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PRODUCTIVITY OF ARABLE CROPS AND PASTURE GRASSES IN ASSOCIATION OF MULTI-PURPOSE TREE SPECIES IN HOT ARID REGION OF RAJASTHAN

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SUMMARY

The field experiment was conducted during 2008 to 2010 at Bikaner to find out an efficient agri-silviculture or silvi-pastoral model for cultivable wastelands of arid tropics of India. Three multi-purpose tree species viz., *khejri* (*Prosopis cineraria*), *ardu* (*Ailanthus excelsa*) and *rohida* (*Tecomella undulata*) suitable for arid tropics were planted in July 2008 and annual grain legumes viz., clusterbean (*Cyamopsis tetragonoloba*), and mothbean (*Vigna aconitifolia*) in **kharif** 2009 and 2010, while pasture grasses viz., *sewan* (*Lasiurus sindicus*) and *anjan* (*Cenchrus ciliaris*) grasses once in July 2009. Results indicated that tree species had no adverse effect on growth and grain/fodder yields of crops and grasses in both the years. Similarly, annual crops/grasses did not exert any significant effect on the growth attributes of any tree species. Among grain crops and grasses, clusterbean recorded higher grain (0.82 and 0.91 t/ha) and straw (1.97 and 2.47 t/ha) yields over mothbean. Whereas *sewan* grass outyielded *anjan* grass with green fodder yield of 12.1 and 16.7 t/ha, and dry matter yield of 4.68 and 6.02 t/ha during 2009 and 2010, respectively. Computation of clusterbean equivalent yields (CEY) showed that CEY recorded with clusterbean (1.31 t/ha) and mothbean (1.28 q/ha) were statistically at par but significantly higher over both the grass species. Slight higher values of net returns and B : C ratio were observed with *khejri* plantation (Rs. 11,697 and 1.78) compared to other tree species, while among crops clusterbean gave maximum values of net returns Rs. 16,837 and B : C ratio 2.05. Organic carbon (%) and available N, P and K contents of soil substantially improved under all treatments in comparison to initial soil fertility status. Thus, study suggests that growing of clusterbean or mothbean with any multi-purpose tree species viz., *khejri*, *ardu* and *rohida* plantation holds promise to provide higher and economical grain productivity with improved fertility status of soil under agri-silviculture system in arid tropics of Rajasthan.

Key words : Arable crops, pasture grasses, multi-purpose tree species, agri-silvi-pastoral system

The Indian arid zone extends in an area of 31.7 million hectares and the major area (about 60%) of total arid zone lies in the western part of Rajasthan covering 12 districts of the state. Moreover, almost 40 per cent land of the region is under cultivable wastelands or degraded pastures. Due to poor and erratic rainfall pattern and low fertility of soils, agri-silvi-pastoral system is the vital life support system of rural folk of this region. Although, traditional agroforestry system with *Prosopis cineraria* exists in arid tropics (Gupta, 1994), but for improvement in productivity of the system to meet increasing demand of food, fodder and fuel, new alternatives of land use system are to be explored on the basis of rainfall pattern and edaphic conditions. There are number of multipurpose tree species viz., *Prosopis cineraria, Ailanthus excelsa, Hardwikia binata, Colophospermum mopane, Tecomella undulata, Azadirachta indica,* etc. suitable for the region and may provide fodder, fuel, timber or other edible and commercial products to mitigate the effect of frequent occurrence of droughts and fulfil the need of rural population. Clusterbean (*Cyamopsis tetragonoloba*) and mothbean (*Vigna aconitifolia*) are two most important legumes generally grown during **kharif** season under rainfed conditions and have capacity to bear harsh climatic situations, while *sewan* (*Lasiurus sindicus*) and *anjan* (*Cenchrus ciliaris*) are the most suitable perennial pasture grass species because of their high yielding, better

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palatability, good fodder quality and suitable for available land resource and climatic situation of the region. Further, the economy of the arid zone farmers depends upon the livestock population dominated by grazing based animals like sheep and goats. The wastelands and rangelands of this region are presently not capable of producing sufficient quantity of fodder for animals even for body maintenance. It is due to continuous over-exploitation of grazing lands, frequent droughts, low and erratic rainfall distribution, people negligence, etc. It is a fact that the improvement in animal husbandry is directly correlated with the improvement of native pastures and in this context, adoption of agri-silvi-pastoral system specially in cultivable wastelands may play a vital role in solving the problem of fodder shortage for animals in addition to fulfil the other daily needs of ever increased human and animal population of the region. The research based information on above is still meagre and keeping these all in view, present investigation was carried out.

