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Assessment of Biological Efficiency of Silvipasture Systems

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Field trials were conducted in agroforestry system involving multipurpose tree species and fodder crops to assess the biomass production in *Acacia leucopholea* , *Ailanthus excelsa* , *Tectona grandis* , *Gmelina arborea, Erythrina indica, Pongamia glabra and Thespesia populenea* based silvipasture system . The results revealed that *A. leucopholea* + *Cenchrus Ciliaris* gave the highest LER of 1.13. Under 15 years old *A. excelsa* plantations, fodder cow pea recorded the highest fodder *yield of 7.08 t ha-1 with LER value of 0.84. Desmanthus virgatus* was found to be a compatible fodder crop for teak plantations of 10 years old and guinea grass recorded the highest green fodder yield of 3.91 t ha-1under pungam based silvipasture system. In all the silvipastoral systems, irrespective of the tree component, grass fodder recorded the highest RYT followed by legume fodder.

Key words: Silvipasture, Fodder yield, Land Equivalent Ratio, Relative yield total.

Contribution of agriculture sector to national GDP is around 25 per cent and the share of livestock in agricultural GDP is around 23 per cent. In India pastures have beeb reduced from about 70 m ha in 1947 to 11 m ha in 2014 . The remaining grazing lands have either been already degraded or in the process of degradation with an average carrying capacity of <1 ACU (adult cattle unit) (GOI, 2011). Silvipastoral system has even been recognized as a low input technique for the utilization of marginal, sub-marginal and wastelands. In fact, silvipasture as an agroforestry practice is specifically designed and managed for the production of trees, tree products, forage and livestock in semi-arid and arid regions (Klopfenstein *et al.,* 2008). The sustainable productivity of trees and crops in such system depends upon their relative ability to tap the available resources such as light, water, and nutrients, which in turn interact to suboptimal levels of these resources (Conner, 1983). Under storey pasture production, normally depends on the degree of competition between trees and pasture for light, moisture and nutrients (Dodd *et al.*2005). Land equivalent ratio (LER) provides an accurate assessment of the competitive relationship between the components; the best usage of land as well as the overall productivity of the system. An intercrop association could be economically advantageous if Relative Crop Yield Total (RYT) was greater than 100 (Wahua and Miller , 1978). Rehabilitation and productivity enhancement of silvipastoral practices of integrating trees with grasses and fodder crops is the most appropriate approach to improve the fodder production. Experiments were conducted to study the productivity of various silvipastoral systems to explore the sustainablility for enhancing the fodder productivity.

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Materials and Methods

The data base on green fodder yield obtained from the various field trials conducted in the existing plantations of tree species at Forest College and Research Institute, Mettupalayam (Lat. 77.56'E ; Lon. 11.19'N ; Mean Annual Rainfall : 830 mm) were collected.

Tree species	Age of plantation	Under storey fodder crops		
		Grass fodder	Cereal fodder	Legume fodder
Acacia leucopholea	15	Cenchrus ciliaris Cenchrus setegerus Cenchrus glaucus	Fodder sorghum	Stylosanthes hamata Desmanthus virgatus Lucerene
Ailanthus excels	15		Fodder sorghum	Fodder cowpea Stylosanthes hamata Desmanthus virgatus
Tectona grandis	10		Fodder sorghum Fodder maize Fodder cumbu	Fodder cowpea Desmanthus virgatus
Gmelina arborea	10	Cenchrus glaucus Bracharia mutica Cumbu Napier Guinea grass		Desmanthus virgatus
Erythrina indica	1	Cumbu Napier Cenchrus ciliaris Guinea grass		Stylosanthes hamata Desmanthus virgatus
Pongamia glabra	6	Cenchrus glaucus Guinea grass	Fodder sorghum	Desmanthus virgatus Stylosanthes hamata Lucerene
Thespesia populenea	1	Thespesia populenea		Desmanthus virgatus Stylosanthes hamata

With the fodder yield data base of these silvipasture systems, LER (Willey, 1979) and RYT (Willey , 1990) were computed.

Results and Discussion

Acacia based silvipasture system

In this silvipasture system, *Cenchrus* spp. recorded the highest LER varied from 1.10 to 1.13. Cereal fodder recorded LER value of 0.34, while the LER values of leguminous fodder ranged from 0.36 to 0.54 (Table 1). *A. leucopholea*+ C. ciliaris gave the highest LER of 1.13 implying the best usage of land as well as the overall productivity of the intercrop system. LER increased due to efficient use of resources (Tahir et al., 2003., Banik et al., 2006). Grass fodder recorded significantly higher yields (5625-6625 kg (ha^{-1}) than cereal and legume fodders.

Table 1. Green fodder yield and LER of Acacia based silvipasture system

Fodder crops	Green fodder yield kg ha^{-1}		LER
	Intercropping	Pure cropping	
Grasses			
C.ciliaris	5625	5000	1.13
C. setegerus	5875	5250	1.12
C. glaucus	6625	6000	1.10
Cereals			
Fodder sorghum	2063	6000	0.34
Legumes			
S. hamata	2313	6500	0.36
D.virgatus	1875	3500	0.54
Lucerne	625	1500	0.42
CD (P=0.05)	196		

Ailanthus based silvipasture system

Under 15 y old *A. excelsa* plantations, fodder cow pea recorded the highest fodder yield of 7.08 t ha^{-1} with LER value of 0.84. The LER value ranged from 0.60 to 0.84 (Table 2). *D.virgatus* recorded the lowest green fodder yield indicating the succeptibility of this crop for shade effect under intercropping system.

