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Performance of castor (*Ricinus communis*) and greengram (*Vigna radiata*) in agroforestry systems in semi-arid tropics

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ABSTRACT

A 3-year study was conducted at the Central Research Institute for Dryland Agriculture, Hyderabad, during in rainy seasons of 2002, 2003 and 2004, to evaluate the influence of 3 agroforestry tree species, viz *amla (Emblica officinalis* Gaertn.), tamarind (*Tamarindus indicus* L.) and (*Acacia senegal* Willd.) on the growth and yield of castor *(Ricinus communis* L.) and greengram [*Vigna radiata* (L.) Wilczek] under rainfed conditions. The yields of arable intercrops were significantly influenced by the trees. Maximum reduction was observed with *A. senegal* and the minimum with *amla.* With increase in age of trees, more reduction in arable crop yield was observed. Pooled over years, the grain yield of greengram was similar in sole crop and as intercrop with the 3 tree species. But in castor sole crop was superior to intercropping with tree species. Among the tree species, castor intercroped with *alma* and tamarind being at par were superior to *A. senegal.* Economic analysis showed the superiority of agroforestry systems over sole crop systems.

Key words : Agroforestry, *Amla, Acacia senegal,* Castor, Greengram, Tamarind

Agroforestry has become an important land-use system in India, where availability of land for meeting the basic need of firewood, timber, fodder, oilseeds, industrial chemicals etc. is declining. However, these traditional agroforestry systems have not been analyzed systematically. The competition for water and nutrients between trees and food crops is perhaps one of the most important interactions in agroforestry systems. The yields of intercrops are reduced as the age of the trees increases (Menezes, 2002). Studies on impact of trees on intercrops are limited. Hence present experiment was conducted to study the performance of arable intercrops with tree species.

MATERIALS AND METHODS

A field experiment was conducted at Hayatnagar Research Farm, Central Research Institute for Dryland Agriculture, Hyderabad, during the rainy seasons of 2002, 2003 and 2004. The study site was sandy-loam soil, medium in inorganic carbon (0.5%), low in available nitrogen (150 kg/ha), medium in available P (13 kg/ha) and available potassium (245 kg/ha). The weekly mean temperature varied from 11.5 to 39.7 °C, 12.2 to 42°C and 11.6 to 39.5°C and relative humidity ranged from 21 to 91, 15 to 88 and 18 to 94% during 2002, 2003 and 2004 respectively. The annual rainfall was 564.3, 664.5 and 581.4 mm in 2002, 2003 and 2004, respectively, against average of 733.7 mm. The experiment was laid out in 4-year-old *amla,* tamarind and *A. senegal* which were planted in August 1998 at a spacing of 10 m × 5 m. Two annual crops, viz. castor ('Kranthi') and greengram ('ML 267') were sown as intercrops and sole crops in the first fortnight of July at spacing of 60 cm × 30 cm and 30 cm × 10 cm respectively. The treatments were laid out in randomized block design and replicated 5 times, the net plot size was 10 m × 5 m. The crops were cultivated with recommended package of practices. Observations on tree height, crown diameter and stem diameter of trees were recorded. The yield components, grain and stover yields of annual crops were recorded. Harvest index and partial land-equivalent ratio (PLER) of arable crops was computed. The economic returns from the system were calculated.

RESULTS AND DISCUSSION

Arable crops

Yield components of castor and greengram (Table 1) indicated that 1,000-grain weight of the crops was relatively less affected by the tree species. However, the number of seeds and seed weight/plant were influenced by the tree species. Highest number of seeds and seed weight were recorded in sole crop and the lowest in association with *A. senegal* in both the crops. These further decreased with age of the trees from 4 years (2002) to 6

years (2004).

Yield of the crops was significantly influenced when grown as intercrops with different tree species. On an average, the sole crop yields were higher than that of intercrops (Table 2). When intercropped, the yield of castor reduced significantly with *A. senegal* during 2002 and yield of castor with *amla* and tamarind was on a par with sole crop during this year. During 2003, castor yields with the 3 tree species being at par were significantly lower than that of sole crop. During 2004, castor yield with all the tree species was significantly lower to sole crop. Further, the yield with *A. senegal* was significantly lower to that with *amla* and tamarind. Among the trees, the average yield of castor was highest in association with *amla.* The reduction in yield of castor increased with the increase in tree age from 4 years (2002) to 6 years (2004). The castor yields reduced by 24, 22 and 53% in 2002–03; by 53, 46 and 58% during 2003–04 and 46, 60, 85% in 2004–05 with *amla,* tamarind and *A. senegal* respectively.

