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Impact of intercropping system on castor growth and production under the semi-arid region of Haryana

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Abstract
The field experiment entitled "Effect of different legume, cereal and oilseed intercrops on castor (*Ricinus communis* L.) Productivity under the semi-arid region of Haryana" was conducted at Regional Research station, Bawal, CCS HAU during the *kharif* season of 2020-21, with the objectives to find out best suitable intercrops *viz*., greengram, pearl millet and sesame for castor intercropping system with respect to castor growth and production under two different row spacings of 150 and 200 cm. The results showed that significantly higher number of branches, length of primary spike, number of spikes plant^{-1}, number of capsules primary spike^{-1}, seed index and yield (seed and stalk) were recorded with values of 3,879 kg ha^{-1} and 5,656 kg ha^{-1}, respectively in the sole castor (200 cm) which was at par with castor sole (150 cm) and castor (150 cm) + mungbean (1:2) intercropping system. The highest castor equivalent yield (4220 kg ha^{-1}) was obtained in castor (200 cm) + mungbean (1:4).

Keywords: Sole, intercrops, growth, productivity, spacing, branches, spike, capsules, yield

Introduction
Castor *(Ricinus communis* L.) is an indeterminate and non-edible oilseed crop. It belongs to the family *Euphorbiaceae.* It is native to Eastern Africa and originated in Ethiopia. Cultivated in low rainfall regions (drought tolerant) of the semi-arid region of India. India is the largest producer of castor in the world. Castor seeds contain 50-55 percent oil and are the world's second-largest source of non-edible oil. Castor oil is mainly used for the manufacture of wide range of ever-expanding industrial products such as nylon fibres, jet engine lubricants, hydraulic fluids, cosmetics, pharmaceuticals. Castor oil is a good choice for converting oil in to bio-diesel. Castor cake provides highly concentrated organic manure with 4.5, 2.6 and 1.2 percent of nitrogen, phosphorous and potash, respectively and it also offers 22.37 percent protein and 45-46 percent of carbohydrates.
However, castor is a long-term, widely spaced crop with a comparatively thin population of plants, providing scope for intercropping with quick growing and short duration food grain (cereal), pulse and oilseed crops in appropriate geometry to increase the growth, yield attributes and yield per unit area. Advantage of intercropping in castor can be increased by reorienting crop geometry for better availability of solar energy (Willey, 1981) [11] and putting suitable intercrops. Intercropping has been recognized as a potentially beneficial system of crop production which can provide sustained yield advantages compared to sole cropping. By looking to good proposal of castor in irrigated ecosystem of Southern-Western Haryana this research 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.

Material and Methods
A field experiment was conducted during 2020-21 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 (0.21%) and nitrogen (125 kg ha^{-1}), medium in available phosphorus (16.2 kg ha^{-1}) and potassium (195.4 kg ha^{-1}). The experiment was conducted in randomized block design with three replications. The intercropping system comprising of castor + greengram, castor + pearl millet and castor + sesame, under two level of row spacing of castor, *viz*., 150 and 200 cm and eleven treatment

combinations were made *viz*., Sole castor (150 cm), Sole castor (200 cm), Sole greengram, Sole pearl millet, Sole sesame, Castor (150 cm) + greengram (1:2), Castor (150 cm) + pearl millet (1:2), Castor (150 cm) + sesame (1:2), Castor (200 cm) + greengram (1:4) and Castor (200 cm) + pearl millet (1:4), Castor (200 cm) + sesamum (1:4). Castor hybrid DCH-177, greengram var. MH-421, pearl millet var. HHB-67 Imp. And sesamum var. HT-2 were sown on 10 July. All intercrops are sown at 30 cm x 10 cm row spacing. During the crop season there was 312.9 mm rainfall. In all these were 5 pickings 120, 150, 180, 230 and 270 days after sowing, respectively. All other intercultural practices were done as per package of practices of CCSHAU.

Results and Discussion

A. Crop growth parameters

Plant growth and development was indicated by plant population, plant height, plant spread and dry accumulation per plant.

