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Productivity and Economics of Castor (*Ricinus communis* L.) based Intercropping Systems in Vertisols under Rainfed Conditions

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ABSTRACT: A filed experiment was conducted at zonal Agricultural Research Station, Babbur Farm, Hiriyur during the rainy seasons of 2008 and 2009 to study different intercrops in castor (*Ricinus communis* L.,) in versitols of rainfed conditions. Paired row systems of castor intercropped with cluster bean in 2:4 row proportion gave significantly highest castor equivalent yield (2400 kg ha^{-1}) closely followed by castor intercropped with cluster bean in 1:3 row proportion. The LER was highest (1.70) with castor + cluster bean in 2:4 proportion while the net returns were greater when castor was intercropped with cluster bean either in 2:4 (Rs. 40485 ha^{-1}) or 1:3 (Rs. 37273 ha^{-1}) row proportion. The benefit: cost ratio was highest with castor + cluster bean in 2:4 row proportion (3.49) and castor + cluster bean in 1:3 row proportion (3.26). The sustainable value index (0.87) and rain water use efficiency (0.44 kg m^{-3}) were highest with paired row of castor + cluster bean in 2:4 row proportions.

Keywords : Intercropping, castor, cluster bean, land equivalent ratio, net returns, rain water use efficiency, sustainable value index.

Castor (*Ricinus communis* L.) is one of the important oilseed crops that has industrial value (Padmavathi and Raghavaiah, 2004). The productivity of castor under rainfed conditions is very low because of low and erratic rainfall, poor soils, improper adoption of latest technology *etc.* Intercropping has been identified as a kind of biological insurance against risks under aberrant rainfall conditions in rainfed regions (Koli *et al*., 2004). Castor is grown both as a sole crop and as a mixed or intercrop. It is ideally suited for intercropping systems owing to wider inter and intra row spacing. The present study was undertaken with an objective of maximizing productivity in castor based intercropping system. Different legumes and cereal were evaluated as intercrops between wide spaced castor rows.

Materials and Methods

Field experiment was conducted at Zonal Agricultural Research Station, Babbur Farm, Hiriyur, Karnataka during 2008 and 2009. The soil of experimental site was clayey and slightly alkaline in reaction (8.04). The soil was medium in available nitrogen (282 kg ha^{-1}), low in available phosphorus (15 kg ha^{-1}) and medium in available potassium (255 kg ha^{-1}). The organic carbon content was also medium (0.51%). The experiment was laid out in a randomized complete block design consisting of thirteen treatments of different sole and intercropping systems and replicated thrice. The treatments were sole castor, castor + groundnut (1:3), castor + finger millet (1:3), castor + *kharif* chickpea (1:3), castor + cluster bean (1:3), paired row of castor + groundnut (2:4), paired row of castor + fingermillet (2:4), paired row of castor + *Kharif* chickpea (2:4), paired row of castor + clusterbean (2:4) and sole crops of groundnut, finger millet. clusterbean and *kharif* chickpea. Furrows were opened with inter and intra row spacing of 90 cm and 45 cm for sole and 1:3 row proportion of castor intercropping systems. For paired row system of planting, two rows of castor were spaced at 60 cm with an inter row space of 120 cm between two pairs. Three rows of inter crops were sown in between two rows of castor and four rows of inter crops in between two pairs of castor (120 cm) with a basal application of 38 kg N ha^{-1} in the form of urea and 17 kg P in the form of SSP and 21 kg K ha^{-1} in the form of MOP. Seed yield and green vegetable yields were recorded and net returns were calculated on the basis of market rates. Rain water use efficiency (kg m^{-3}) was calculated by dividing castor equivalent yield (kg ha^{-1}) by the total volume of rainfall received during the crop

growth period (m^3). Sustainable value index (SVI) was calculated as per the method of Reddy and Kumar (1999).

