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Evaluation of Castor (*Ricinus communis* L.) Based Intercropping Systems

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ABSTRACT

A field experiment on 'evaluation of castor (*Ricinus communis* L.) based intercropping systems' was conducted at Regional Research Station, Bawal, CCS HAU during the *kharif* season of 2020-21 in the loamy sand soils to study the performance of castor based intercropping system with different row proportion and planting geometry. The results showed that significantly higher yields (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 various intercropping indices computed among these intercropping systems *viz.,* LER, ATER, A, RCC and CR indicated that pearl millet was most competitive and mungbean was most complementary among intercrops for base crop. The highest castor equivalent yield (4220 kg ha^{-1}), net returns (1,57,453 Rs.ha^{-1}) and B:C (3.78) was exhibited in castor (200 cm) + mungbean (1:4) intercropping system.

Keywords : Nanochemicals, Maize hybrid, Dry dressing, Polymer coating & seed quality

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, which is 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 per cent oil and are the world's second-largest source of non-edible oil. Castor oil is the only natural source of a hydroxylated fatty acid which is containing around 90 per cent of the ricinoleic acid; no other vegetable oil produces such a high predominance of a single fatty acid (Yamanura and Mohan, 2020). 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 and 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 per cent of nitrogen, phosphorous and potash, respectively and it also offers 22.37 per cent protein and 45-46 per cent 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 growth, yield and economics per unit area. Growing castor at wider row spacing reduces the plant population on acreage basis but castor can compensate the yield loss by increasing growth and yield of individual plant (Dhimmar and Raj, 2009). Advantage of intercropping in castor can be increased by reorienting crop geometry for better availability of solar energy 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. These advantages are especially important because they are achieved not by means of costly inputs but the simple expedient of growing crop together. It provides an insurance against total crop failure and also reduces soil erosion if the plants of the subsidiary crops have trailing habit. The success of intercropping is mainly dictated by crop compatibility, suitable modification in planting patterns and careful selection of crops which could reduce mutual competition between main and intercrop to a considerable extent. Intercropping in castor could increase the production and net profit per unit area per unit time (Rajput and Mishra, 1995). By 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.

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 sole castor, castor + greengram, castor + pearl millet and castor + sesame, under two level of row spacing of castor, *viz.,* 150 and 200 cm and made eleven treatment combinations *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 hybrid. HHB-67 Imp. and sesamum var. HT-2 were sown on 10th July. All intercrops are sown at 30 cm x 10 cm row spacing. The recommended half dose of N (45 kg ha^{-1}), full dose of P_2O_5 (45 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 (45 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 applied 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 312.9 mm rainfall. Castor spikes were harvested in 5 pickings *viz*., 120, 150, 180, 230 and 270 days after sowing, respectively. All other intercultural practices were done as per package of practices.

Results and Discussion

The present study entitled, 'evaluation of castor based intercropping systems' was conducted during *kharif* season of 2020-21 aimed to predict the best intercrop with suitable row ratio in castor whereby, a farmer will get full harvest of castor yield and possible additional returns with different intercrops. Therefore, three intercrops *viz.,* mungbean, pearl millet and sesame were intercropped with castor at 1:2 and 1:4 row ratios within spacing of castor at 150 and 200 cm, respectively and were compared to the sole castor. In this chapter, it is intended to discuss the variations observed in yield, competitive indices and economics of intercrops under different treatments. This efficiency depends on all crop components and how those components interact with each other. In this chapter, the attempt has been made to discuss the cause and effect relationship behind those variations that occurred due to different intercropping treatments. The results of the study are discussed and described in light of available evidences and literature of all other workers in this area, from earlier findings. The complete discussion has been divided in following heading for better understanding.

Influence of Different Sole and Intercropping Systems on Yield Attributes of Castor

Length of primary spike, number of spikes $plant^{-1}$, number of branches $plant^{-1}$ and number of capsules primary spike^{-1} were significantly higher in sole castor at 200 cm, which is on par with castor sole at 150 cm as compared to other intercropping system (Table 1). This was due to increased amount of light interception, availability of more space, less competition for nutrients, water and light. Keshavamurthy and Yadav (2019), recorded similar results that higher yield attributes (length of primary spike, number of spikes plant^{-1}, number of branches plant^{-1} and number of capsules primary spike^{-1}) in castor sole (240 cm). Daisy *et al.* (2013) also reported that wider row spacing in castor recorded higher number of spikes plant^{-1} and number of branches plant^{-1}. Among intercrops highest number of spikes plant^{-1} and number of capsules primary spike^{-1} was obtained when castor (200 cm) was intercropped with mungbean (1:4) and corroborated by Mohsin *et al.* (2018) and Porwal *et al.* (2006). The data in Table 1 indicated that different treatments had no significant effect on seed index of castor. Sharma (1985), also reported that 100 seed weight of castor did not differ significantly due to altered crop geometry. Mohsin *et al.* (2018), Keshavamurthy and Yadav (2019), Kumar (2002) and Patel *et al.* (2007) also reported similar results.