1. Plant population

Plant growth and development studies data in Table 1 revealed that plant population at 30 days after sowing did not differ significantly but at harvest. Maximum plant population was recorded in sole castor (5,333 plants ha^{-1}) at 150 cm row spacing which was followed by castor (150 cm) + mungbean (5,222 plants ha^{-1}) in 1:2 row ratio treatment. The lowest plant population was recorded in castor (200 cm) + pearl millet (4,255 plants ha^{-1}) which was lesser by 20.21 percent as compared to sole castor (200 cm) because of pearl millet is an exhaustive crop and more competitive to castor which removes more nutrients from soil and in turn reduced the plant population. Similar results were found by Kumar *et al.* (2013) [3] that significantly higher plant population was found in castor + mungbean (1:2) cropping system among different row intercrop spacing systems.

2. Plant dry matter weight

Sole castor sown in row spacing of 150 and 200 cm had higher dry matter accumulation per plant at harvest (Table 1) as compared to castor based intercropping system with mungbean, pearl millet and sesame. The dry matter per plant was decreased by 299.0 and 123.9 g $plant^{-1}$, 386.9 and 353.9 g $plant^{-1}$, 309.2 and 236.0 g $plant^{-1}$, respectively by mungbean, pearl millet and sesame in 1:2 and 1:4 row ratios with castor as compared to sole castor in 150 and 200 cm row spacing. This might be due to the competitive effect of intercropping for soil moisture, light, nutrients and space to castor. Mohsin *et al.* (2018) [5] and Keshavamurthy and Yadav (2019) also observed that castor sole in 240 cm row spacing recorded maximum dry matter accumulation per plant at harvest as compared to narrow sole spacing and intercropping systems.

3. Plant height

The data (Table 2) indicated that plant height of castor was significantly affected by to different intercropping systems and row spacing of castor except at 30 DAS. Plant height of castor was recorded highest in sole castor (200 cm) at all the stages except at 30 DAS. Castor sown under wider row spacing recorded higher plant height of castor. Similar results were found by Mohsin *et al.* (2018) [5] that castor sole (240 cm) obtained maximum plant height as compared to all other intercropping systems. Among various intercropping, lower plant height in castor was recorded by castor + pearl millet intercropping. Vaghela *et al.* (2019) [10] reported similar results that pearl millet intercropping system recorded least plant height than mungbean and sesame intercropping system with castor.

4. Plant spread

Plant spread (Table 2) of castor was significantly affected by to different intercropping systems and row spacing of castor except at 30 DAS. Maximum plant spread of castor was recorded in sole castor (200 cm). Among various intercropping, lower plant spread of castor was recorded in castor (150 cm) + pearl millet (1:2) system. Similar results were reported by Dhimmar *et al.* (2009) [1], where castor sole had noted higher plant spread as compared to different intercropping systems. Castor sown under wider row spacing recorded maximum plant spread among all other treatments.

B. Yield

Seed and stalk of castor showed significantly difference due to different intercropping in two different row spacing of castor.

The data (Table 3) indicated that seed yield of castor increased in wider intercropping system of 200 cm over narrow row spacing of 150 cm. Sole planted castor recorded higher seed yield than intercropping system due to competition offered by these intercrops for natural resources. Among different intercrops, higher seed yield in castor was obtained when castor was intercropped with mungbean. Intercropping of mungbean in two row spacing of 150 and 200 cm remained at par to each other but superior than intercropping with pearl millet in their respective row spacings. This might be due to the fact that legume might have improved nitrogen status of the soil on account of atmospheric N-fixation which was utilized by castor after harvest of legumes. Reddy *et al.* (2008) [8] reported that pulses had a complementary effect and cereals had a competitive effect when they were grown as intercrops with castor. Castor (200 cm) + pearl millet in 1:4 row ratio system recorded lowest yield among all intercropping system of 1:2 and 1:4 row ratio. Rana *et al.* (2006) [13] also recorded similar results that wider row spacing (90 cm) produced high castor yield than castor spaced at 60 and 75 inter-row spacing. The higher castor seed yield obtained when intercropped with leguminous crops as compared to non-leguminous crops as reported by Narayan Mavarkar (2006) [12] and Leela Rani (2008) [4]. They also observed reduction in seed yield of castor under intercropping systems as compared to sole cropping. The results showed that significantly higher stalk yield was recorded under sole castor (200 cm) which could be attributed due to a greater number of yield attributing characters. Mohsin *et al.* (2018) [5] also reported similar results in castor-based intercropping. Castor sole planting obtained higher stalk as compared to different intercropping systems.