The stover yield of castor was significantly reduced with all the tree species. Sole crop recorded higher stover yields. The lower seed and stover yields when intercropped with tree species might be due to poor crop growth. The higher yield of castor in the first year was owing to extended monsoon in October, whereas in the second and third years the reduction in castor yield was due to early cessation of rains. The lower yield of castor with trees may be attributed to competition between trees and crops for moisture (Korwar and Radder, 1994), nutrients and solar radiation (Bheemaiah *et al.,* 1996). The de-

Table 1. Yield components of castor and greengram with different tree species

Tree species	2002			2003			2004		
	Seeds/ plant	1,000-seed weight (g)	Seed weight/ plant (g)	Seeds/ plant	1,000-seed weight (g)	Seed weight/ plant (g)	Seeds/ plant	1,000-seed weight (g)	Seed weight/ plant (g)
Castor									
Sole	110	243	26.7	68	240	16.1	55	241	13.30
Amla	109	240	26.1	42	239	10.0	43	240	10.10
Tamarind	111	239	26.4	47	238	11.0	33	238	7.70
A. senegal	76	238	18.0	38	237	9.1	32	237	3.00
Greengram									
Sole	126	31.1	3.9	84	30.3	2.5	30	30.2	0.90
Amla	125	30.2	3.8	61	30.3	1.8	25	29.8	0.74
Tamarind	89	30.0	2.6	53	30.0	1.6	28	29.7	0.81
A. senegal	76	29.3	2.2	59	30.1	1.8	7	29.5	0.18

Table 2. Effect of different tree species on seed yield, stover yield (kg/ha) and harvest index of castor and greengram

Tree species	Seed yield (q/ha)				Stover yield (q/ha)				Harvest index (%)		
	2002	2003	2004	Pooled	2002	2003	2004	Pooled	2002	2003	2004
Castor											
Sole	14.15	8.02	7.22	9.80	32.60	18.51	10.00	20.37	30	30	41
Amla	10.77	3.77	3.95	6.16	18.11	6.41	6.16	10.23	37	37	39
Tamarind	11.16	4.34	2.90	6.13	23.24	9.29	5.24	12.59	32	31	35
A. senegal	6.76	3.40	1.12	3.76	17.39	8.77	2.02	9.39	28	27	35
Mean	10.71	4.88	3.80		22.84	10.75	5.87				
CD (P=0.05)											
Tree species	3.53	1.62	1.04	2.87	2.83	2.57	1.23	11.43			
Years				2.49				9.90			
Greengram											
Sole	12.66	7.86	2.95	7.82	22.29	15.75	5.67	14.57	36	33	34
Amla	10.60	4.30	1.75	5.55	19.45	9.40	1.88	9.92	35	31	48
Tamarind	6.35	3.80	1.95	4.04	15.95	8.25	2.94	8.83	28	32	39
A. senegal	5.33	4.21	0.43	3.33	12.19	9.55	1.20	7.29	30	31	26
Mean	8.74	5.04	1.77		17.47	10.06	2.92				
CD (P=0.05)	1.07	0.93	4.01	6.93	2.69	1.66	0.82	8.93			
Tree species											
Years				6.01				7.74			

crease in castor yields in association with tree species, with increase in tree age may be due to increase in tree growth and root system which competes for moisture, nutrients and solar radiation (Bheemaiah *et al.*, 1996; Subramanyam and Bheemaiah, 2003). Higher harvest index of castor was observed in association with *amla,* compared with sole and other tree species, indicating better partitioning of dry matter.

Pooled analysis (Table 2) indicated that, over years castor seed yield in sole crop was significantly superior to that intercropped with *amla,* tamarind and *A. senegal.* Castor with *amla* and tamarind being at par were significantly superior to that with *A. senegal.* The year 2002 was significantly superior to 2003, which was again significantly superior to 2004. The stover yield of castor over years did not vary significantly due to the tree species. However, the stover yield in 2002 was significantly superior to that in 2003 and2004, which were at par.

The greengram yield was highest in the first year and lowest in the third year (Table 2). The lower yields were due to a dry spell during vegetative growth. Sole crop recorded significantly highest yield during all the 3 years. The yield of greengram was significantly reduced when intercropped with the 3 tree species during all the 3 years. Greengram yield with *amla* was significantly higher than that with tamarind and *A. senegal* during 2002. During 2003, greengram yield with the 3 species was at par; and during 2004 green-gram yield with *amla* and tamarind being at par was significantly superior to that with *A. senegal.* The yield reduction in greengram with *amla* was 17, 46 and 41% in 2002, 2003 and 2004, whereas it was 50, 52 and 34% with tamarind; and 58, 47 and 86 with *A. senegal* in 2002, 2003 and 2004 respectively. The yield reduction was highest with *A. senegal* than that with *amla* and tamarind. The decrease in yield with *A. senegal* was more in third year and this higher yield reduction might be due to more competition for moisture, which was limiting in the third year. The fodder yields of greengram were influenced similar to grain by different treatments. Like castor, the harvest index of greengram was highest with *amla.* On an average, the yield reduction with the tree species in both castor and greengram was similar (40, 42 and 62% in castor and 33, 44 and 63% in greengram under *amla,* tamarind and *A. senegal* respectively).

