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Effect of Castor Based Intercropping Systems on Yields and Economics of Castor (*Ricinus communis* L.)

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A B S T R A C T

A field experiment was conducted at Regional Research Station, Bawal, Haryana during 2015-16 on loamy sand soil under irrigated condition to find out suitable intercrops *viz*., greengram, groundnut, clusterbean and sesamum under three different row spacings of castor 120, 180 and 240 cm. Results revealed that oil content of castor was not affected by different intercropping systems and row spacing of castor. The mean seed yield of sole castor (120 cm) was 5246 kg ha^{-1}, which was more than rest of the treatments. Results showed that magnitude of reduction in seed yield of castor was more severe with sesamum followed by clusterbean. Significantly highest castor equivalent yield (6037 kg ha^{-1}) was obtained in castor (180 cm) + groundnut (1:4), closely followed by castor (240 cm) + greengram (1:2) intercropping system. Net returns was greater when castor was intercropped with greengram either in 1:6 (Rs. 121455 ha^{-1}) or 1:2 (Rs. 119986 ha^{-1}) row proportion. The benefit: cost ratio was highest with castor (240 cm) + greengram in 1:6 row proportion (1.79) and castor (180 cm) + greengram in 1:2 row proportion (1.75).

Introduction

Castor (*Ricinus communis* L.) is an important non edible oilseed crop widely grown in arid and semiarid region. India is the largest producer of castor in the world. It earns valuable forex of worth Rs. 8000 crores and plays an important role in the agricultural economy of the country. Castor oil is mainly used for the manufacture of wide range of ever expanding industrial products such as nylon fibers, jet engine lubricants, hydraulic fluids, cosmetics, pharmaceuticals. Castor (*Ricinus communis* L.) is an important non edible oil seed crop of India being cultivated in 1.09 million hectares with a production of 1.86 million tonnes In Haryana castor occupies 3 thousand hectares with production of 4 thousand tonnes (Anonymous 2015). The basic concept of intercropping systems involve growing together two or more crops with the assumptions that two crops could exploit the environment better than one and ultimately producing higher yields, the reason being that the component crops differ in resources use and if growing together, they complement each other and make better overall use of resources. This practice leads to

some advantages like, economy of land, insurance against aberrant weather, production of higher yields and higher economic returns, build up or maintenance of soil fertility and diversification of farm produce. Intercropping provides substantial yield advantage over sole crop owing to temporal and spatial complementarity and minimizing inter or intra specific competition.

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 food grain, 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. Advantage of intercropping in castor can be increased by reorienting crop geometry for better availability of solar energy (Willey, 1979) and putting suitable intercrops. Legume crops may be better choice owing to beneficial effect of fixing atmospheric nitrogen and thereby some extra nitrogen was perhaps made available to the castor to utilize more efficiently beyond 90 DAS to harvest of castor. Crop geometry is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil and with above soil by harvesting the maximum possible solar radiation and in turn better photosynthates formation (Thavaprakaash*et al.*, 2005). By adopting appropriate crop geometry in the intercropping systems, the total productivity can be enhanced (Umrani*et al.*, 1984). Looking to good proposal of castor in irrigated ecosystem of Southern-Western Haryana this was conducted to realize higher net return. In order to have best utilization of available resources, present study was planned with crop geometry and short duration intercrop between underutilized inter row space on account of initial slow growth of castor.

Materials and Methods

A field experiment was conducted during 2015-16 at Regional Research Station, Bawal (Rewari), CCS Haryana Agricultural University. The soil of the experimental field was loamy sand in texture and slightly alkaline in reaction (pH 8.5), low in organic carbon (0.20 %) and nitrogen (148 kg ha^{-1}), medium in available phosphorus (13.4 kg ha^{-1}) and potassium (151 kg ha^{-1}). The experiment was conducted in randomized block design with three replications. The intercropping system comprising, sole castor, castor + greengram, castor + sesamum, castor + groundnut and castor + clusterbean under three level of row spacing of castor, viz., 12,0 180 and 240 cm and fifteen treatment combinations were made viz., Sole castor (120 cm), Castor (120 cm) + greengram (1:2), Castor (120 cm) + sesamum (1:2), Castor (120 cm) + groundnut (1:2), Castor (120 cm) + clusterbean (1:2), Sole castor (180 cm), Castor (180 cm) + greengram (1:4), Castor (180 cm) + sesamum (1:4), Castor (180 cm) + groundnut (1:4), Castor (180 cm) + clusterbean (1:4), Sole castor (240 cm), Castor (240 cm) + greengram (1:6), Castor (240 cm) + sesamum (1:6), Castor (240 cm) + groundnut (1:6) and Castor (240 cm) + clusterbean (1:6).

