

INFLUENCE OF PLANT GEOMETRY AND FERTILITY LEVELS ON GROWTH AND YIELDS OF RABI CASTOR (*RICINUS COMMUNIS* L.)

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KEYWORDS

Castor
Ricinus communis L.
Plant geometry
Fertility levels

Received on :
09.03.2015

Accepted on :
06.01.2016

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ABSTRACT

A field experiment was carried out on influence of plant geometry and fertility levels on growth and yield of castor during *rabi* season of 2013-14 at Department of Agronomy, JAU, Junagadh. The results indicated that sowing the castor at 90cm x 45cm spacing recorded significantly higher plant population and plant height (153.5 cm). While, no. of branches plant⁻¹(8.8) and dry matter accumulation (187.2 g plant⁻¹), no. of spikes plant⁻¹(8.3), length of main spike (60.4 cm) and no. of capsules per spike (64.4) as well as seed (82.2 g plant⁻¹) and stalk yields plant⁻¹(103.8 g plant⁻¹) were significantly higher under wider spacing of 120cm x 60cm. Seed yield (1444 kg ha⁻¹), N uptake by seed (34.6 kg ha⁻¹), phosphorus (10.6 kg ha⁻¹) potash (12.0 kg ha⁻¹) were significantly higher under plant geometry of 90cm x 60cm spacing. Almost all the growth characters, yield attributes, quality parameters, seed and stalk yields were found significantly higher when crop was fertilized with 100-50-50 NPK kg ha⁻¹. It was concluded that under clayey soils of South Saurashtra agro-climatic zone for getting higher yield, *rabi* castor should be sown at 90 cm x 60 cm and crop should be fertilized with 100-50-50 NPK kg ha⁻¹.

INTRODUCTION

Castor, *Ricinus communis* is an important cash crop of arid and semi arid regions of India due to its extensive deep root system and can be grown successfully under rainfed or irrigated conditions. Total area, production and productivity of castor crop in India during 2013-14 were 10.63 lakh hectares, 17.26 lakh tones and 1624 kg ha⁻¹, respectively (Anon., 2014). In India, during last decade area, production and productivity were increased by 37, 59 and 35 per cent, respectively (SEA, 2013). In Gujarat, total area, production and productivity of castor crop during 2013-14 were 6.27 lakh hectares, 12.87 lakh tones and 2054 kg ha⁻¹, respectively. Thus, Gujarat ranks first in productivity at national and international level and contributes 58 and 74 per cent of national castor acreages and production, respectively (Anon., 2014). Crop geometry and plant population plays an important role in obtaining high yield and therefore, it is very necessary to quantify optimum plant population by adjusting the spacing (Ughade and Mahadkar, 2015). Castor is generally grown in *kharif* season under rainfed as well as irrigated conditions in India and being a long duration *kharif* crop, occupies the land for about 7-8 months and requires more costly and scarce inputs i.e. fertilizer, labour, irrigation etc. However, semi *rabi* or *rabi* castor matures within 100 to 135 days and therefore; it is possible to take other crop during the *kharif* season. During recent past, area under castor cultivation during *rabi* season increased due to ever demand of castor seed, higher market price, requirement of less inputs and save the crop from diseases. Therefore, an experiment was undertaken to study

the effect of plant geometry and fertility levels on growth, yield attributes and yields of *rabi* castor.

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh-362001 (Gujarat) during *rabi* season of 2013-14. The soil was medium black and clayey in texture, slightly alkaline (7.9), having 0.69% organic carbon, 254.0kg ha⁻¹ available nitrogen, 23.0kg ha⁻¹ available P₂O₅ and 245.0 kg ha⁻¹ K₂O. The experiment was laid out in Split Plot Design comprised of four levels of plant geometry viz., S₁ = 120cm x 45cm, S₂ = 120cm x 60cm, S₃ = 90cm x 45cm and S₄ = 90cm x 60cm were allotted to main plot and three fertility levels (F₁ = 50-25-25, F₂ = 75-50-50, and F₃ = 100-50-50 NPK kg ha⁻¹) were assigned to sub plot and replicated thrice. Sowing of castor (*var.* GCH-4) was done as per treatments. Two inter cultivation followed by a hand weeding was done at 40 and 70 DAS to control the weeds. Immediately after sowing and at 8-10 DAS light irrigations were given for proper germination and ensuring better establishment of the crop and rest of the irrigations were given as per recommendations made for the crop. Full dose of phosphorus and potash was applied as basal at time of sowing through diammonium phosphate and muriate of potash, respectively. Half dose of nitrogen applied as basal and remaining quantity of nitrogen applied as top dressing in two equal splits at 30 and 70 DAS in form of urea. Observations

