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Effect of row direction and row spacing on growth and productivity in castor based intercropping system

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Abstract
The field experiment entitled "Effect of row direction and row spacing on growth and productivity in castor based intercropping system" was conducted during the kharif season of 2017-18 at Regional Research station, Bawal, CCS HAU with the objective to quantification of growth and yield of castor, The experiment was laid out in split plot design and replicated thrice with 14 treatment combinations comprised of two row direction, East-west and North-south as main plots and seven treatments comprised by two row spacing 180cm x 60cm and 240cm x60cm, two intercrops such as mung and methi in 1:4 and1:6 combinations. The results indicated that the higher plant height, dry matter yield, seed yield was obtained when castor was grown in East-west direction. 180 cm row spaced castor has taller plants. 240cm row spaced sole castor resulted in higher dry matter weight per plant, number of branches per plant and yield and yield components like number of spikes per plant, length of primary spike, number of capsules per plant and test weight. On contrary 180cm row spaced castor intercropped with methi resulted in higher seed yield.

Keywords: Castor, spacing, row direction, intercropping, growth and yield

Introduction
Castor (*Ricinus communis* L.) is well known non-edible oilseed crop, belongs to family *Euphorbiaceae*. This is one of the most suitable oilseed crop for arid and semi-arid parts of country, which can be used to fulfill the ever increasing demand of industrial oil. Castor, due to its low input and water requirement, low cost of production and higher economic returns, is getting popular among the farmers in the country. This would also minimize salinity problems and improve soil health. Now a day with increasing demands for castor oils for industrial purposes, castor fetches good market price and provides higher economic returns.
Yield of a crop is a function of yield per plant and number of plants per unit area. Therefore, the optimum plant population for a particular region with specific variety must be determined for maximum yield and efficient utilization of land. Proper spacing provides sufficient interception of sunlight and satisfactory absorption of nutrients and water from the soil resulting in higher crop yield. Optimum plant stand can be obtained by planting the crop at proper inter and intra-row spacing. 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 (Dhimmer *et al*., 2009) [1].
Intercropping has been recognized as a potentially beneficial system of crop production which can provide sustained yield advantages compared to sole cropping. To take the advantages of different rooting depths, duration, nutrient and water requirement of the crops and better utilization of all the resources, the concept of intercropping has been introduced in primitive agriculture. 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. Reddy *et al*. (2008) reported that pulses had a complementary effect and cereals had a competitive effect when they were grown as intercrops with castor.

Material and Methods
A field experiment was conducted at Regional Research Station, Bawal during *Kharif* 2017 under irrigated condition. The experiment was laid out in split plot design and replicated thrice

with 14 treatment combinations comprised of two row direction, East-west (M_1) and North-south (M_2) as main plots and seven treatments comprised by two row spacing 180cm x 60cm and 240cm x 60cm, two intercrops such as mung and methi in 1:4 and1:6 combinations.

The castor crop (variety DCH-177) was sown by dibbling with onset of monsoon (7th July of 2017) at row spacing as per treatments with seed rate of 5kg ha^{-1}. Mung bean seeds were sown on same day by line sowing method. At each spot two seeds of castor were dibbled in their respective rows in differential row proportion according to the treatments allotted in the plan and after complete germination of castor only one plant was allowed to grow. Castor as sole crop and 1:4 row proportion intercropping system was sown at spacing of 180cm x 90cm and in 1:6 row proportions intercropping was sown at spacing of 240cm x 90cm. The intercrops *viz*, mung bean and fenugreek were sown at a spacing of 30cm x 10cm as sole crops. While, four rows of intercrops were sown in between two rows (180cm) of castor in 1:4 row proportion and six rows of intercrops were sown at a spacing of 30 cm in between two rows (240cm) of castor in 1:6 row proportion. Fenugreek was sown on 15th Oct of 2017 by leaving 30cm both sides of castor rows.

Result and Discussion

Crop growth parameters

Plant growth and development was indicated by plant height, number of branches per plant and plant dry weight accumulated.

