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Effect of intercropping millets, pulses and oilseeds on yield and economics of castor (*Ricinus communis*) under rainfed conditions*

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Castor (*Ricinus communis* L.) is a promising crop of poor farmers owing to its drought tolerance under rainfed conditions and its ability to grow on less fertile and coarse textured soils. In India, it occupies an area of 8.70 lakh hectares and produce 11.15 lakh tonnes of beans. In Andhra Pradesh, it is cultivated on 1.57 lakh hectares producing 0.8 lakh tonnes of beans. The national productivity of this crop is 1 282 kg/ha while the average yield in Andhra Pradesh is 510 kg/ha (CMIE 2009).

It is cultivated in wide rows ranging from 60 to150 cm depending upon the soil type and rainfall pattern. Initially it is sluggish in growth. This encourages weed growth which compete with the available resources. Taking advantage of this, it can possibly be intercropped with quick growing and short duration foodgrain, pulse and oilseed crops in appropriate geometry to exploit more yield and economics per unit area. Intercropping these crops may also be an option to the farmer to realize nutritive cereal, pulse or oilseed crop for the dietary requirement in addition to the cash crop of castor. Hence the present study was undertaken to find out more productive and profitable castor based intercropping systems.

The field experiment was conducted at the Agricultural Farm, National Academy of Agricultural Research Management (NAARM), Rajendranagar, Hyderabad during *kharif* 2007 and 2008. The soil was sandy clay loam in texture, slightly alkaline in reaction (*p*H 7.8), low in available N (142 kg/ha), phosphorus (9.96 kg P/ha) and rich in potassium (341 kg K/ha). The soil had a tendency for crust formation.

The experiment was laid out in randomized block design (RBD) with three replications. There were 14 treatments. Castor (var. 'Kranti') was sown in uniform row spacing of 90 cm and paired row planting at 120/60 cm. It was intercropped with one row of sorghum (CSV-20) and sunflower (Morden), two rows of pearl millet (ICMV-221), greengram (WGG-37), black gram (TAU-I) and soybean (JS-335) in the uniform row planting of castor. Two rows of sorghum and sunflower but three rows of pearl millet, greengram, blackgram and soybean were intercropped between the paired rows of castor. There was also a sole crop of castor in either of the planting geometries. The plant population of castor was 55 555/ha in both uniform and paired row planting. The plant population of sorghum was 65 185/ha in uniform row and 96 666/ha in paired row planting of castor. The plant population of pearl millet was 148 889 and 111 111, greengram 223 333 and 166 666, black gram 223 333 and 166 666, soybean 223 333 and 166 666 and sunflower 32 593 and 48 333/ha in the corresponding plant geometries of castor. The crop stands were low (60-70%) in sorghum and sunflower due to poor germination during the two years. Castor was fertilized with 80:60:40 kg N, P_2O_5 and K_2O/ha. The fertilizer application to all the intercrops was additional and in proportion to their sole optimum plant densities. All the recommended agronomical practices were followed and crops were raised completely as rainfed.

Castor equivalent yield of intercropping system was computed by converting the yield of intercrops into castor seed equivalent on the basis of prevailing market price with the help of following formula.

Castor equivalent yield of intercropping system (kg/ha) =

$$\frac{Y_i \times P_i}{P_c} + \text{Yield of castor (kg/ha)}$$

where, Y_i = Yield of intercrop (kg/ha), P_i = Price of intercrop (Rs/kg), P_c = Price of castor (Rs/kg)

The relative net returns (RNR) index proposed for any intercropping system to be compared with the major sole crop was worked out following the approach suggested by

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Jain and Rao (1980) as

$$RNR = \frac{(P_i Y_i + P_j Y_j) \pm D_{ij}}{P_i Y_{ii}}$$

where,

Y_i and Y_j = The yields of i^{th} major crop per hectare and j^{th} intercrop per hectare on i, j^{th} crop combination

P_i and P_j = The prices of i^{th} major crop and j^{th} intercrop respectively

Y_{ii} = The yield of i^{th} sole crop per hectare

D_{ij} = The differential cost of cultivation of i, j^{th} crop combination in comparison to i^{th} sole crop

The results showed that the yield of castor beans did not differ significantly by planting the crop in uniform or paired row pattern (Table 1). The varying rainfall pattern during the two years influenced the crop yields substantially. There was a rainfall of 361 mm with good distribution over 32 rainy days during the crop growing period in 2007. A high rainfall of 844 mm was received with 32 rainy days in 2008. There was a continuous wet spell of rains from sowing until 50 days in the second year. The surplus moisture caused water-logged conditions and created anoxia to the roots. This condition arrested the crop growth. Hence the yields were low in the second year. The adverse effect of excess rain on growth and yield of castor and intercrops was also reported by Padmavathi and Raghavaiah (2004).