C. Castor equivalent yield

Apart from the competitive effects, prevailing prices of economic produce become an additional factor in choosing the components of intercropping system and so yield of intercrops were converted to castor equivalent yield and added to castor yield. Castor equivalent yield (Table 3) was significantly higher in castor (200 cm) + mungbean (1:4) and castor (150 cm) + mungbean (1:2) intercropping systems over sole castor and other intercropping systems which might be due to high price along with higher yield of greengram as well as less reduction of castor seed yield in this intercropping system. These results are in agreement with the findings

Narayan Mavarkar (2006) [12] and Thanunathan *et al*. (2006) [9]. According Mohsin *et al.* (2018) [5], who reported higher castor equivalent yield in castor + greengram intercropping system. The reduction of castor equivalent yield was recorded more in intercropping with pearl millet and sesame; therefore, lower castor equivalent yield was obtained. Vaghela *et al*. (2019) [10] reported similar results that castor intercropped with pearl millet and sesame recorded lower castor equivalent yield compared to mungbean intercropping system.

Table 1: Effect of different intercropping systems on plant population and dry matter accumulation of castor at harvest

Treatments		Plant population (000' plants ha^{-1}) at harvest	Dry matter accumulation (g $plant^{-1}$) at harvest
T_1	Castor sole (150cm)	5.33	1,384
T_2	Castor sole (200cm)	5.17	1,491
T_3	Mungbean sole	-	-
T_4	Pearl millet sole	-	-
T_5	Sesame sole	-	-
T_6	T1 + Mungbean (1:2)	5.22	1,085
T_7	T1 + Pearl millet (1:2)	4.37	997
T_8	T1 + Sesame (1:2)	5.19	1,075
T_9	T2 + Mungbean (1:4)	4.95	1,367
T_{10}	T2 + Pearl millet (1:4)	4.25	1,137
T_{11}	T2 + Sesame (1:4)	4.93	1,255
	SEm±	0.20	41
	C.D. (p=0.05)	0.62	125

Table 2: Impact of various intercropping systems on periodical changes in plant height and spread of castor

Treatments		Plant height (cm)				Plant spread (cm)			
		90 DAS	150 DAS	210 DAS	270 DAS	90 DAS	150 DAS	210 DAS	270 DAS
T_1	Castor sole (150cm)	96.60	133.29	176.60	102.99	102.99	136.62	174.68	191.34
T_2	Castor sole (200cm)	100.76	140.84	183.16	115.79	115.79	138.00	181.11	199.78
T_3	Mungbean sole	-	-	-	-	-	-	-	-
T_4	Pearl millet sole	-	-	-	-	-	-	-	-
T_5	Sesame sole	-	-	-	-	-	-	-	-
T_6	T_1 + Mungbean (1:2)	83.52	124.83	164.63	90.55	90.55	124.53	151.02	168.02
T_7	T1 + Pearl millet (1:2)	82.13	119.63	155.51	78.63	78.63	106.89	130.95	146.95
T_8	T1 + Sesame (1:2)	82.46	123.68	161.16	79.03	79.03	113.30	136.73	154.73
T_9	T2 + Mungbean (1:4)	94.84	130.59	171.92	102.42	102.42	134.96	166.13	184.13
T_{10}	T2 + Pearl millet (1:4)	85.83	125.20	166.45	92.54	92.54	124.38	155.72	171.06
T_{11}	T2 + Sesame (1:4)	92.99	129.49	169.99	94.78	94.78	124.24	157.33	176.33
	SEm±	2.67	3.87	5.01	4.59	4.59	4.31	7.27	6.47
	C.D. (p=0.05)	8.17	11.84	15.34	14.04	14.04	13.20	22.25	19.80

Table 3: Influence of different intercropping systems on yield of castor and different intercrops and castor equivalent yield

