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OPTIMIZING PLANT GEOMETRY AND NITROGEN FERTIGATION FOR ENHANCED YIELD IN DRIP-IRRIGATED CASTOR (*RICINUS COMMUNIS* L.)

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ABSTRACT

A field experiment was conducted at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh (Gujarat) during *kharif-Rabi* season of 2019-20 to 2021-22. The soil was medium black and clayey in texture. The experiment was laid out in factorial randomized block design comprising four levels of plant geometry (P_1:120 cm *60 cm, P_2: 120 cm *12 cm, P_3: 150 cm *60 cm and P_4: 150 cm *120 cm) allotted to one factor and threenitrogen levels (N_1: 75% N (90 kg N/ha), N_2: 100% N (120 kg N/ha) andN_3: 125% N (150 kg N/ha)) assigned to another factor and replicated thrice. The results indicated that castor sown at 150 cm * 60 cm and 120 cm * 60 cm spacing recorded significantly higher plant height, number of branches andspikes, number of capsules per spike and seed yield in pooled results. While, almost all the growth characters, yield attributes, quality parameters and seed yield were found significantly higher when crop was fertilized with Fertigation @ 100% and 125%. Interaction effect between crop geometry and nitrogen fertigation levels was found non-significant. It was concluded that *kharif-Rabi* castor should be sown at 150 cm * 60 cm and 120 cm * 60 cm with an application of N- fertigation @ 100 % (120 kg/ha) along with recommended dose of phosphorus and potassium (50-50 kg PK/ha) for obtaining higher seed yield and net return.

Key words: Castor, Crop geometry, Nitrogen, Fertigation, Yields

Introduction

Productivity of crop depends upon several agronomic factors. Among them plant geometry and nutrient management play an important role in castor production. Plant population is the basic component of package of production technology, but more important than this, is the proper adjustment of plants in field. Yield is a function of inter and intra plant competition and there is a considerable scope for increasing the yield by adjusting plant population to an optimum level. Balance fertilizer is also necessary for raising the castor yield, maintaining the quality of crop and productivity of soil. Nitrogen element is important in growth of crop, seed formation and development.

Castor *(Ricinus communis* L.) is non edible oil seed crop having high industrial importance due to presence of unique fatty acid and ricinoleic acid. The crop is grown mainly under irrigated condition. Castor is extensively cultivated in India, China, Brazil, Ethiopia, Thailand *etc*., in the world. Drip irrigation system optimizes the irrigation water and puts it uniformly and directly to the root zone of the plants at frequent interval based on crop water requirement through a closed network of low-pressure plastic pipes. Superiority of drip system in terms of water saving and increased in yield along with other benefits over surface method of irrigation is proved by many research evidences.

In India total acreage, production and productivity of castor crop during 2023-24, were 7.86 lakh hectares, 15.52 lakh tonnes and 1973 kg/ha, respectively (Annon. 2024). The contribution of India in the world is 56 per cent in acreage and 84 per cent in production of castor. Thus, India is leading country in the world not only in acreage and production but in productivity of castor also.

Further, Gujarat occupying area, production and productivity of castor crop were 5.60 lakh ha, 12.72 lakh MT and 2270 kg/ha, respectively (https://upag.gov.in/).

Now its cultivation is becoming popular due to its high export potential and medicinal value. Introducing new hybrids of castor are different from the traditional ones in terms of morphology, duration, growth and productivity. Plant spacing requirement of hybrid castor vary, substantially with management practices. It is well documented that yield per unit area is not only dependent on the number of plants per unit area but it also depends on arrangement of plants on the ground surface, as this enables the plant to utilize natural and manmade resources both spatially and temporally in better and efficient ways leading to better plant growth and development, eventually to higher crop yield per unit area. Considering the above facts, the present study was undertaken to evaluate the different plant geometry and nitrogen for drip irrigated hybrid castor in terms of growth and productivity.

Materials and Methods

A field experiment was conducted at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, Gujarat during *kharif-Rabi* season of 2019-20 to 2021-22. The soil was medium black and clayey in texture. The initial soil organic carbon content, pH and bulk density were 0.64%, 7.94 and 1.31 Mg/m^3, respectively and having 266, 36.78 and 341.5 kg/ha available N, P_2O_5 and K_2O respectively. The experiment was laid out in factorial randomized block design comprising four levels of plant geometry (P_1:120 cm * 60 cm, P_2: 120 cm * 12 cm, P_3: 150 cm * 60 cm and P_4: 150 cm * 120 cm) allotted to one factor and three potassium levels (N_1: 75% N (90 kg N/ha), N_2: 100% N (120 kg N/ha) and N_3: 125% N (150 kg N/ha)) assigned to another factor and replicated thrice. The experiment comprises twelve treatments combination.