Pooled analysis of greengram seed yield (Table 2) indicated that, the yield with different tree species and in sole crop was at par. In respect of years, 2002 and 2003 were at par; and 2003 and 2004 were at par. Pooled analysis for fodder yield of greengram indicated that like the seed yield the greengram stover yield over years in sole crop and with different tree species was at par. And years 2002 and 2003 were at par and year 2003 was on a par with 2004.

In general, the PLER of crops averaged over tree species and years was similar in both greengram and castor (Table 3). The PLER of both the arable crops was lowest with *A. senegal,* and highest with *amla*; and with tamarind it was marginally lower than *amla.* In general, PLER of crops decreased with age of trees. This is expected in agroforestry sysems, as with age, arable crop component yield reduces, and this could be made good through the yield from tree components.

Tree growth

The growth characters of trees, viz. tree height, stem diameter and canopy diameter, were recorded after harvest of intercrops (Table 4). All the growth parameters increased from 2002 to 2004 in all tree species. However, the increment in individual growth parameter was differ-

Table 3. Effect of different tree species on partial land-equivalent ratio of castor and greengram

Tree species	Castor				Greengram			
	2002	2003	2004	Mean	2002	2003	2004	Mean
Sole	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Amla	0.76	0.47	0.54	0.59	0.83	0.54	0.59	0.65
Tamarind	0.78	0.54	0.40	0.57	0.50	0.48	0.66	0.55
A. senegal	0.47	0.42	0.15	0.35	0.42	0.53	0.14	0.36

Table 4. Growth parameters of different tree species

Tree species	Height (cm)				Crown diameter (cm)				Stem diameter (cm)			
	Initial Sep. 2002	Dec. 2002	Dec. 2003	Dec. 2004	Initial Sep. 2002	Dec. 2002	Dec. 2003	Dec. 2004	Initial Sep. 2002	Dec. 2002	Dec. 2003	Dec. 2004
Amla	289.5	300.8	329.3	374.8	282.7	320.0	361.7	370.7	3.24	3.57	4.20	12.95
Tamarind	217.2	228.5	262.8	297.1	234.1	284.6	304.4	332.5	1.66	1.73	8.08	8.57
A. senegal	283.6	298.6	346.9	360.0	253.3	294.2	305.4	326.4	2.08	2.75	6.98	7.48
Mean	263.4	275.9	304.0	343.9	256.3	266.3	317.6	316.9	2.32	2.68	6.42	9.67

Table 5. Economics of castor and greengram with different tree species

Tree species	Gross returns (Rs/ha/year)			Net returns (Rs/ha/year)			Benefit : cost ratio		
	2002	2003	2004	2002	2003	2004	2002	2003	2004
Castor									
Sole	18,044	12,555	12,052	13,344	7,705	7,152	3.839	2.589	2.460
Amla	14,209	14,958	18,154	9,109	9,808	12,954	2.786	2.904	3.491
Tamarind	14,108	5,499	4,902	9,158	499	−148	2.850	1.100	0.971
A. senegal	8,712	4,383	1,995	5,212	833	−1,605	2.489	1.235	0.554
Greengram									
Sole	18,687	11,793	4,402	16,337	9,393	1,952	7.952	4.914	1.797
Amla	20,675	8,000	30,393	17,925	5,200	27,543	7.518	2.857	10.664
Tamarind	9,850	5,765	2,829	7,800	3,665	679	4.805	2.745	1.316
A. senegal	8,148	6,428	679	6,398	4.653	−1,121	4.656	3.621	0.377

ent in different years. Higher increment in tree height (37%), stem diameter (416%) and canopy diameter (42%) was observed in tamarind. However, in general, intercropping of arable crops did not exert any visible antagonistic effect on the growth of trees during both the years since the competition between these 2 species was only for a short period, and the arable crops did not overgrow the trees. The increment in the height and stem diameter increased with age of the tree irrespective of the rainfall. However in *A. senegal* and tamarind, the increase in height and stem diameter was higher in second year when compared to first and third years. This might be due to higher rainfall in this year when compared to other years.

Economics

Economic analysis of different intercrops (Table 5) indicated that during 2002, highest economic net returns were obtained from *amla* + greengram system and the lowest from *A. senegal* + castor system. During 2003, the highest net returns were obtained from *amla* + castor system and the lowest from tamarind + castor system. During 2004, highest net returns were obtained from *amla* + greengram system and the lowest from *A. senegal* + castor system. Highest benefit : cost ratio was obtained in 2004 from *amla* + greengram system and the lowest from *A. senegal* + greengram system.

In most of the years, agroforestry systems involving *amla* + arable crops were economically superior to sole crop systems, indicating the sustainability and economic superiority of agroforestry systems over sole crops, in rainfed environments.

The study indicates that *amla* is more drought tolerant than tamarind and *A. senegal.* Thus, growing of arable crops like greengram and castor as intercrops with tree species like *amla* is profitable. Tamarind and *A. senegal*-based agroforestry systems may become economic once these species start yielding. The off-season precipitation would be gainfully utilized by the tree species; it would be an insurance against total crop failures during years of drought. The yield reduction in arable crops was marginal in *amla* and this reduction in yield was compensated by tree yields.

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