further sheep component had given higher productivity by utilizing the grazing land for feeding and thereby it reduced the cost incurred on feed and fodder. Higher benefit cost ratio of 2.58 was recorded in *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* with sheep and buffalo and this system was found to be the best income generating silvipastoral farming system (Table 2). The profitability of the buffalo enterprise in integrated farming system had been earlier reported by Esther Shekinah (2002) [3]. It is in conformity with the experimental results of Sivasankaran *et al.* (1995) [14] and Vairavan *et al.* (2000) [15] who have recorded higher productivity with increased economic contribution in dry land silvipastoral farming system. Higher gross return was obtained during first year owing to an increased live weight of sheep and by the sale of buffalo milk. Thus, crop-livestock compatibility would, therefore, influence the productivity and sustainability of integrated farming systems.

Silvipastoral farming system with integration of livestock components provided higher employment opportunity for family labour. *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* with sheep and buffalo system gave higher labour employment. Sheep component generated employment of 57 and 41 man days/ ha/ year during first year and second year, respectively, whereas buffalo component generated employment opportunity of 137 and 79 man days/ ha/ year during first year and second year, respectively (Table 3). Livestock components created employment of 0.5 man day throughout the year, which can be effectively met with the available family labour. Such higher employment generation was reported in dry land integrated farming system earlier by Radhamani (2001) [9]. The generation of employment further makes the buffalo unit a positive linkage in silvipastoral farming system. Buffalo rearing provided assured, constant income on the day one itself and provided nutritional security to the family members. Family members contributed substantially for rearing the livestock components (Esther Shekinah *et al*., 2005).

Cenchrus setigerus + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* with sheep and buffalo resulted in higher energy output of 261900 MJ with an energy efficiency of 49.9 per cent indicating the advantages of linked components. The energy value of milk and meat was 4.90 and 4.94 MJ as against 18 MJ for forage crops. In *Cenchrus setigerus* + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* system energy was effectively utilized as compared to other systems (Table 4). Energy analysis made by Han *et al.* (1985) [4] in China indicated the merit of animal crop integration in increasing the energy output and energy use efficiency.

Integration of sheep and buffalo, *Acacia leucophloea* tree + fodder crops as component in the silvipastoral farming system would enhance the productivity, income of the farm, employment of family labour and energy use efficicncy.

Table 1: Productivity (*Cenchrus* equivalent) of silvipastoral farming system

Silvipastoral farming system	Component productivity (kg)							
	First year				Second year			
	Forage	Sheep	Buffalo	System productivity (kg)	Forage	Sheep	Buffalo	System productivity (kg)
SFS_1	4510	6000	54140	64650	5190	9000	37080	51270
SFS_2	6830	6000	54140	66970	8410	9000	37080	54490
SFS_3	5910	6000	54140	66050	6990	9000	37080	53070
SFS_4	11510	6000	54140	71650	13350	9000	37080	59430
SFS_5	13360	6000	54140	73500	15740	9000	37080	61820

Table 2: Economic analysis of silvipastoral farming system

Silvipastoral farming system	Economics							
	First year				Second year			
	Total cost (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio	Total cost (Rs/ha)	Gross return (Rs/ha)	Net return ((Rs/ha)	B:C ratio
SFS_1	27807	60140	32333	2.16	13965	46080	32115	3.30
SFS_2	27637	60140	32503	2.18	13850	46080	32230	3.33
SFS_3	27637	60140	32503	2.18	13850	46080	32230	3.33
SFS_4	27970	60140	32170	2.15	14083	46080	31997	3.27
SFS_5	27520	60140	32620	2.19	13730	46080	32350	3.36

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Table 3: Employment generation (man days) of silvipastoral farming system

Silvipastoral farming system	Employment generation (man days)							
	First year				Second year			
	Forage	Sheep	Buffalo	System total (man days)	Forage	Sheep	Buffalo	System total (man days)
SFS_1	11	57	137	205	7	41	79	127
SFS_2	12	57	137	206	8	41	79	128
SFS_3	12	57	137	206	8	41	79	128
SFS_4	13	57	137	207	9	41	79	129
SFS_5	14	57	137	208	9	41	79	129

Table 4: Energy budgeting in silvipastoral farming system

Silvipastoral farming system	Energy budgeting (MJ ha^{-1})					
	First year			Second year		
	Total input energy	Total energy output	Energy efficiency	Total input energy	Total energy output	Energy efficiency
SFS_1	5293	81180	15.3	4418	93420	21.1
SFS_2	5377	122940	22.9	4502	151380	33.6
SFS_3	5377	106380	19.8	4502	125820	27.9
SFS_4	5872	207180	35.3	4997	240300	48.1
SFS_5	5690	240480	42.3	4814	283320	58.8

Conclusion

Cenchrus setigerus + *Stylosanthes hamata* & fodder sorghum + *Pillipesara* system with sheep (5+1) and buffalo (2 No.'s) was promising, which generated the highest system productivity of 67660 kg of *Cenchrus* equivalent yield with net return of 32485 /ha/ year and benefit cost ratio of 2.58 with an employment opportunity of 169 man days/ ha/ year. Integration of sheep and buffalo, *Acacia leucophloea* tree + fodder cops as component in the silvipastoral farming system would enhance the productivity, income of the farm, employment of family labour and energy use efficiency.

Conflict of Interest: Not available

Financial Support: Not available

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