Table 2. Green fodder yield and LER of Ailanthus based silvipasture system

Fodder crops	Green fodder yield t ha^{-1}		LER
	Intercropping	Pure cropping	
Cereals			
Fodder sorghum	6.36	9.33	0.68
Legumes			
Fodder cow pea	7.08	8.38	0.84
S. hamata	3.02	4.61	0.66
D. virgatus	0.68	1.14	0.60
CD (P=0.05)	0.41		

Teak based silvipasture system

D. virgatus recorded the highest green fodder yield with a LER value of 1.00 (Table 3). Under teak plantations of 10 y old , *D. virgatus* was found to be a compatible fodder crop. In this system, LER value ranged from 0.50 to 1.00. Green biomass yield of fodder cowpea was significantly higher (29.37 t ha^{-1}) than cereal fodder.

Table 3. Green fodder yield and LER of teak based silvipasture system

Fodder crops	Green fodder yield t ha^{-1}		LER
	Intercropping	Pure cropping	
Cereals			
Fodder sorghum	23.43	32.15	0.73
Fodder maize	20.21	40.27	0.50
Fodder cumbu	22.54	30.32	0.74
Legumes			
Fodder cow pea	29.37	32.54	0.90
D. virgatus	13.50	13.47	1.00
CD (P=0.05)	0.06		

Gmelina based silvipasture system

Under Gmelina plantations, guinea grass recorded the highest green fodder yield and the LER was 1.15. In this 10 y old plantation, LER ranged from 0.67 to 1.15 (Table 4). When LER values are higher than one, there is an advantage of intercropping in terms of the use of resources for the plant growth compared to sole cropping (Sullivan,1998 and Adetiloye et al., 1983). Guinea grass recorded significantly higher green fodder yield under silvipasture system than pure cropping.

Table 4. Green fodder yield and LER of Gmelina based silvipasture system

Fodder crops	Green fodder yield t ha^{-1}		LER
	Intercropping	Pure cropping	
Grasses			
C. glacus	7.68	8.13	0.94
B. mutica	5.21	7.68	0.68
Cumbu Napier	9.84	14.61	0.67
Guinea grass	129.28	111.95	1.15
Legumes			
D. virgatus	68.02	81.80	0.83
CD (P=0.05)	0.21		

Erythrina based silvipasture system

In E. indica based silvipasture systems, cumbu Napier grass and Cenchrus recorded the highest green fodder yield. The LER values ranged from 0.67 to 0.85 (Table 5). When LER values are lower than one, sole cropping would use the resources more efficiently in comparison with intercropping (Sullivan , 1998). Among the grass fodder crops, cumbu Napier recorded significantly higher yield in intercropping system. The grass fodder crops recorded higher LER values than legumes indicating the efficient use of resources.

Table 5. Green fodder yield and LER of Erythrina based silvipasture system

Fodder crops	Green fodder yield t ha^{-1}		LER
	Intercropping	Pure cropping	
Grasses			
Cumbu Napier	24.25	28.50	0.85
C. setegerus	3.33	4.15	0.80
Guinea grass	3.17	4.00	0.79
Legumes			
D. virgatus	1.35	1.84	0.73
S. hamata	1.00	1.50	0.67
CD (P= 0.05)	0.13		

Pungam based silvipasture system

Guinea grass recorded the highest green fodder yield of 3.91 t ha-1 and the LER value was 0.98. In pungam based silvipasture system, the LER values ranged from 0.77 to 0.98 (Table 6). Based on the LER values, for pungam plantations guinea grass would be a suitable fodder crop for the maximum utilization of available resources.

Table 6. Green fodder yield and LER of Pungam based silvipasture system

Fodder crops	Green fodder yield t ha^{-1}		LER
	Intercropping	Pure cropping	
Cereals			
Fodder sorghum	18.45	20.50	0.90
Grasses			
C. setegerus	3.88	4.15	0.93
Guinea grass	3.91	4.00	0.98
Legumes			
D. virgatus	1.50	1.95	0.77
S. hamata	0.75	0.88	0.85
Lucerne	0.44	0.50	0.88
CD (P= 0.05)	0.13		

Thespesia based silvipasture system

Under one year old Thespesia plantations , cumbu Napier grass recorded the highest green fodder yield of 24.25 t ha-1 with the LER value of 0.85. In this silvipasture system, the LER values ranged from 0.68 to 0.85 (Table 7). D.virgatus recorded the highest green fodder yield and this system was found to be highly significant.

Relative yield total

In all the silvipastoral systems, irrespective of the tree component, grass fodder recorded the highest RYT followed by legume fodder (Table 8). The RYT values indicated that the intercropping combinations were better than monoculture. Intercrop and sole crop yield performance was compared using RYT by Willey (1990). RYT values greater than one often observed with intercrops have been attributed to the suppression of weeds, pests and pathogens and enhanced the use of resources (Francis, 1989 and Vandermeer,1989).

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