Results and Discussion

Yield attributes and yield

Sole castor recorded significantly higher number of spikes per plant (9.0) and primary spike length (29.4 cm) at harvest as compared to other treatments except paired row systems of castor + cluster bean (2:4) and castor + groundnut (2:4) which were on par with each other. Significantly lower number of spikes per plant (7.5) and primary spike length was observed in castor + finger millet (1:3) intercropping. Similarly in all pickings significantly higher number of capsules per spike was recorded with sole crop of castor over castor + finger millet (1:3) and other treatments except paired row systems of castor + cluster bean and castor + groundnut intercropping system (Table 1). Castor grown in paired rows had no significant influence on the number of spikes $plant^{-1}$, length of primary, secondary and tertiary spike and the number of capsules per spike. This indicated that the pairing of rows did not increase the intra specific competition. This provided a scope to accommodate more number of rows of intercrops than in castor sown in equidistant rows. Similar results were reported by Srilatha *et al.* (2002) in castor with leguminous intercropping systems.

The mean seed yield of sole castor (1416 kg ha^{-1}) was higher than that in the rest of intercropping systems. Next best treatment for castor seed yield was castor + cluster bean (2:4) followed by castor + groundnut (2:4) The reduction in seed yield of castor when intercropped with finger millet was comparatively high. Thus with the leguminous crops like cluster bean, groundnut and chickpea, higher castor yields were recorded compared to castor intercropped with finger millet (Table 2).

Castor equivalent Yield (CEY) and land equivalent ratio (LER)

The castor equivalent yield was significantly higher in castor + cluster bean in 2:4 and 1:3 row proportions than sole crop of castor. Intercropping of castor with cluster bean (2:4) was found to be a profitable system. Similar results of castor + cluster bean intercropping systems were reported by Padmavathi and Raghavaiah (2004). The higher castor equivalent yield was due to additional intercrop yield with lower reduction in main crop yield. These results are in agreement with the findings of Tanunathan *et al*. (2006). Among different intercrops, castor + cluster bean (2:4) recorded higher land equivalent ratio (1.70) than other intercropping systems. While lowest was observed in 1:3 row proportion of castor + finger millet.

Economics, sustainable value index and rain water use efficiency

Among the castor based intercropping systems, intercropping of castor + cluster bean in 2:4 (₹ 40,485 ha^{-1}) and castor + cluster bean in 1:3 (₹ 37273 ha^{-1}) recorded higher net returns and B:C ratio of 3.49 and 3.26, respectively (Table 2). Paired row of castor + clusterbean (2:4) recorded the highest sustainable value index (0.87) followed by castor + cluster bean and castor + groundnut in 1:3 row proportion. Similar findings with higher net returns and sustainable value index in castor based intercropping system were reported by Koli *et al*. (2004). Therefore, clusterbean was found to be a compatible intercrop with castor. It indicates that the system exploited the resources in a better way and created less competition to castor. The higher castor yield intercropped with leguminous crops as compared to non leguminous crops was reported by Leelarani (2008). Lowest net returns were obtained in sole castor compared to its intercropping. The cluster bean yields were higher when they were sown in 4 rows compared to that of 3 rows due to more population. Similar observation was also reported by Padmavathi and Raghaviah (2004). Cluster bean intercropped in castor either in 1:3 or 2:4 row proportion recorder higher rain water use efficiency (0.44 kg m^{-3}) closely followed by castor + groundnut in 2:4 row proportion (0.38 kg m^{-3}).

Conclusion

From the study it can be concluded that paired row system of castor intercropped with cluster bean in 2:4 row proportion gave significantly highest castor equivalent yield (2400 kg ha^{-1}) closely followed by castor intercropped with cluster bean in 1:3 row proportion. Thus, 4 rows of cluster bean intercropped in paired rows of castor (60-120-60 cm) is beneficial in maximizing the productivity and profitability under rainfed conditions.