Performance of Castor and Intercrops as Affected by Different Treatments

Seed, stalk and biological yield of castor showed (Table 2) significantly difference due to different intercropping's in two different row spacing of castor except the harvest index. The data indicated that seed yield of castor increased in wider intercropping system of 200 cm over narrow row spacing of 150 cm. In row spacing of 150 cm, seed yield of castor decreased due to lesser yield attributes as compared to sole castor at 200 cm. Sole planted castor recorded higher seed yield than intercropping system due to competition offered by these intercrops for natural resources. 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. Among different intercrops, higher seed yield of 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. Similar results observed by Sunil Kumar and Shivaramu (2015), planting pattern with wider spacing result in higher seed yield of rainfed castor.

TABLE 1

Impact of different intercropping systems on castor yield attributes

	Treatments	No. of branches plant^{-1}	Length of primary spike (cm)	No. of spikes plant^{-1}	No. of capsules primary spike^{-1}	Seed index (g)
T_1	Castor sole (150cm)	12.80	57.73	17.87	81.11	31.92
T_2	Castor sole (200cm)	13.20	60.60	18.47	89.33	32.29
T_3	Mungbean sole	-	-	-	-	-
T_4	Pearl millet sole	-	-	-	-	-
T_5	Sesame sole	-	-	-	-	-
T_6	T1 + Mungbean (1:2)	10.73	56.87	14.53	72.78	31.12
T_7	T1 + Pearl millet (1:2)	8.00	52.27	11.90	71.56	30.40
T_8	T1 + Sesame (1:2)	9.87	56.07	13.27	72.67	30.67
T_9	T2 + Mungbean (1:4)	12.47	54.80	17.80	80.50	31.50
T_{10}	T2 + Pearl millet (1:4)	8.47	53.40	12.87	72.04	31.54
T_{11}	T2 + Sesame (1:4)	10.61	52.60	14.80	74.44	31.87
	SEm±	0.59	3.69	1.03	2.96	1.09
	C.D. (p=0.05)	1.81	N S	3.16	9.06	N S

TABLE 2

Influence of different intercropping systems on seed, stalk, biological yield and harvest index of castor crop

	Treatments	Seed yield ($kg\ ha^{-1}$)	Stalk yield ($kg\ ha^{-1}$)	Biological yield ($kg\ ha^{-1}$)	Harvest index (%)
T_1	Castor sole (150cm)	-	-	-	-
T_2	Castor sole (200cm)	-	-	-	-
T_3	Mungbean sole	1,402	4,137	5,539	25.31
T_4	Pearl millet sole	3,002	6,504	9,506	31.58
T_5	Sesame sole	556	1,631	2,187	25.43
T_6	T1 + Mungbean (1:2)	551	1,681	2,232	24.68
T_7	T1 + Pearl millet (1:2)	1,200	2,846	4,047	29.67
T_8	T1 + Sesame (1:2)	157	463	621	25.41
T_9	T2 + Mungbean (1:4)	970	2,953	3,924	24.74
T_{10}	T2 + Pearl millet (1:4)	2,414	5,233	7,647	31.57
T_{11}	T2 + Sesame (1:4)	327	960	1,287	25.42
	SEm±	61	154	215	1.42
	C.D. (p=0.05)	185	467	651	4.29

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. Rana *et al.* (2006) 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 data showed that significantly higher stalk and bio logical yield were recorded under sole castor (200 cm) which could be attributed due to a greater number of yield attributing characters. Mohsin *et al.* (2018) also reported similar results in castor-based intercropping.