Castor hybrid DCH-177, greengram var. Basanti, Groundnut var. MH-4, sesamum var. HT-1 and Clusterbean var. HG 2-20 were sown on 3 July. All intercrops are sown at 30 cm x 10 cm row spacing. The recommended dose of N (40 kg ha^{-1}), full dose of P_2O_5 (50 kg ha^{-1}) and K_2O (25 kg ha^{-1}) was applied to castor through urea, DAP and MOP at the time of sowing by drilling in furrows 5-8 cm below the seeds. Remaining 50 per cent N (40 kg ha^{-1}) was top dressed in two equal splits at

20 days crop growth stage and 30 days thereafter. Recommended dose of fertilizer for intercrops apply as per the package of CCSHAU, Hisar. In all the intercrops nitrogen was applied as top dressing. Castor was weeded manually twice 20 and 40 DAS. During the crop season there was 292.8 mm rainfall. In all these were 7 pickings 120, 150, 180, 210, 240, 270 and 300 days after sowing, respectively. All other intercultural practices were done as per package of practices. For oil extraction, one gm dried and grinded seed samples were treated with petroleum- ether for 1- 2 hours in Soxhlet apparatus. After oil extraction, the treated samples were dried and weighed. Per cent reduction in oil content was calculated using simple formula given below:

$$\text{Oil content (\%)} = \frac{\text{(Weight of sample before extraction – Weight of sample after extraction)}}{\text{Weight of sample before extraction}} \times 100$$

Seed yield in each picking after threshing and winnowing was weighed. Seed weight of all pickings for each plot was summed to record yield in kg plot^{-1}. Finally plot yield was converted to kg ha^{-1}. For stover yield, plants were uprooted after last picking and kept for drying in the same plot. After satisfactory drying, the stalk was weighed and the weight was recorded in kg plot^{-1} and subsequently converted to kg ha^{-1}.The weight of completely sun dried plants and total capsules weight in respective plots were added and expressed as biological yield in kg ha^{-1}.Castor equivalent yield (CEY) was calculated in terms of castor yield of all intercropping treatments on the basis of prevailing market prices (Rs.kg^{-1}). It was calculated using formula suggested by Lal and Ray (1976).

CEY (Kg ha^{-1}) = [Seed yield of intercrops (kg ha^{-1}) x Price of intercrop (Rs kg^{-1}) / Price of castor (Rs kg^{-1})] + seed yield of castor (kg ha^{-1})

All the experimental data were statistically analysed by usual method of 'Analysis of Variance as described by Gomez and Gomez (1984).

Results and Discussion

Oil content and oil yield

Experiment results revealed that different intercropping systems and row spacing of castor have no significant influence on oil content of castor. These findings are in accordance with the findings of Patel *et al.*, (2007). Highest oil yield (2554 kg ha^{-1}) was recorded in sole castor (120 cm) followed by castor (120 cm) + greengram (1:2) intercropping system. Among row spacing of castor oil yield were declined 1.40 and 13.89 per cent in sole castor (180 cm) and sole castor (240 cm) over sole castor (120 cm), respectively. Among different intercropping systems higher oil yield of castor was recorded in castor + greengram intercropping due to higher seed yield of castor as compared to other intercropping systems. Similar result was also observed by Agarwal (2005) who reported that among different intercropping systems higher oil yield was obtained in castor + greengram intercropping system.