on growth and yield attributes, nutrients uptake, yields and oil content were recorded and analyzed statistically. For the oil content, Random seed sample from each net plot produce was drawn to estimate the oil content. The oil content was determined by IBM DC/20 series, NMR (Nuclear Magnetic Resonance) analyzer and oil per cent was recorded (Tiwari *et al.*, 1974) and the amount of oil yield /ha for various treatments was calculated by using following formula.

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content in seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

Nitrogen content and uptake

Total nitrogen content from seed and stalk samples was determined by using Micro Kjeldhal's method (Jackson, 1974). The uptake of nitrogen by the castor crop was calculated by the formula.

$$\text{Nitrogen uptake (kg ha}^{-1}\text{)} = \frac{\text{N content in seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)} + \text{N content in stalk (\%)} \times \text{Stalk yield (kg ha}^{-1}\text{)}}{100}$$

Phosphorus content and uptake

Phosphorus was determined by Vanadomolybdo phosphoric acid yellow colour method using HNO_3 as described by Jackson (1974). The uptake of phosphorus by the castor crop was calculated by using following formula.

$$\text{Phosphorus uptake (kg ha}^{-1}\text{)} = \frac{\text{P content in seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)} + \text{P content in stalk (\%)} \times \text{Stalk yield (kg ha}^{-1}\text{)}}{100}$$

Potassium content and uptake

Potash was determined by the method of Flame Photometer (Jackson, 1974). The uptake of potassium by crop of castor was calculated by using following formula

$$\text{Potassium uptake (kg ha}^{-1}\text{)} = \frac{\text{K content in seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)} + \text{K content in stalk (\%)} \times \text{Stalk yield (kg ha}^{-1}\text{)}}{100}$$

RESULTS AND DISCUSSION

Plant geometry

Effect of plant geometry on crop growth

Sowing of castor at 90cm x 45cm plant geometry recorded significantly maximum plant population and plant height. Increase or decrease in plant population per unit area is a direct effect of the adopted plant geometry *i.e.* spacing between two rows and between two plants within the row. Thus, plant population per unit area was higher in closer inter and intra row spacing over wider spacing. The results are substantiated by the studied conducted by Sardana *et al.*, (2008). Increased plant height under narrow inter and intra row spacings might be due to higher competition under narrow spacing for space and light with rapid meristematic activity and increase in size of cell which ultimately increases in plant height. Plant geometry

of 120cm x 60cm recorded significantly more number of branches, dry matter accumulation, number of internodes, number of spikes, length of main spike and number of capsules per spike (Table 1). Wider plant geometry provided more space around each plant resulting in more metabolic activities through better utilization of light, space, water and nutrients which might be turned in better vegetative growth. Dense population under closer plant geometry reduced number of branches per plant might be due to less availability of space for resources. The results corroborates with the findings of Lakshamma *et al.* (2003), Singh (2003) and Venugopal *et al.* (2007).

Effect of plant geometry on yield attributes

The seed and stalk yields per plant (Table 2) were increased significantly with increase in inter and intra row spacing from 90cm x 45cm to 120cm x 60cm. This was due to reflection of yield attributing characters usually achieved well under optimum availability of space, where competition within the crop plant was minimum. On the other hand, closer plant geometry might be increased competition within the crop plant which resulted in poor growth that decreased the seed and stalk yields per plant. Wider spacing favour individual plant performance and produced higher seed yield per plant than narrow spacing. These consequences are in comprehensive agreement with those obtained by Vala *et al.* (2000), Singh (2003) and Venugopal *et al.* (2007).