1. Plant height

Data presented in Table 1is indicating that row directions of crop were not significantly differ for plant height at 30 days after sowing This might be due to interception of solar radiation is same between crop row directions and in 150days after sowing. Similar findings also revealed by Karlen *et al*. (1986), who measured plant characteristics in maize, including stalk length and fresh weight of leaves and concluded that there were no significant orientation effect on plant growth and development, whereas in 90 days after sowing treatments were significantly differed for plant height. East-west sown crop has increased plant height (119.2 cm) over North-south sown crop. Closely sown sole castor shows significantly increased plant height over narrow spacing and with intercrops at 30 days after sowing. Similar trend also observed at 90 and 150 days after sowing and least plant height was noticed in S_5 treatment where castor grown in 240 cm row spacing and intercropped with mung (1:6). This might be due to competition for resources set by mung bean. Since plant height was taken up to base of primary spike, there was no increase in plant height after 150 days of sowing as castor produces primary spike by that time. Significant interaction effect was found between row spacing and row direction for plant height at 90DAS and 150DAS but not significant at 30 DAS.

2. Number of branches per plant

Data on number of branches produced per plants is presented in Table 1. Row directions were not significantly differing for number of branches per plant whereas spacing with intercrop treatments showed significant difference. Sole castor with 240cm row spacing shows increased production of branches over narrow row spacing and with intercrops. Treatment S_2 (Castor 180cm + Mung bean) showed least number of branches per plant. This might be due to competition for resources set by mung bean and methi. Similar results were found by Kumar (2009) and Mohsin (2016) [3].

3. Plant dry matter weight

Plant dry matter accumulation was found more in North - south sown crop in 90, 150, 210 days after sowing and at harvest except 30 days of sowing. Sole castor sown with row spacing of 240 cm has higher plant dry weight. This line is in agreement with Shehsavari *et al*. (2003) who observed that plant dry matter was increased by increasing the inter-row spacing. Interaction between row direction and row spacing was significant for dry matter weight of plant at all the stages of crop growth.

Yield parameters

1. Number of spikes per plant

The directions of crop rows were showing significant difference for number of spikes per plant. East-west sown crop has increased number of spikes over North-south sown crop. But contrary result was revealed by Singh (2012) in mung bean, observed that yield attributing characters found more in North-south sown crop. Castor crop sown as sole with row spacing of 240cm has produced significantly more number of spikes per plant (21.6) over other treatments. Castor intercropped with mung bean (1:4) and sown in closer row spacing showed least performance in production of spikes per plant (17.2). Castor intercropped with methi showed intermediary performance between sole castor and castor intercropped with mung bean at different row spacing (180cm and 240cm). The similar findings were reported by Reager *et al*. (2016) [5] who found that number of effective tillers per plant increases with row spacing.

2. Number of capsules per spike

The directions of crop rows were close in producing number of capsules per spike, effect of row orientation was not found. Similar result in wheat was revealed by Pandey (2013) [2], who concluded that row direction did not have a significant effect. Sole castor was sown with 240cm have significantly increased number of capsules per spike (95.3) over other treatments. Treatments with 240cm show increased number of capsules per plant irrespective of intercrop sown. Castor intercropped with mung (1:4) at 180cm row spacing shows least number of capsules per plant (84.5). Similar results were found by Patel *et al*. (2004) who reported that number of capsules was increased with row spacing.

3. Length of primary spike

Row orientations of crop were not found significant in producing differed length of primary spike. Similar finding was made in wheat crop by Pandey *et al*. (2013) [2] who revealed that row directions did not have significant effect on spike length. Row spacing had not significantly produced effect on length of primary spike. The results are in close agreement with Patel *et al.* (2013) who concluded that effect of plant geometry on length of primary spike was not significant.

4. Test weight

Significant difference for test weight between directions of crop rows was not found. Similar research finding was revealed by Pandey *et al*. (2013) [2] in wheat, who observed that there was no significant effect of direction of sowing in kernel weight. Row spacing and inter crops were not significant in producing effect on test weight. Same result was reported by Mohsin (2016) [3] who concluded that test weight of castor was not affected by different intercropping systems and row spacing.