Yields

Sole castor recorded higher seed yield than intercropping system due to competition offered by these intercrops for natural resources The highest castor seed yield (5246 kg ha^{-1}) was obtained when castor crop was sown as sole castor (120 cm) though, it was found at par with sole castor (180 cm) and castor (120 cm) + greengram (1:2). Among different intercropping systems higher seed yield of castor was obtained in castor (120 cm) + greengram (1:2) followed by castor (120 cm) + groundnut (1:2). A significant reduction in seed yield of castor was observed under

intercropping treatments. The reduction in seed yield of castor, in the intercropping system was mainly due to reduction in plant stand of castor in different intercropping treatment replacement type of intercropping system was followed in the present study. Minimum magnitude of reduction in seed yield of castor was observed with greengram because greengram seems to be less harmful for castor might be due to its short life span and also their growth peaks are never coincide with each other which reduced demand pressure and environmental resources are efficiently utilized by both the crops. The magnitude of reduction in seed yield of castor was more severe with sesamum followed by clusterbean. Chand and Sujatha (2000) reported similar result that castor + sesamum intercropping recorded lower seed yield. The stalk yield of castor in sole planting at 240 cm and with 1:6 row combination with all the intercrops in this row spacing decreased significantly as compared to sole castor planted at 120 cm row spacing. Lowest stalk yield (6565 kg ha^{-1}) of castor was obtained in castor (240 cm) + clusterbean (1:6) intercropping system. The data (Table 1) showed that significantly higher stalk yield was recorded under sole castor (120 cm) which could be attributed to more number of plant population in sole castor (120 cm). Among intercropping highest biological yield (12752 kg ha^{-1}) of castor was recorded in castor (120 m) + greengram (1:2) and lowest (10996 kg ha^{-1}) in castor (240 cm) + clusterbean (1:6).

The data (Table 1) indicated that seed and stover yield of greengram, groundnut, clusterbean and sesamum were increased in 1:4 and 1:6 as compared to 1:2 row proportion due to higher plant densities of intercrops in 1:4 and 1:6 row ratio. Among the intercrops groundnut recorded higher grain yield of 1120 and 886 kg ha^{-1} at 1:6 and 1:4 row proportion, respectively as compared to other intercrops.

Table.2 Effect of different treatments on economics of castor

Treatments		Cost of cultivation (Rs ha^{-1})	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit: Cost ratio
T_1	Sole castor (120 cm)	70031	168666	98635	1.41
T_2	Castor (120 cm) + greengram (1:2)	71786	191772	119986	1.67
T_3	Castor (120 cm) + sesamum (1:2)	70839	168102	97263	1.37
T_4	Castor (120 cm) + groundnut (1:2)	74092	185262	111170	1.50
T_5	Castor (120 cm) + clusterbean (1:2)	71662	170597	98935	1.38
T_6	Sole castor (180 cm)	69419	168593	99174	1.43
T_7	Castor (180 cm) + greengram (1:4)	68604	188367	119763	1.75
T_8	Castor (180 cm) + sesamum (1:4)	68419	171035	102616	1.50
T_9	Castor (180 cm) + groundnut (1:4)	73318	192382	119064	1.62
T_{10}	Castor (180 cm + clusterbean(1:4)	70244	165327	95083	1.35
T_{11}	Sole castor (240 cm)	68887	143234	74347	1.08
T_{12}	Castor (240 cm) + greengram (1:6)	67979	189434	121455	1.79
T_{13}	Castor (240 cm) + sesamum (1:6)	68707	150942	82235	1.20
T_{14}	Castor (240 cm) + groundnut (1:6)	74053	186487	112434	1.52
T_{15}	Castor (240 cm) + clusterbean (1:6)	69469	158054	88585	1.28