Effect of plant geometry on yields

Crop sown at 90cm x 60cm and 90cm x 45cm produced significantly higher seed and stalk yields of 1444 and 2016 kg ha⁻¹, respectively. The magnitude of increase in seed and stalk yields under 90cm x 60cm and 90cm x 45cm was 18.2 and 17.3 per cent over 120cm x 60cm, respectively. Higher seed and stalk yields (Table 2) under 90cm x 60cm and 90cm x 45cm geometry proved conspicuously superior to the other plant geometry treatments. Higher seed and stalk yields with 90cm x 60cm and 90cm x 45cm plant geometry might be due to the fact that narrow spacing having higher plant population than wider spacing and numerically higher uptake of nutrients by seed and stalk. The findings are in close conformity with the Vala *et al.* (2000), Singh (2003), Tank *et al.* (2007), Kathmale *et al.* (2008).

Effect of plant geometry on nutrient uptake

Different plant geometry failed to exert their significant influence on nitrogen and phosphorus uptake. While, significantly maximum potash uptake (12.0 kg ha⁻¹) was observed when crop was sown at 90cm x 60cm spacing. The results obtained in present study are in close agreement with those reported by Venugopal *et al.* (2007) and Patel *et al.* (2010).

Fertility levels

Effect of fertility levels on crop growth and yield attributes

Significantly maximum plant height (152.3cm), number of branches (8.6), dry matter accumulation (178.9g), number of internodes (18.4), yield attributes *viz.*, number of spike (7.9), length of main spike (60.2cm), number of capsule per spike (67.1), test weight (29.9g), shelling per cent (69.6%) and oil content (48.6%) were recorded when crop was fertilized with

Table 1: Growth and yield attributes as well as quality of castor as influenced by plant geometry and fertility levels

Treatments	Plant population Initial	Plant population Harvest	Plant height (cm)	No. of branches	Dry matter (g plant ⁻¹)	No. of internodes	No. of spikes	Length of main spike (cm)	No. of capsules per spike	100- seed weight (g)	Harvest index (%)	Shelling (%)	Oil content (%)
Plant geometry : (S)													
S ₁ : 120cm x 45cm	18511	18303	136.4	7.7	171.6	17.2	7.0	56.5	61.8	28.8	44.6	68.0	47.6
S ₂ : 120cm x 60cm	13912	13754	130.3	8.8	187.2	18.3	8.3	60.4	64.4	29.1	41.7	68.7	47.2
S ₃ : 90cm x 45cm	24727	24497	153.5	7.2	156.3	16.1	6.9	51.7	53.9	28.8	37.7	67.2	48.0
S ₄ : 90cm x 60cm	18583	18500	143.7	8.5	170.1	17.5	7.1	55.3	59.0	28.2	42.71	68.0	48.4
S \bar{E} m \pm	504.7	485.5	4.4	0.2	4.5	0.5	0.2	1.5	1.6	0.7	1.4	1.2	0.6
CD at 5%	1747	1680	15.2	0.8	15.6	NS	0.8	5.3	5.7	NS	NS	NS	NS
Fertility levels: (F)													
F ₁ : 50-25-25 NPK kg ha ⁻¹	18924	18686	131.5	7.3	165.2	15.6	6.6	49.9	50.6	27.6	42.4	66.0	46.8
F ₂ : 75-50-50 NPK kg ha ⁻¹	18989	18829	139.1	8.3	169.8	17.9	7.5	57.7	61.7	28.7	41.1	68.4	47.9
F ₃ : 100-50-50 NPK kg ha ⁻¹	18886	18775	152.3	8.6	178.9	18.4	7.9	60.2	67.1	29.9	41.5	69.6	48.6
S \bar{E} m \pm	380.6	384.3	2.9	0.2	2.9	0.3	0.2	0.8	1.1	0.4	0.6	0.8	0.4
CD at 5%	NS	NS	8.7	0.5	8.6	0.8	0.5	2.5	3.4	1.2	NS	2.4	1.2

Table 2: Yield, economics and nutrient uptake by castor as influenced by plant geometry and fertility levels