Table 1: Effect of row directions, row spacing and intercrops on plant height of castor (cm) and number of branches per plant

Treatments		Plant height (cm)			Number of branches per plant
A) Row directions		**30DAS**	**90DAS**	**150DAS**	
M_1 : (East-west)		35.76	119.2	121.0	6.9
M_2 : (North-south)		36.06	118.1	120.3	7.5
S.Em±		0.060	0.07	0.26	0.33
C.D. (P=0.05)		N.S.	0.44	N.S	N.S
B) Intercropping					
S_1 : Sole castor (180cm)		36.82	120.1	122.7	7.7
S_2 :Castor (180cm) + Mung bean (1:4)		35.28	118.4	121.4	5.7
S_3 :Castor (180cm) + Methi (1:4)		35.87	119.0	121.8	6.7
S_4 :Sole castor (240cm)		36.43	118.5	119.9	8.7
S_5 :Castor (240cm) + Mung bean (1:6)		35.25	117.7	118.4	6.5
S_6 :Castor (240cm) + Methi (1:6)		35.80	118.1	119.4	8.0
S.Em±		0.25	0.49	0.19	0.58
C.D. (P=0.05)		0.75	0.147	0.56	1.73
Factor (B) at same level of A	S.Em±	0.147	0.194	0.648	0.804
	C.D. (P=0.05)	-	1.178	1.317	-
Factor (A) at same level of B	S.Em±	0.335	0.350	0.361	0.821
	C.D. (P=0.05)	-	1.104	1.767	-

Table 2: Effect of row directions, row spacing and intercrops on plant dry matter weight of castor (g)

Treatments		Plant dry matter weight (g)				
A) Row directions		**30DAS**	**90DAS**	**150DAS**	**210DAS**	**270DAS**
M_1 : (East-west)		2.32	43.38	287.18	582.66	711.86
M_2 : (North-south)		2.25	42.88	284.27	572.40	710.12
SEm±		0.014	0.022	0.163	0.32	0.887
C.D. (P=0.05)		N.S	0.142	1.069	2.07	N.S
B) Intercropping						
S_1 : Sole castor (180cm)		2.23	42.5	285.05	570.34	705.88
S_2 :Castor (180cm) + Mung bean (1:4)		2.00	42.0	274.70	561.30	698.34
S_3 :Castor (180cm) + Methi (1:4)		2.20	42.5	284.40	567.87	704.45
S_4 :Sole castor (240cm)		2.53	44.8	298.30	600.40	723.33
S_5 :Castor (240cm) + Mung bean (1:6)		2.25	42.4	277.32	578.68	714.00
S_6 :Castor (240cm) + Methi (1:6)		2.50	44.5	294.60	588.00	719.95
SEm±		0.032	0.061	0.291	0.291	2.19
C.D. (P=0.05)		0.095	0.182	0.865	0.865	6.5
Factor (B) at same level of A	S.Em±	0.034	0.053	0.773	0.4	2.17
	C.D. (P=0.05)	0.151	0.28	0.997	1.458	10.2
Factor (A) at same level of B	S.Em±	0.044	0.082	0.352	0.41	2.96
	C.D. (P=0.05)	0.146	0.265	2.05	1.45	9.75

Table 3: Effect of row directions, row spacing and intercrops on yield components of castor

Treatments	Yield components				Yield (kg ha^{-1})
A) Row directions	**Number of spikes per plant**	**Number of capsules per spike**	**Length of primary spike**	**Test Weight**	
M_1 : (East-west)	19.8	87.34	60.23	28.80	3415
M_2 : (North-south)	18.4	91.00	60.00	28.86	3399
SE.m±	0.16	2.12	0.705	0.162	2.1
C.D. (P=0.05)	1.05	N.S.	N.S.	N.S.	13.76
B) Intercropping					
S_1 : Sole castor (180cm)	18.8	86.17	60.03	29.13	3482
S_2 :Castor (180cm)+ Mung bean (1:4)	17.2	84.5	58.12	28.72	3348
S_3 :Castor(180cm)+ Methi (1:4)	18.2	85.83	57.8	28.83	3573
S_4 :Sole castor (240cm)	21.6	95.33	62.95	29.25	3453
S_5 :Castor (240cm)+ Mung bean (1:6)	18.2	89.5	60.87	28.43	3191
S_6 :Castor(240cm)+ Methi (1:6)	20.0	93.83	60.23	28.60	3393
SE.m±	0.82	2.6	1.29	0.249	79.1
C.D. (P=0.05)	2.44	7.73	N.S.	N.S.	235.0

All parameters found non -significant for interaction between factor A and factor B
N.S - Non significant

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