Treatments		Seed Yield (kg ha^{-1})		Stalk Yield (kg ha^{-1})		CEY (kg ha^{-1})
		Castor	Intercrop	Castor	Intercrop	
T_1	Castor sole (150cm)	3,840	-	5,648	-	3,840
T_2	Castor sole (200cm)	3,879	-	5,656	-	3,879
T_3	Mungbean sole	-	1,402	-	4,137	-
T_4	Pearl millet sole	-	3,002	-	6,504	-
T_5	Sesame sole	-	556	-	1,631	-
T_6	T1 + Mungbean (1:2)	3,547	551	5,248	1,681	4,098
T_7	T1 + Pearl millet (1:2)	3,020	1,200	4,566	2,846	3,570
T_8	T1 + Sesame (1:2)	3,443	157	5,150	463	3,680
T_9	T2 + Mungbean (1:4)	3,250	970	4,792	2,953	4,220
T_{10}	T2 + Pearl millet (1:4)	2,410	2,414	3,628	5,233	3,516
T_{11}	T2 + Sesame (1:4)	3,195	327	4,751	960	3,686
	SEm±	110	61	164	154	120
	C.D. (p=0.05)	339	185	504	467	367

Fig 1: Field view of experimental area

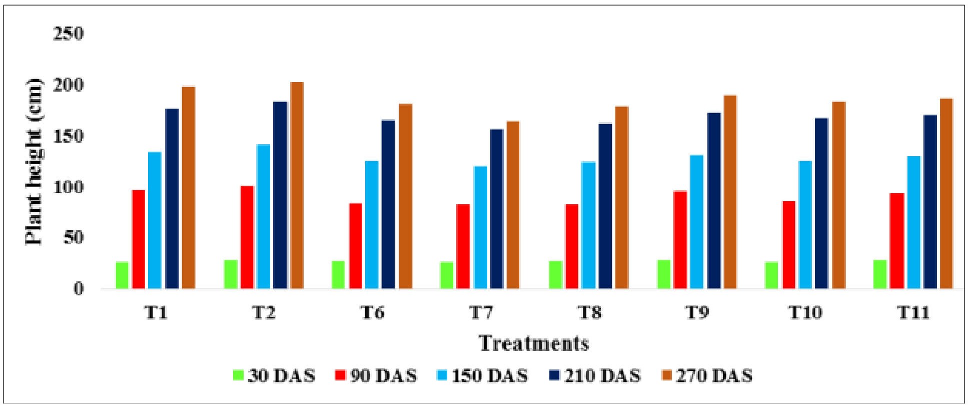

Fig 2: Effect of various treatments on plant height of castor

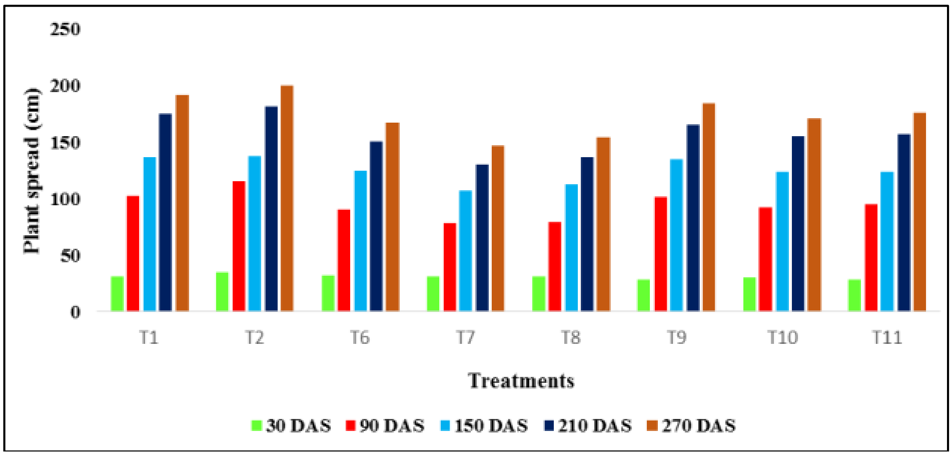

Fig 3: Influence of various treatments on plant spread of castor