MATERIALS AND METHODS

The field experiment was conducted during 2008-10 at Central Sheep and Wool Research Institute, Arid Region Campus, Bikaner (Rajasthan), India. The soil of experimental site was sandy and had low contents of organic carbon (0.13%), nitrogen (74.6 kg/ha), phosphorus (6.35 kg/ha) and potassium (73.7 kg/ha). The soil topography was moderately undulated and having pH value of 8.43 and EC 0.68 dS/m. The experiment was laid out in split plot design with three replications by assigning three multi-purpose tree species viz., *khejri* (*Prosopis cineraria*), *ardu* (*Ailanthus excelsa*) and *rohida* (*Tecomella undulata*) as main plot treatment and four crops and grasses viz., clusterbean (*Cyamopsis tetragonoloba*), mothbean (*Vigna aconitifolia*), *sewan* (*Lasiurus sindicus*) and *anjan* (*Cenchrus ciliaris*) as sub-plot treatments. This trial was initiated in July, 2008 with preparation of field and digging of 0.53 m^3 size pits by tractor drawn auger (pitter). Ten kg sheep manure and soil were mixed and filled in pits up to 15 cm below the soil surface. Six months old poly-bags raised healthy saplings of multipurpose tree species were planted at a distance of 10 x 10 m as per layout of the trial and maintained 12 plants in each plot. In first year, plantation was maintained and any dried or destroyed plants were immediately replaced and watered to maintain full tree population. Planted tree saplings were watered as per need. Crops and grasses were raised with recommended package of practices during **kharif** seasons of 2009 and 2010 and varieties 'RGC 936' of clusterbean, 'RMO 40' of mothbean , 'CAZRI-M-30-5' of *sewan* grass and 'CAZRI-75' of *anjan* grass were sown in the trial. Grain crops were sown in both the years, while perennial grasses were sown once in first year and its re-growth was used in second year. Trees growth attributes viz., tree height, stem girth and tree canopy were observed at different intervals. Grain crops were harvested at physiological maturity, while grasses were harvested once at flowering stage in both the years. Yield and yield attributes of crops and grasses were taken at harvest and plant samples of grasses were collected for dry matter yields. Soil samples were collected in beginning and at the end of experimentation at 0-15 cm soil layer and analysed for physical and chemical properties of soil as per standard procedures. The total annual precipitation was 239.7, 343.9 and 390.8 mm occurred in 19, 21 and 18 rainy days during 2008, 2009 and 2010, respectively.

RESULTS AND DISCUSSION

Growth Attributes of Tree Species

Data collected on growth parameters viz., tree height, stem girth and canopy diameter of tree species at different intervals showed substantial improvement at all stages (Table 1). Results indicated that overall *A. excelsa* recorded maximum values of all the growth attributes as well as improvement (%) at all the growth stages followed by the *P. cineraria* up to the age of 12 months, but thereafter *T. undulata* excelled up its growth at the stage of 18 and 24 months, which recorded higher values of all growth attributes except canopy diameter at 18 months, where *P. cineraria* recorded greater values. The minimum growth of *P. cineraria* was mainly because of its nature of growth after a certain stage when it sheds the leaves and plant converts to bushy nature and improvement in canopy size decreases. Arya *et al.* (2008) also reported *A. excelsa* a suitable tree species for hot arid region and highest tree height among other multipurpose tree species.