TABLE 3

Influence of different intercropping systems on seed, stalk, biological yield and harvest index of intercrops

	Treatments	Seed yield ($kg\ ha^{-1}$)	Stalk yield ($kg\ ha^{-1}$)	Biological yield ($kg\ ha^{-1}$)	Harvest index (%)
T_1	Castor sole (150cm)	3,840	5,648	9,488	40.47
T_2	Castor sole (200cm)	3,879	5,656	9,535	40.68
T_3	Mungbean sole	-	-	-	-
T_4	Pearl millet sole	-	-	-	-
T_5	Sesame sole	-	-	-	-
T_6	T1 + Mungbean (1:2)	3,547	5,248	8,795	40.33
T_7	T1 + Pearl millet (1:2)	3,020	4,566	7,586	39.93
T_8	T1 + Sesame (1:2)	3,443	5,150	8,605	40.01
T_9	T2 + Mungbean (1:4)	3,250	4,792	8,042	40.41
T_{10}	T2 + Pearl millet (1:4)	2,410	3,628	6,038	39.91
T_{11}	T2 + Sesame (1:4)	3,195	4,751	7,946	40.21
	SEm±	110	164	275	1.54
	C.D. (p=0.05)	339	504	844	N S

Castor sole planting obtained higher stalk and biological yield as compared to different inter cropping systems. The harvest index of castor (39.91 to 40.68%) showed no significant difference among castor based intercropping systems with mungbean, pearl millet and sesame over sole castor.

The Table 3 indicated that seed, stover, biological yield and harvest index of mungbean, pearl millet and sesame were higher in 1:4 as compared to 1:2 row proportion due to their higher plant densities as intercrops. Sole planting of intercrop has recorded higher seed, stalk and biological yield. Among different intercropping system, higher seed yield was obtained in pearl millet, mungbean and sesame in 1:4 row ratio with castor (200 cm) intercropping system. Vaghela *et al*. (2019) reported same results that pearl millet had recorded higher seed yield than mungbean and sesame. Between two different row ratio, lower yield was obtained in sesame compared to other intercrops. Agarwal (2005), also obtained similar result that sesame recorded lowest yield than other intercrops of greengram, blackgram and clusterbean. The straw and biological yields also followed the trend of seed yield. The maximum value of harvest index was recorded in pearl millet (31.58%), sesame (25.43%) and mungbean (25.31%) in their sole stands whereas, in 1:2 row ratio was 29.67, 25.41 and 24.68 per cent, respectively and in 1:4 row ratio exhibited 31.57, 25.43 and 24.74 per cent, respectively with castor intercropping system.

Assessment of Different Intercropping

The various intercropping advantages/competitive indices were calculated based on sole and intercrop yields of castor, mungbean, pearl millet and sesame crops are represented in Table 4 and 5.

Castor Equivalent Ratio

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

TABLE 4

Influence of different intercropping systems on castor equivalent ratio

	Treatments	CEY (kg ha^{-1})
T_1	Castor sole (150cm)	3,840
T_2	Castor sole (200cm)	3,879
T_3	Mungbean sole	-
T_4	Pearl millet sole	-
T_5	Sesame sole	-
T_6	T_1 + Mungbean (1:2)	4,098
T_7	T_1 + Pearl millet (1:2)	3,570
T_8	T_1 + Sesame (1:2)	3,680
T_9	T_2 + Mungbean (1:4)	4,220
T_{10}	T_2 + Pearl millet (1:4)	3,516
T_{11}	T_2 + Sesame (1:4)	3,686
	S.Em±	120
	C.D. (p=0.05)	367

TABLE 5

Intercropping indices as affected by different intercropping systems

Treatments	LER	IER (Rs. ha^{-1})	ATER	Aggressivity		Crowding coefficient			Competitive ratio		MAI (Rs. ha^{-1})
				Castor	Intercrop	Castor	Intercrop	Total	Castor	Intercrop	
T_6 T1 + Mungbean (1:2)	1.32	1.33	1.01	0.022	-0.022	24.24	0.32	24.56	4.70	0.21	14,740
T_7 T1 + Pearl millet (1:2)	1.19	1.19	0.88	0.018	-0.018	7.37	0.33	7.70	3.93	0.25	9,080
T_8 T1 + Sesame (1:2)	1.18	1.18	0.95	0.023	-0.023	17.35	0.20	17.55	6.31	0.16	3,795
T_9 T2 + Mungbean (1:4)	1.53	1.53	0.99	0.033	-0.033	20.67	0.56	21.23	4.84	0.21	40,849
T_{10} T2 + Pearl millet (1:4)	1.43	1.43	0.81	0.021	-0.021	6.56	1.03	7.59	3.09	0.32	38,453
T_{11} T2 + Sesame (1:4)	1.41	1.41	0.93	0.034	-0.034	18.70	0.36	19.05	5.60	0.18	16,580

LER - Land Equivalent Ratio; IER - Income Equivalent Ratio; ATER - Area Time Equivalent Ratio; MAI - Monetary Advantage Index to castor equivalent yield and added to castor yield. Castor equivalent yield 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 Sharath *et al.* (2011), Narayan Mavarkar (2006) and Thanunathan *et al*. (2006).