Table.1 Effect of different treatments on oil content and yield of castor

Treatments		Oil content (%)	Oil yield (kg/ha)[1]	Seed yield (kg/ha)		Stalk/Stover yield (kg/ha)		Biological yield (kg/ha)		Castor equivalent yield (kg/ha)
				Castor	Intercrop	Castor	Intercrop	Castor	Intercrop	
T_1	Sole castor (120 cm)	48.67	2554	5246		7721		12967		5246
T_2	Castor (120 cm)+ greengram (1:2)	49.10	2524	5140	420	7612	1156	12752	1576	6026
T_3	Castor (120 cm) + sesamum (1:2)	48.90	2438	4987	155	7441	486	12427	641	5287
T_4	Castor (120 cm)+ groundnut (1:2)	48.60	2455	5053	636	7429	1354	12482	1991	5813
T_5	Castor (120 cm) + clusterbean (1:2)	48.47	2434	5020	280	7190	861	12210	1141	5359
T_6	Sole castor (180 cm)	48.73	2518	5163		7552		12715		5163
T_7	Castor (180 cm) + greengram (1:4)	47.10	2314	4913	580	7267	1617	12180	2197	5907
T_8	Castor (180 cm) + sesamum (1:4)	47.87	2301	4807	330	7129	1035	11935	1365	5307
T_9	Castor (180 cm) + groundnut (1:4)	48.10	2358	4898	886	7395	1529	12293	2416	6037
T_{10}	Castor (180 cm + clusterbean(1:4)	48.47	2354	4859	368	7239	1191	12098	1560	5180
T_{11}	Sole castor (240 cm)	48.70	2199	4515		6745		11260		4515
T_{12}	Castor (240 cm) + greengram (1:6)	48.03	2192	4567	720	6824	2103	11390	2823	5933
T_{13}	Castor (240 cm) + sesamum (1:6)	47.90	2082	4350	421	6652	1379	11002	1800	4717
T_{14}	Castor (240 cm) + groundnut (1:6)	48.57	2203	4533	1120	6821	2410	11354	3530	5828
T_{15}	Castor (240 cm) + clusterbean (1:6)	47.30	2082	4401	688	6565	2287	10966	2976	4919
	SEm±	0.43	87.23	173	55	329	186	318	234	267
	C.D. (P=0.05)	NS	247.25	490	163	678	549	853	690	526

In all three row proportion lowest yield was obtained in sesamum compared to other intercrops. Agarwal (2005) also obtained similar result that sesamum recorded lowest yield than other intercrops greengram, blackgram and clusterbean. Among the intercrops groundnut recorded higher biological yield of 3530 and 2416 kg ha^{-1} at 1:6 and 1:4 rows proportion, respectively as compared to other intercrops. Groundnut recorded significantly higher stover yield (3530 kg ha^{-1}) at 1:6 row proportion though, it was found at par with the castor (240 cm) + clusterbean (1:6).

Although significant reduction in the seed yield of base crop and intercrops in different intercropping treatments was recorded, yet the recovery in the seed yield in treatment like castor + groundnut (1:4) and castor + greengram (1:2) was higher which leads to higher castor equivalent yield than sole castor. Castor equivalent yield was significantly higher in castor + groundnut (1:4) and castor+ greengram (1:2) over sole castor and other intercropping systems which might be due to higher yield of groundnut and greengram as well as less reduction of castor seed yield in this intercropping system. Similar results reported by Dhimmar (2009) that castor + greengram intercropping system recorded highest castor equivalent yield. Higher castor equivalent yield under castor + legume intercropping system over sole castor and castor + sesamum. These results are in conformity with the earlier findings of Sharma and Singh (2014).

Economics

Highest gross return was obtained in castor (180 cm) + groundnut (1:4) followed by castor (120 cm) + greengram (1:2). The monetary return as elucidated by net return was significantly higher in intercropping as compared to sole castor (Table 2). Looking to the economics, castor + greengram (1:6) and castor + greengram (1:2) gave higher net realization than other intercropping system and sole castor. This could be due to higher yield of castor as well as intercrops in intercropping systems. Castor + greengram (1:6) intercropping system gave highest net return (Rs. 121455 ha^{-1}) due to higher yield of greengram as well as less reduction in seed yield of castor. Intercropping of sesamum and clusterbean reported lower seed yield of castor because it might suppressed the growth of castor and reduced the yield of castor and ultimately monetary return was decreased as compared to other intercropping systems and their sole crops. Rajput and Shrivastava (1996) reported that adoption of castor + sesamum intercropping system reduced the net returns. Castor (240 cm) + greengram (1:6) intercropping provided 23.13, 22.46 and 63.36 per cent higher net return over sole castor (120 cm), sole castor (180 cm) and sole castor (240 cm), respectively. Highest B: C ratio (1.79) was obtained in castor (240 cm) + greengram (1:6) followed by castor (180 cm) + greengram (1:4) with B: C ratio of (1.75)

Based on the results it can be concluded that intercropping of castor (240 cm) + greengram at 1:6 row ratio was distinctly superior over sole castor and found more profitable by realizing the net return of Rs. 121455 ha^{-1} and benefit cost ratio of 1.79 on loamy sand soils of Bawal (Rewari) under Southern-Western Haryana conditions.

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