Sowing of castor (*var*. GCH-9) was done as per treatments. Two inter cultivation followed by a three-hand weeding was done to control the weeds. Recommended normal fertilizer dose for castor are 120-50-50 kg NPK/ha. Irrigate the crop at 0.8 PEF through drip irrigation and apply nitrogen 25% (two split) as a basal and one month after sowing, remaining 75% nitrogen through drip in form of urea in five equal splits at an interval of 12 days starting after cessation of monsoon) along with recommended dose of phosphorus and potash (kg/ha) as basal. The crop was harvested by picking of matured spikes at different growth stages. The oil content in seed was determined using nuclear magnetic resonance. Five plants were tagged randomly in the net plot area for sampling in each plot at 50 days and were used for recording growth and yield attributes of the crop under different treatments. Economics such as net returns and benefit: cost ratios were worked out at the existing market rate. Bulk density, pH and soil organic carbon and available K content of soil were determined at the beginning of experiment and after harvesting of crop by flame photometric method as described by Jackson (1974) for this purpose, soil samples were drawn fromeach treatment and analyzed for these physico-chemical properties.

Standard analysis of variance was used to do the statistical analysis of the data (Cochran and Cox (1957),

Table 1: Effect of plant geometry and Nitrogen though fertigation on growth, yield attributes and yield of castor.

Treatment	Plant height (cm) at 135 DAS	No. of branches/ plant at 135 DAS	No. of spikes / plant at135 DAS	Capsules/ spike	100 seed weight (g)	Oil %	Total seed yield (kg/ha)
A : Plant geometry							
P_1	96.4	7.09	8.84	84.94	29.19	48.4	2806
P_2	101.36	8.97	11.12	92.25	29.48	48.46	2477
P_3	96.26	8.41	10.21	89.17	29.92	48.46	**2869**
P_4	**102.14**	**9.1**	**11.88**	**97.73**	29.35	48.35	2297
S.Em±	1.8	0.33	0.57	1.25	0.26	0.05	44
CD at 5%	6.21	1.14	1.96	3.52	NS	NS	124
B: Nitrogen though fertigation							
N_1	96.76	8.01	10.06	85.92	28.64	48.41	2429
N_2	97.3	8.55	**10.77**	91.68	29.76	48.40	**2772**
N_3	**103.07**	**8.61**	10.70	**95.47**	**30.06**	48.38	2636
S.Em.±	0.81	0.16	0.21	1.08	0.23	0.04	38
C.D.at 5%	5.07	0.93	1.6	3.52	0.74	NS	124
C.V. %	4.89	11.32	11.83	7.11	4.63	0.51	8.74
M×S S.Em.±	3.99	0.48	0.7	3.46	0.55	0.08	148
M×S C.D.at 5%	NS	NS	NS	NS	NS	NS	NS

Panse and Sukhatme (1885)). The F-test was used to assess the treatment effects' significance. Using the least significant difference (LSD) at the 5% probability level, the significance of the difference between the means of the different treatments was examined.

The yield and cost-effectiveness of plant geometry and nitrogen fertigation were evaluated to determine whether to add more castor production. Utilizing crop yield and produce market price, net realization return and benefit cost ratio were computed to compare the economics.

Results and Discussion

Effect of planting geometry

Plant geometry to show significant effect on plant height, number of branches and number of spikes per plant at 135 DAS, capsules per spike and 100-seed weight, oil content and seed yield (Table 1). Plant height cause significantly affected by plant geometry. Number of branches and spikes per plant at 135 DAS was more with P_4 (150 cm * 120 cm) and statically at par with P_2 and P_3. This might be due to more radiation interception above the canopy and higher availability of nutrients and water below canopy to the individual plant under wider crop canopy during the growth cycle of the crop. The variability of micro climate condition of a crop alters the number of spikes per plant and variability in the yield. This is in agreement with the earlier findings of Kittock and Williams (1970) in castor. Reduced number of spikes under closer spacing might be due to higher competition for nutrients, space and air between the plants. The number of capsules per spike was influenced significantly by spacing. But, higher number of capsules per spike (97.73) was recorded by 150 cm * 120 cm. Though higher seed yield was registered with P_3 (150 cm * 60 cm), significantly higher seed (2,869 kg/ha) and statically at par with P_1 (120 cm * 60 cm) were realized owing to closer intra-row spacing because of significantly more plant population. Similar results were also reported by Rana *et al.*, (2006).

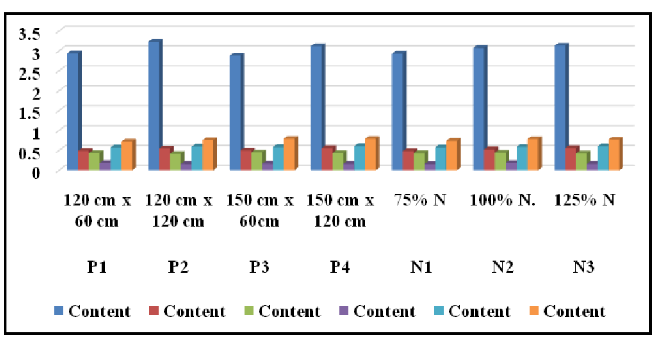

Fig. 1: Effect of different treatments on chemical property of soil, seed and stalk of castor.