Growth and Yield of Grain Crops and Pasture Grasses

None of the tree species had its significant effect

TABLE 1
Mean values of growth attributes of planted tree species at different intervals

Fodder tree	Growth parameters	6 months	9 months		12 months		18 months		24 months	
		Value	Value	Imp. (%)	Value	Imp. (%)	Value	Imp. (%)	Value	Imp. (%)
P. cineraria	Tree height (cm)	31.4	33.2	5.7	33.8	1.81	71.3	110.9	89.7	25.8
	Stem girth (cm)	1.18	1.48	25.4	2.85	92.6	5.33	87.0	6.17	15.8
	Canopy diameter (cm)	4.26	11.4	167.6	19.1	67.5	75.9	297.4	97.2	28.1
A. excelsa	Tree height (cm)	52.1	53.7	3.07	57.9	32.5	165.3	185.5	231.0	39.7
	Stem girth (cm)	2.00	2.47	23.5	3.30	33.6	16.5	400.0	23.2	40.6
	Canopy diameter (cm)	14.1	16.3	15.6	13.2	109.5	74.4	463.6	167.0	124.5
T. undulata	Tree height (cm)	21.4	21.4	0	22.2	3.74	62.0	179.3	121.3	95.6
	Stem girth (cm)	1.23	1.52	23.6	1.95	28.3	5.67	190.8	10.3	81.6
	Canopy diameter (cm)	6.08	10.0	64.5	15.2	52.0	56.8	273.7	103.9	82.9

on the growth attributes of grain crops and grasses in both the years (Table 2). It might be due to slow growing nature of all tree species, which could not affect the growth attributes of crops and grasses. The results also agreed with the view of Jhorar *et al.* (2005), that trees had no effect on associated crop for initial first four years. Grain and straw yields recorded with clusterbean were significantly higher over mothbean in both the years, except straw yield in 2009, where difference was non significant (Table 3). Similarly, *sewan* grass gave significantly higher green fodder (12.07 and 16.74 t/ha) and dry matter (4.68 and 6.02 t/ha) yield in both the years over *anjan* grass. The magnitude of increase in green and dry fodder yield was to the tune of 34.5 and 44.0 per cent and 20.1 and 32.6 per cent over *anjan* grass during 2009 and 2010, respectively. The higher fodder yield under *sewan* grass was the function of greater number of tillers per tussock and tussock diameter than *anjan* grass. Vyas (2003) also observed enhanced values of growth and yield of senna in association of *khejri* plantation. Kaushik and Kumar (2003) also reported no effect of top feed tree species on the yield of understory crops, but crops varied significantly among themselves. Computation of clusterbean yield equivalent (CEY) showed that CEY was not significantly influenced by any of the tree species but grain crops due to better market prices of products, recorded greater values of CEY (clusterbean 1.31 and mothbean 1.28 t/ha) than grasses. The CEY values recorded with clusterbean and mothbean were statistically

TABLE 2
Growth attributes of different crops and grasses at harvest as influenced by treatment variables

Treatment	Plant height (cm)		No. of plants/m²		No. of tillers/tussock of grasses		Tussock diameter of grasses	
	2009	2010	2009	2010	2009	2010	2009	2010
A. Tree species								
P. cineraria	83.0	103.4	20.5	14.7	63.6	109.6	62.3	76.8
A. excelsa	81.1	100.4	18.7	15.4	59.1	108.5	59.6	75.5
T. undulata	80.1	101.9	19.9	16.4	62.8	109.2	62.0	76.9
S. Em±	0.90	1.24	0.73	0.61	2.66	0.94	1.86	2.86
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
B. Crops and grasses								
C. tetragonoloba	84.0	125.4	27.6	23.0	-	-	-	-
V. aconitifolia	39.2	42.7	26.9	17.4	-	-	-	-
L. sindicus	118.9	126.2	10.1	9.0	73.0	142.7	69.8	85.0
C. ciliaris	83.5	113.1	14.1	12.4	50.7	75.5	52.9	67.8
S. Em±	1.14	2.55	0.80	0.56	1.14	2.30	1.69	2.34
C. D. (P=0.05)	3.38	7.57	2.37	1.67	3.94	7.97	5.86	8.10

NS–Not Significant.