The intercropping of two rows of blackgram between the uniform rows of castor produced a bonus yield of 338 kg/ha in 2007 and 266 kg/ha in 2008 without affecting the production of castor. The intercropped castor produced 878 and 571 kg seed yield/hectare which was on par with the sole crop yield of 897 and 600 kg/ha in 2007 and 2008. Similar advantage was also recorded by intercropping three rows of blackgram between the paired rows of castor. A bonus yield of 287 kg/ha in the first year and 243 kg/ha in the second year resulted with no loss in yield of castor compared to the sole crop. Owing to its short duration of 65 days, blackgram completed its reproductive phase of growth and development during the vegetative growth of castor. The second picking of this intercrop was completed at the time of first spike development of the castor. The blackgram had dwarf stature, moderate growth and less canopy coverage. Hence, it did not exert stiff competition for the resources on castor during both the years. Thus the farmer can best exploit the inter row spaces of castor to obtain the pulse crop for his dietary requirement or additional cash. The other intercrop yields

Table 1 Yields of castor and intercrops as influenced by planting pattern and intercropping

Treatment	*Kharif* 2007			*Kharif* 2008		
	Castor bean yield (kg/ha)	Intercrop grain yield (kg/ha)	Castor equivalent yield (kg/ha)	Castor bean yield (kg/ha)	Intercrop grain yield (kg/ha)	Castor equivalent yield (kg/ha)
Uniform row planting						
Sole Castor	854		854	586		586
Castor+sorghum	474	221	571	284	167	361
Castor+pearl millet	361	1218	897	245	1093	753
Castor+greengram	516	754	1179	425	482	942
Castor+blackgram	928	338	1225	614	266	903
Castor+soybean	666	388	900	400	243	553
Castor+sunflower	574	275	794	288	254	541
Paired row planting						
Sole castor	940		940	614		614
Castor+sorghum	480	243	587	336	194	425
Castor+pearl millet	315	1009	759	198	958	642
Castor+greengram	452	683	1053	445	416	891
Castor+blackgram	829	287	1081	526	243	786
Castor+soybean	737	312	923	468	206	601
Castor+sunflower	666	316	919	323	298	621
SEm ±	43		68	38		85
CD (*P*=0.05)	126		141	111		175

MSP(Rs/kg grain)		Castor	Sorghum	Pearl millet	Green gram	Black gram	Soybean	Sunflower
Year	*2007–08*	25	11	11	22	22	15	20
	2008–09	28	13	13	30	30	18	28

were obtained at the expense of significant reduction in the yield of castor grown in uniform or paired rows. Although intercropped greengram was also of the same duration and phenology as that of blackgram, it was aggressive to castor. Greengram attained maximum leaf area around 40-45 DAS. Due to its profuse growth and flowering, it competed for resources with castor in the initial stage and depleted the soil resources which had a drastic effect on the growth and development of castor in the later period. Soybean and sunflower were longer duration crops when compared to greengram or blackgram. They attained maximum leaf area around 70 DAS, by that time castor had put forth sufficient vegetative growth and the capsule formation in its first spike was over. As a result of which, castor and these intercrops experienced mutual competition for available resources leading to considerable reduction in their yields. Pearl millet was the most aggressive intercrop found to inflict maximum damage to the castor crop. It was due to its fast growth right from the initial stage, tall growing nature, production of more leaf area and tillering habit. This intercrop completely dominated the castor during both the years. Sorghum was second more aggressive intercrop to castor. This intercrop was slow in growth in the initial stage. By the time it attained maximum vegetative growth, the capsule development in the first spike of castor was completed. Hence both the crops competed for available resources simultaneously and their yields were reduced drastically. The results on the advantage of intercropping castor with different component crops are not consistent in the literature. The leguminous crops like greengram, blackgram or soybean were reported to have severe competitive effect on the yield of castor (Patel *et al*. 2002). On the other hand, the intercropping of legumes like greengram, blackgram, soybean or cluster bean was recorded to increase the yield of castor in other investigations of Padmavathi and Raghavaiah (2004) and Porwal *et al*. (2006). The highly variable findings on the prospects of different intercrops on the yield of castor could probably be due to several cause and effect relationships on their competitive growth influenced by the confounded interactive role of rainfall pattern, edaphic factors, crop duration, rooting pattern of the varieties, their morphological growth etc. The most prospective advantage of significant increase in castor equivalent yield occurred by intercropping two rows of greengram or blackgram between the uniform rows or three rows of these intercrops flanked between the paired rows of castor. This improvement in the marketable value of the total produce by intercropping these quick growing proteinecious pulse crops was mainly because of their lucrative sale price. An economic analysis of the intercropping treatments is presented in Table 2. The marketable value of intercropping