Treatments	Yield (g plant ⁻¹)		Yield (kg ha ⁻¹)		Oil yield (kg ha ⁻¹)	Uptake (kg ha ⁻¹)			Realization (Rs. ha ⁻¹)		B:C ratio
	Seed	Stalk	Seed	Stalk		Nitrogen	Phosphorus	Potash	Gross	Net	
Plant geometry : (S)											
S ₁ : 120cm x 45cm	71.8	87.4	1385	1719	659	32.7	10.0	11.1	57118	33045	2.37
S ₂ : 120cm x 60cm	82.2	103.8	1226	1720	578	30.0	9.7	10.3	50766	26421	2.08
S ₃ : 90cm x 45cm	52.0	63.5	1221	2016	587	32.2	10.2	11.2	50843	27310	2.16
S ₄ : 90cm x 60cm	69.5	86.1	1444	1939	700	34.6	10.6	12.0	59705	35902	2.50
S \bar{E} m \pm	3.2	3.3	48.4	61.8	27.5	0.94	0.28	0.31			
CD at 5%	11.0	11.6	168	214	NS	NS	NS	1.08			
Fertility levels: (F)											
F ₁ : 50-25-25 NPK kg ha ⁻¹	60.4	77.8	1256	1706	589	29.8	9.3	10.3	51948	26920	2.07
F ₂ : 75-50-50 NPK kg ha ⁻¹	70.8	86.2	1322	1892	633	32.7	10.3	11.3	54790	27833	2.03
F ₃ : 100-50-50 NPK kg ha ⁻¹	75.4	91.6	1378	1948	671	34.8	10.9	11.9	57087	29927	2.10
S \bar{E} m \pm	1.7	1.6	24.6	27.4	12.4	0.61	0.16	0.23			
CD at 5%	5.0	4.9	74	82.1	37.3	1.83	0.47	0.69			

100-50-50 NPK kg ha⁻¹ (Table 1). This was due to favourable effect of nitrogen in increasing cell wall material resulted in increased size of cell. Also meristematic tissue has very active protein metabolism and photosynthetic transport to sites of growth which are used predominantly in synthesis of nucleic acid and protein. Phosphorus play an important role in metabolism and it is structural element of certain co-enzymes like NADP, ATP and ADP which act as energy transfer currency and thus improves photosynthesis. The potash is known to augment cell division and cell expansion resulting in positive effect on growth parameters. These results are in accordance with the findings of Mavarkr *et al.* (2009), Patel *et al.* (2010), Shirisha *et al.* (2010), Hans and Sundaramoorthy (2004), Patel *et al.* (2005), Lakshmi and Reddy (2006) and Reddy *et al.* (2006).

Effect of fertility levels on crop yields

The data furnished in Table 2 indicated that seed and stalk yields per hectare were significantly influenced by different fertility levels. Application of 100-50-50 NPK kg ha⁻¹ to castor produced significantly higher seed and stalk yields of 1378 and 1948 kg ha⁻¹, respectively and which was found at par with lower fertility level of 75-50-50 NPK kg ha⁻¹. The magnitude of increase in seed and stalk yields over 50-25-25 NPK kg ha⁻¹ was to the tune of 9.7 and 14.2 per cent, respectively (Table 2). Thus, increasing trend as observed in seed and stalk yields

was evidently due to cumulative effects of increasing trend observed on major growth and yield attributes. Moreover, overall improvement in vegetative growth at higher fertility level, which favorably influenced flowering and fruiting which ultimately resulted in increased number of capsules per spike. The results confirms the findings of Patel *et al.* (2005), Rana *et al.* (2006), Reddy *et al.* (2006), Venugopla *et al.* (2007), Kathmale *et al.* (2008), Patel *et al.* (2010) and Patel and Patel (2012).

Effect of fertility levels on nutrient uptake

Castor fertilized with higher fertility level of 100-50-50 NPK kg ha⁻¹ appreciably improved nitrogen, phosphorus and potash uptake of 34.8, 10.9 and 11.9 kg ha⁻¹, respectively. The probable reason for increase in NPK uptake might have improve nutritional environment in rhizosphere as well as plant system leading to absorption, uptake and translocation of nutrient in reproductive structure which leads to higher content and uptake. Similar findings were also reported by Thadoda *et al.* (1996), Chavan *et al.* (2005), Lakshmi and Reddy (2006), shukla *et al.* (2013) and Hadvani *et al.* (2010).

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