Land Equivalent Ratio

The land equivalent ratio (LER) signifies relative land area required under sole stand to produce equivalent yield in intercropping system under same management practices (Willey, 1979). In terms of LER, castor (200 cm) + mungbean (1:4) had maximum yield advantage. Sharath *et al.* (2011), has reported similar results growing of short-term legume crops gives intercrop advantage. The LER value of 1.53 indicated that 53 per cent more land area will be required by sole castor crop to produce equivalent yield of this system. The yield advantage indicated greater efficiency of intercropping systems and efficient use of resources per unit area (Varia and Sadhu, 2011).

Income Equivalent Ratio

Similar trend was observed in income equivalent ratio (IER). Maximum IER (1.53) was observed in castor (200 cm) + mungbean intercropping system of 1:4 row ratio. Higher IER values (greater than one) among various intercropping systems depicted superiority of intercropping treatments over sole castor cultivation. Singh *et al.* (2005) reported that intercropping of both pearl millet and green gram in cluster bean was compatible as witnessed by the biological parameters like land equivalent ratio, area time equivalent ratio, income equivalent ratio, monetary advantage index and crowding coefficient were more as compared to sole cluster bean.

Appendix

Price of Outputs

Particulars	Price (Rs. kg^{-1})
Castor seed	48
Mung bean	48
Pearl millet seed	22
Sesame	72

Area Time-Equivalent Ratio

ATER value indicates utilization of available land and space efficiently with respect to time. The value of ATER ranged from 0.81 to 1.01 in different inter cropping systems. Maximum ATER value was observed in castor (150 cm) + mungbean in 1:2 row ratio (1.01) and followed by castor (200 cm) + mungbean with 1:4 row ratio (0.99), which indicated higher complementary effect of mungbean in 1:2 and 1:4 row ratio with castor and has least competition as compared to other intercropping treatments. Corroborative results were also reported by Baishya *et al.* (2014) in maize who reported that intercropping system of cereals and legumes (maize-green gram) had higher area time equivalent ratio (1.19) in 1:1 row ratio.

Aggressivity

The Aggressivity (A) values explain that highest aggressivity was recorded in intercropping system of castor with sesame in 1:4 row ratio (0.034). Positive values of aggressivity of castor among all the intercropping systems showed dominance of main crop in intercropping treatments. The intercrops had negative aggressivity thereby representing poor competitiveness of these crops when grown as intercrop with castor. Highest negative value of aggressivity was recorded in castor (200) + sesame (-0.034) in 1:4 row ratio intercropping system, indicating more dominance of sesame to the castor as compared to mungbean and pearl millet. Corroborative research carried out by Yadav *et al.* (2015) showed that higher value of aggressivity was in pearl millet + sesame indicated that sesame was relatively more aggressive in comparison to mung bean and cluster bean.

Relative Crowding Coefficient

Crowding coefficient of castor recorded higher values (6.56 to 24.24) than intercrops (0.20 to 1.03) indicated its dominance in the system. Highest value of castor crowding coefficient was recorded in castor (150 cm) + mungbean (24.24) with 1:2 row ratio intercropping system which was followed by castor (200 cm) + mungbean (20.67) in 1:4 row ratio system thereby, indicating that these were the most complementary combination among all cropping systems. Among the different intercrops, highest value of castor crowding coefficient was recorded in castor (200 cm) + pearl millet (1.03) in 1:4 row ratio intercropping system was found as non-advantageous intercropping system than all other intercropping systems. Suman (2020), has reported similar results in pearl millet with sesame intercropping system.

Competitive Ratio

The castor competitive ratio was greater (3.09 to 6.31) than intercrops (0.16 to 0.32) indicated more competitiveness of castor over intercrops. Among different intercropping systems, castor (200 cm) + pearl millet (0.32) in 1:4 row ratio showed more competitive than other intercrops within same row ratio. Among different treatments highest competitive ratio of castor was observed in castor (150 cm) + sesame (6.31) intercropping system of 1:2 row ratio.

Monetary Advantage Index

The highest monetary advantage index (MAI) was noticed in castor (200 cm) + mungbean (Rs.40,849 ha^{-1}) intercropping system with 1:4 row ratio which was followed by castor (200 cm) + pearl millet (Rs.38,453.65 ha^{-1}) and castor (200 cm) + sesame (Rs.16,580.46 ha^{-1}) in 1:4 row ratio. Renu (2016) found that the greater values of MAI observed in pearl millet and mungbean intercropping system, which also contributed by the greater LER and net returns as compared to other systems.