Table 2: Effect of plant geometry and Nitrogen though fertigation on economics of castor.

Treat-ment	GMR (₹/ha)	CoP (₹/ha)	NMP (₹/ha)	B:C
A : Plant geometry				
P_1	154328	**43650**	110677	3.54
P_2	136240	43350	92890	3.14
P_3	**157809**	42250	**115559**	**3.74**
P_4	126338	41950	84388	3.01
B: Nitrogen though fertigation				
N_1	133577	42388	91189	3.15
N_2	**152470**	42800	**109670**	**3.56**
N_3	144989	**43213**	101776	3.36

Varying plant geometry did not significantly influence available soil N, P, K and oil content in castor seed (Fig. 1). Sardana *et al.*, (2008) in castor also reported the non-significant response of oil content to various spacing.

Plant geometry of 150 cm * 60 cm accrued maximum gross returns of 1,57,809 ₹/ha and net returns of 1,15,559 ₹/ha with benefit: cost ratio of 3.74 (Table 2 and Fig. 2). The increase in net profit was attributed to large yield differences with very minute differences in cost of production. Wider spacing was found superior to closer ones. Singh (2003), Tank *et al.*, (2007) and Man *et al.*, (2017) also reported similar pattern.

Effect of Nitrogen

Though positive effect of N on growth and yield-attributing characters were reported earlier by Paida and Parmar (1980), Patel *et al.*, (2010) and Rana *et al.*, (2006). All growth, yield attributes and yield characters of castor were significantly influenced by application of fertigation of N in our experiment. Nitrogen application has multifarious effect on plant growth and influenced the various growth parameters significantly. Since N levels unable to produce any significant impact on plant stand, it indicates the uniformity of plants/unit area in all the treatments (Table 1).

Fertigation of N levels to exert significant impact on plant height, plant height, number of branches and number of spikes per plant at 135 DAS, capsules per spike and 100-seed weight and seed yield. it was found to be increased with increase in N levels.

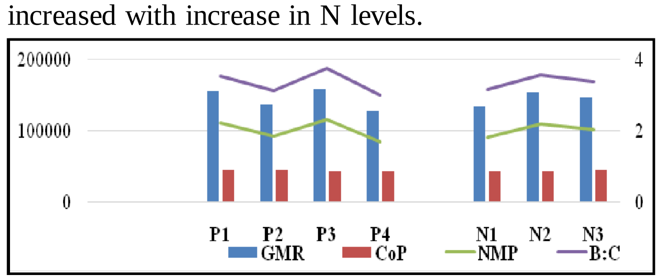

Fig. 2: Economics of different treatments.

Application of 150 kg N/ha recorded taller plants. This improvement in crop growth might be because of the increased availability and uptake of nitrogen at higher N levels. Yadav *et al*., (2002) also reported similar observations. Plant height at 135 DAS and Number of branches at 135 DAS was significantly influenced by nitrogen treatment @ 125 % N (150 kg/ha).

Number of spikes per plant was more with N_2 (120 kg N/ha) but was on par with 90 kg N/ha and 150 kg/ha. Higher number of capsules per spike were recorded with 125% N (150 kg/ha). Hundred seed weight was significantly influenced by nitrogen. Significantly higher seed yield was recorded with 120 kg N/ha. The favorable effect of high doses of nitrogen on yield attributes and their cumulative effect on seed yield were mainly responsible for higher seed yield. Soil-available P, K after crop harvesting, oil content was not affected significantly due N fertigation, except N content in soil (Fig. 2). Oil content in castor seed followed decreasing trend with increase in N level.

Economics

Economics of different treatments are presented in Fig. 2 Gross monitory return, cost of cultivation, net monitory return and B:C ratio of different treatments were worked out on the basis of current market prices of castor and inputs used. The three years pooled data of plant geometry indicated that maximum the gross monitory return (₹157809/ha) and net return (₹115559/ha) with B: C ratio (3.74) found high at 150cm * 60cm (Table 2). While, maximum the gross monitory return (₹152470/ha) and net return (₹109670/ha) with B: C ratio (3.56) recorded high in the application of 100 % N (120 kg N/ ha) in N_2 similar result also noted by Mavarkar *et al*., (2009).

Conclusion

South Saurashtra Agro-climatic Zone growing irrigated castor during *kharif-Rabi*season are recommended to adopt plants geometry of 120cm * 60cm or 150 cm * 60cm and irrigate the crop through drip irrigation and apply RDN 25% (30 kg/ha) as a soil application (15 kg/ha as basal and 15 kg/ha after 30 DAS), remaining 75% (90 kg/ha) RDN through drip in form of urea in five equal splits at an interval of 12 days (starting after cessation of monsoon) along with recommended dose of phosphorus and potash (50-50 kg P_2O_5 and K_2O/ ha) as basal for obtaining higher castor seed yield and net return.

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