TABLE 3
Grain, straw, fodder and clusterbean equivalent yields of different crops and grasses as influenced by treatment variables

Treatment	Grain crops yield (kg/ha)				Grasses yield (t/ha)				CEY* (t/ha)
	Grain		Straw		GFY		DMY		
	2009	2010	2009	2010	2009	2010	2009	2010	
A. Tree species									
P. cineraria	719	837	1770	2280	10.96	15.39	4.13	5.47	1.04
A. excelsa	676	823	1800	2140	10.34	15.24	3.89	5.28	1.01
T. undulata	716	817	18.2	2130	10.25	15.38	3.86	5.09	1.01
S. Em±	52	48.0	191.0	111	0.17	0.27	0.06	0.09	0.04
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
B. Crops and grasses									
C. tetragonoloba	818	915	1970	2470	-	-	-	-	1.31
V. aconitifolia	590	735	1630	1890	-	-	-	-	1.28
L. sindicus	-	-	-	-	12.07	16.74	4.68	6.02	0.86
C. ciliaris	-	-	-	-	8.97	13.93	3.25	4.54	0.62
S Em±	28.0	23.0	129.0	48.0	0.21	0.51	0.08	0.13	0.02
C. D. (P=0.05)	97.0	81.0	NS	165.0	0.74	1.75	0.29	0.46	0.07

*Clusterbean equivalent yield on the basis of mean data of grain, straw and dry fodder yields. NS–Not Significant.

at par but significantly higher over values recorded with grasses (*sewan* grass 0.86 and *anjan* grass 0.62 t/ha). It was also observed that *sewan* grass recorded significantly higher value of CEY over *anjan* grass.

Economics

Working out of economic benefits in the terms of net returns and benefit : cost ratio showed that among tree species *P. cineraria* plantation recorded maximum and numerically higher net returns (Rs. 11, 697/ha) and B : C ratio (1.78) compared with other tree species (Table 4). It was mainly because of slight improvement in yields of crops and grasses in treatment of *P. cineraria*, while cost of cultivation was similar. Among crops and grasses, clusterbean recorded maximum values of net returns (Rs. 16,837/ha) and B : C ratio (2.05) followed by mothbean (NR Rs. 15, 925/ha and B : C ratio 1.99). Grasses were less remunerative than grain crops due to low price of produce. Between grasses, *sewan* was found more beneficial than that of *cenchrus* and recorded higher values of net returns

TABLE 4
Economics and soil fertility status as influenced by treatment variables

Treatment	Economics				Soil fertility status			
	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B : C ratio	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
A. Tree species								
P. cineraria	14,297	25,994	11,697	1.78	0.18	92.2	6.98	81.9
A. excelsa	14,297	25,154	10,857	1.72	0.17	91.1	7.03	82.7
T. undulata	14,297	25,173	10,826	1.72	0.17	90.8	7.04	81.1
B. Crops and grasses								
C. tetragonoloba	15,935	32,772	16,837	2.05	0.19	98.6	7.17	84.4
V. aconitifolia	16,085	32,010	15,925	1.99	0.18	94.1	7.13	81.2
L. sindicus	12,809	21,391	8,585	1.67	0.16	85.3	6.83	79.9
C. ciliaris	12,359	15,589	3,230	1.26	0.17	87.5	6.94	82.2
Initial	-	-	-	-	0.13	74.6	6.35	73.7

(Rs. 8,585/ha) and B : C ratio (1.67) compared with *cenchrus* (Rs. 3,230/ha and 1.26).

Soil Fertility Status

Soil samples analysed at the end of experimentation for organic carbon and available nutrients status revealed that OC (%), N, P and K contents substantially improved compared with initial levels (Table 4). Although, among treatments, differences were very negligible but encouraging when compared with initial fertility levels. Numerically, among trees species *P. cineraria* recorded highest contents of organic carbon and available N in soil, while P and K contents were higher in the plots of *T. undulata* and *A. excelsa*, respectively. Whereas in case of crops and grasses, clusterbean had its more pronounced effect on soil and observed highest values of all the nutrients including organic carbon. Both grain crops being legumes accumulated higher contents of organic carbon and available N, possibly due to greater leaf litter fall on soil specially clusterbean crop, which resulted in higher contents of available P and K in soil. Yadav *et al.* (2007) and Ram *et al.* (2007) also reported increased values of organic carbon and available plant nutrients under MPTs based silvipastoral system.

Thus, it is inferred that grain crop of clusterbean or mothbean can be safely grown in association of multipurpose tree species (*P. cineraria*, *A. excelsa* and *T. undulata*) for getting higher and remunerative productivity in cultivable wasteland of arid region of Rajasthan as agri-silviculture model without any adverse effect on growth performance of tree species. However, in exigency of fodder for livestock production, *sewan* grass was found potential perennial grass species for growing under silvipastoral system.

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