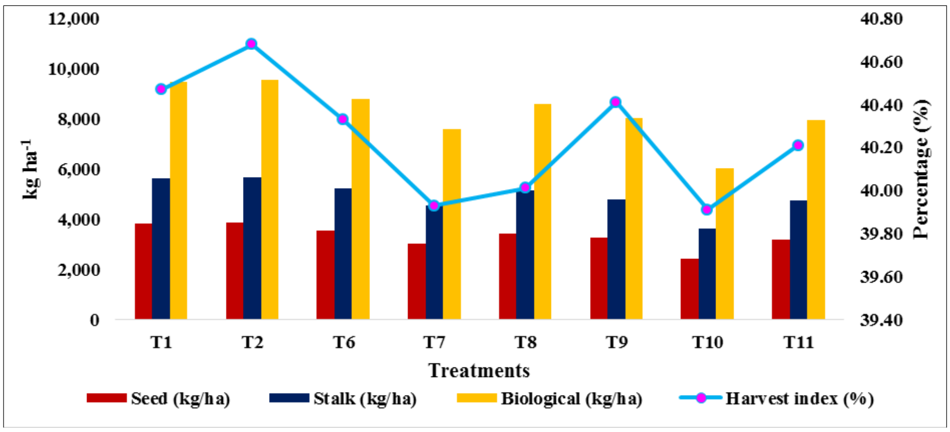

Fig 4: Influence of different treatments on castor yield and harvest index

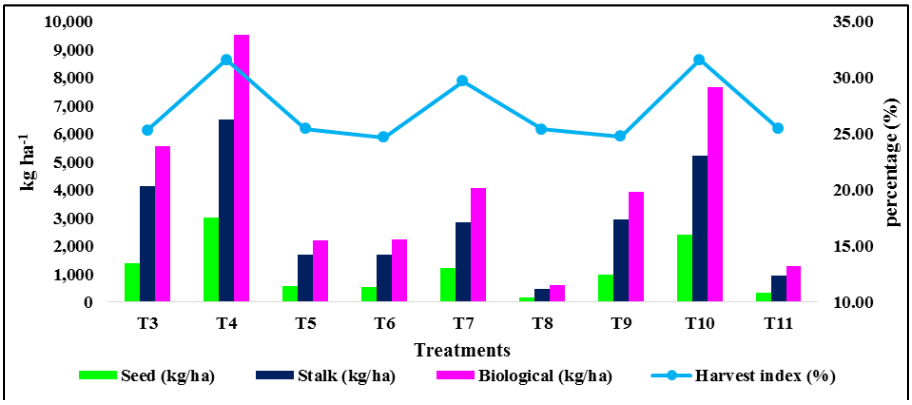

Fig 5: Impact of various treatments on yield and harvest index of intercrop

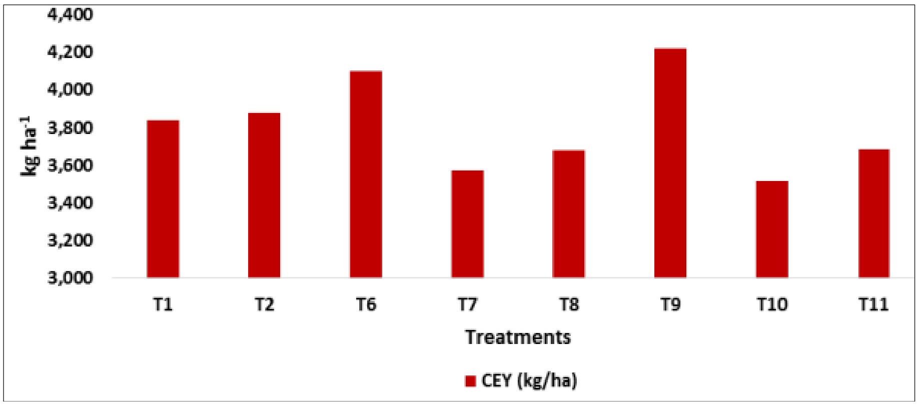

Fig 6: Impact on castor equivalent yield by various treatments

Conclusion

This study provides information that by introducing the legume intercrop with wider spacing found advantageous by obtaining higher castor yield and castor equivalent yield as compared other intercropping and sole cropping system. Castor (200 cm) + mungbean in 1:4 row ratio exhibited the superiority over all other treatments.

Hence intercropping system found more profitable and sustainable as compared with sole castor, gives high remunerative to farmers under semi-arid region of Haryana.

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