Table 2 Monetary returns as influenced by planting pattern and intercropping in castor

Treatment	*Kharif* 2007				*Kharif* 2008			
	Gross returns (₹/ha)	Net returns (₹/ha)	Net returns (₹/Re)	*RNR	Gross returns (₹/ha)	Net returns (₹/ha)	Net returns (₹/Re)	*RNR
Uniform row planting								
Sole castor	21 351	11 351	1.14		16 391	6 391	0.64	
Castor + sorghum	15 630	630	0.04	0.97	11 343	-3 657	-0.24	1.03
Castor + pearlmillet	24 705	9 705	0.65	1.39	23 126	8 126	0.54	1.78
Castor + greengram	31 464	16 464	1.10	1.72	27 823	12 823	0.85	2.09
Castor + blackgram	31 573	16 573	1.10	1.72	26 142	11 142	0.74	1.97
Castor + soybean	22 894	7 594	0.50	1.34	15 750	450	0.03	1.31
Castor + sunflower	19 850	4 850	0.32	1.16	15 164	164	0.01	1.30
Paired row planting								
Sole castor	23 494	13 494	1.35		17 180	7 180	0.72	
Castor + sorghum	16 077	1 077	0.07	0.89	13 185	-1 815	-0.12	1.05
Castor + pearlmillet	20 988	5 988	0.40	1.11	19 950	4 950	0.33	1.49
Castor + greengram	28 119	13 119	0.87	1.41	26 287	11 287	0.75	1.85
Castor + blackgram	27 894	12 894	0.86	1.41	22 799	7 799	0.52	1.63
Castor + soybean	23 447	8 147	0.53	1.23	17 048	1 748	0.11	1.33
Castor + sunflower	22 980	7 980	0.53	1.19	17 391	2 391	0.16	1.34
SEm ±				0.09				0.25
CD (*P*=0.05)				0.18				0.53

MSP(Rs/kg grain)		Castor	Sorghum	Pearl millet	Greengram	Blackgram	Soybean	Sunflower
Year	*2007–08*	25	11	11	22	22	15	20
	2008–09	28	13	13	30	30	18	28

*RNR: Relative net returns

two rows of greengram or blackgram between the uniform rows of castor was increased substantially both during 2007 and 2008. Maximum gross and net returns per hectare were realized from these intercropping systems. The more conservative index of monetary evaluation for the small and rainfed farmers is profit per rupee investment. There was no substantial advantage in terms of net returns per rupee investment by intercropping when compared to sole cropping of castor. The results imply that the poor farmer who cannot invest more may rely on the sole crop. The robust index to measure the relatively more profitable intercropping system, Relative Net Returns (RNR) established that the intercropping two rows of greengram or blackgram between uniform rows of castor was significantly superior to all other systems.

SUMMARY

A field experiment was conducted at NAARM during *kharif* 2007 and 2008 to find out suitable intercrop to be planted in castor under rainfed conditions. There were six intercrops, viz sorghum, pearl millet, greengram, blackgram, soybean and sunflower tested under two planting geometries of the base crop castor. The results of the experiment showed that the intercropping of two rows of blackgram between the uniform rows of castor produced additional yield of 338 and 266 kg/ha without reducing the yield of castor during the two years respectively. The intercropping of two rows of blackgram or greengram in uniform rows of castor or three rows between the paired rows of castor emerged as statistically superior systems with higher crop equivalent yields than the sole crops during both the years of investigation. The intercropping of greengram and blackgram between uniform rows of castor maximized the gross and net returns per hectare and the RNR indices during the two years. The study confirmed that under divergent conditions of rainfall both in quantity and distribution castor planted in uniform rows at spacing of 90 cm can be efficiently intercropped with two rows of blackgram. This will produce bonus yield of the pulse. The intercropping of greengram was also equally profitable.

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