Economics

The economic returns as clarified by gross and net returns were significantly higher in intercropping treatments as compared to sole castor (Table 6). Looking to the economics, castor (200 cm) + mungbean (1:4) and castor (150 cm) + mungbean (1:2)

TABLE 6

Economic evaluation of different treatments

	Treatments	Crowding coefficient			Crowding coefficient			Crowding coefficient			B:C
		Castor	Intercrop	Total	Castor	Intercrop	Total	Castor	Intercrop	Total	
T_1	Castor sole (150cm)	1,88,011	-	1,88,011	53,612	-	53,612	1,34,399	-	1,34,399	3.51
T_2	Castor sole (200cm)	1,89,801	-	1,89,801	51,742	-	51,742	1,38,059	-	1,38,059	3.67
T_3	Mungbean sole	-	70,439	70,439	-	30,458	30,458	-	39,981	39,981	2.31
T_4	Pearl millet sole	-	72,688	72,688	-	41,434	41,434	-	31,254	31,254	1.75
T_5	Sesame sole	-	69,527	69,527	-	24,643	24,643	-	44,884	44,884	2.82
T_6	T1 + Mungbean (1:2)	1,75,289	27,353	2,02,643	53,612	3,750	57,362	1,21,677	23,603	1,45,281	3.53
T_7	T1 + Pearl millet (1:2)	1,47,406	29,322	1,76,729	53,612	2,480	56,092	93,794	26,842	1,20,637	3.15
T_8	T1 + Sesame (1:2)	1,68,512	28,884	1,97,397	53,612	2,460	56,072	1,14,900	26,424	1,41,325	3.52
T_9	T2 + Mungbean (1:4)	1,66,000	48,055	2,14,055	51,742	4,860	56,602	1,14,258	43,195	1,57,453	3.78
T_{10}	T2 + Pearl millet (1:4)	1,17,962	58,478	1,76,441	51,742	2,940	54,682	66,220	55,538	1,21,759	3.23
T_{11}	T2 + Sesame (1:4)	1,56,083	46,410	2,02,493	51,742	2,830	54,572	1,04,341	43,580	1,47,921	3.71

gave higher gross and net returns realization than other intercropping systems and sole castor. This could be due to higher yield of castor as well as intercrops in intercropping systems. Castor + mungbean (1:4) intercropping system gave highest gross (Rs.2,14,055 ha^{-1}) and net returns (Rs.1,57,453 ha^{-1}) due to higher yield of mungbean as well as less reduction in seed yield of castor. Mohsin *et al.* (2018) also found similar results that castor mung bean intercropping had recorded higher net returns. Castor intercropping with sesame and pearl millet reported lower seed yield of castor because of suppress in effect on castor growth and ultimately economic returns was decreased as compared to other intercropping systems and their sole crops. Corroborative results were also reported by Vaghela *et al*. (2019) that castor + summer sesame and castor + summer pearl millet intercropping system gave less gross and net returns when compared with castor + summer mungbean intercropping system. In terms of B:C (Table 6), maximum value was recorded in castor (200 cm) + mungbean (3.78) with 1:4 row ratio. Mohsin *et al.* (2018) reported that castor intercropped with mungbean at different row ratio has maximum B:C as compared to their respective sole cropping system. The range of B:C among treatments was between 1.75 to 3.78. Therefore, intercropping system of castor (200 cm) + mungbean in 1:4 row ratio was found more efficient in terms of gross and net returns as compared to sole crop in terms of benefit: cost. The least B:C was observed in castor (150 cm) + pearl millet (3.18) with 1:2 row ratio. Similar results were also reported by Vaghela *et al*. (2019) that castor + summer sesame and castor + summer pearl millet intercropping system realized less B:C as compared to castor + summer mungbean intercropping system.

Intercropping studies carried out in castor crop with legume, cereal and oilseeds exhibited the superiority of treatments castor (200 cm) + mungbean in 1:4 row ratio in terms of castor equivalent yield, gross returns, net returns and benefit: cost over sole castor crop. Assessment of yield advantages through various indices also revealed the higher values of land equivalent ratio, income equivalent ratio, area time equivalent ratio and monetary advantage index of this treatment. Hence intercropping system marked superior over sole castor and found more profitable and sustainable as compared with sole castor on sandy loam soils of Haryana.

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