Table 1 : Growth and yield atributes of castor as influenced by different intercropping systems

Treatments	Spikes / plant		Spike length (cm)						Number of capsules per plant					
			Primary		Secondary		Tertiary		1st picking		2nd picking		3rd picking	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Sole castor	9.1	8.8	29.7	29.0	21.3	20.8	16.4	16.7	42.5	41.0	26.5	25.8	25.5	24.2
Castor + groundnut (1:3)	8.3	7.9	28.1	27.4	19.5	18.8	15.1	15.3	39.3	38.1	24.2	24.9	22.8	20.8
Castor + fingermillet (1:3)	7.7	7.2	24.8	24.0	19.2	18.4	14.4	14.6	31.8	30.6	23.2	21.6	22.1	19.9
Castor + *Kharif* chickpea (1:3)	8.2	8.0	27.9	27.1	19.2	18.7	14.9	15.1	38.3	37.0	23.9	22.6	22.8	20.8
Castor + cluster bean (1:3)	8.4	8.8	28.2	27.5	19.6	18.8	15.4	16.1	40.1	38.5	24.5	23.1	23.5	22.5
Paired row of castor + groundnut (2:4)	8.7	8.1	29.1	28.3	20.2	20.0	15.7	16.3	41.1	39.5	25.4	23.9	24.7	22.8
Paired row of castor + fingermillet (2:4)	8.0	7.9	26.1	25.6	19.4	18.9	14.5	14.7	37.9	36.6	23.8	22.7	22.5	21.1
Paired row of castor + *Kharif* chickpea (2:4)	8.4	8.0	28.2	27.4	19.7	18.9	15.5	15.7	39.9	38.7	25.1	23.6	23.8	21.8
Paired row of castor + cluster bean (2:4)	8.8	8.3	29.1	28.5	20.8	20.1	15.8	16.3	42.2	40.7	25.6	24.5	24.8	23.2
SEm±	0.2	0.16	0.4	0.25	0.4	0.26	0.3	0.20	0.8	1.14	0.4	0.69	0.3	0.85
CD at 5%	0.6	0.49	1.3	0.75	1.2	0.77	0.8	0.61	2.4	3.47	1.2	2.07	0.8	2.55

Table 2 : Seed yield of castor, intercrop yield, CEY, LER and economics of different intercropping systems

Treatments	Castor seed yield (kg ha^{-1})		Intercrop yield (kg ha^{-1})		CEY (kg ha^{-1})		LER		Net returns (Rs ha^{-1})		SVI	RWUE (kg m^{-3})	B:C ratio	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	Pooled	Pooled	2008	2009
Sole castor	1434	1398	-	-	1434	1398	1.00	1.00	19447	21077	046	0.26	2.50	2.60
Castor + groundnut (1:3)	1314	1253	723	654	2102	1947	1.66	1.63	30891	30129	0.78	0.37	2.78	2.71
Castor + fingermillet (1:3)	1175	1132	1198	1090	1638	1665	1.43	1.42	24660	26225	0.59	0.31	2.72	2.80
Castor + *Kharif* chickpea (1:3)	1272	1225	672	605	1974	1793	1.68	1.67	28575	27378	0.66	0.35	2.75	2.65
Castor + cluster bean (1:3)	1334	1323	3706	3210	2345	2371	1.69	1.65	33076	41470	0.72	0.44	3.02	3.49
Paired row of castor + groundnut (2:4)	1400	1334	676	600	2136	1970	1.67	1.62	32717	31728	0.78	0.38	3.00	2.92
Paired row of castor + fingermillet (2:4)	1258	1219	1124	1119	1692	1767	1.45	1.49	26069	28968	0.61	0.32	2.85	3.00
Paired row of castor + *Kharif* chickpea (2:4)	1351	1300	620	590	1999	1854	1.69	1.70	30065	27777	0.66	0.36	2.95	2.77
Paired row of castor + cluster bean (2:4)	1417	1377	3530	3200	2380	2421	1.71	1.68	37938	43032	0.87	0.44	3.36	3.63
SEm±	27.1	35.99	-		27.56	28.25	-	-				-	-	
CD. at 5%	81.2	107.9	-		82.64	84.75	-	-				-	-	

Sole crop yields (kg/ha) : Groundnut (975 and 897) , fingermillet (1961 and 1795), *kharif* chickpea (840 and 764) and clusterbean (4920 and 4585) during 2008 and 2009, respectively.
SVI = Sustainable value index, LER = Land equivalent ratio, RWUE= Rain water use efficiency, CEY=Castor equivalent yield

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