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Performance of Castor (*Ricinus communis* L.) Genotypes with Varying Fertility Levels under North Gujarat Agro-climatic Condition

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Abstract: A field experiment was undertaken at Castor-Mustard Research Station, SD AU, Sardarkrushinagar, Banaskantha, Gujarat, India during kharif season of 2017. The experiment consisted eight castor hybrids (JHB 1018, SHB 974, SLCH 158, ICH 66, ICH 68, Maharaja 9, DCH 519 and GCH 7) grown with two fertility levels (100% and 125% RDF) replicated thrice in factorial randomized block design. Results revealed that the castor hybrid GCH 7 recorded tallest plant (81.6 cm), Maharaja 9 recorded higher number of nodes plant^{-1} (21.5), SLCH 158 registered significantly higher length of primary spike (80.5 cm) and number of capsules on primary spike (131.3). While, JHB 1018 recorded significantly higher number of effective branches plant^{-1} (18.8) but ICH 66 produced significantly higher 100 seed weight (33.6 g). Hybrid ICH 68 recorded significantly higher seed yield (3418 kg ha^{-1}), Oil yield (1600 kg ha^{-1}), crop productivity (14.8 kg ha^{-1} day^{-1}), net returns (Rs. 97689 ha^{-1}, B:C ratio (3.50) and crop profitability (Rs. 423 ha^{-1} day^{-1}). Application of 125% RDF produced numerically higher seed yield and net returns but it was failed to showed significant variation. Crop productivity and profitability was unaffected due to different fertility levels but recorded numerically higher with the application of 125% RDF. Partial factor productivity has not influenced significantly due to various genotypes but it was observed significantly higher with the application of 100% RDF.

Key words: Castor, fertility, genotypes, productivity, profitability and seed yield.

Among nine cultivated oilseeds crops, castor is an important non-edible oilseed crop of the arid and semi-arid regions (Jat *et al.*, 2020) cultivated mainly by resource poor small and marginal farmers of the world having industrial importance due to the presence of fatty acid (ricinoleic acid). Castor oil having 85-90% ricinoleic acid, a unique fatty acid. Ricinoleic acid is a principal component of preparation of numerous industrial products. By-product after castor oil extraction, the castor cake or de-oiled cake, is also considered as excellent organic manure which is used to improve soil health and restore soil fertility. Castor oil has more than 700 industrial uses (Anjani, 2012). Castor oil is known for its usage as lubricant in jet engines, manufacture of paints, varnishes, soaps, dyeing and preservation industry across the globe (Ramanjaneyulu *et al.*, 2021). Castor is extensively cultivated on commercial scale in 30 countries including India, Brazil, China, Russia, Ethiopia, Thailand and Philippines are the pioneer castor growing countries in the world. At present, India is the world leader in castor production and sole exporter of castor oil, seed and its derivatives. A spectacular rise in production and productivity of castor in India from 2.1 to 10.03 lakh tons and 220 to 1334 kg ha^{-1}, respectively during the last six decades. Currently, the total castor production is 11.96 lakh tons obtained from 7.51 lakh ha with a productivity of 1593 kg ha^{-1} in India (Anonymous, 2019). Gujarat is the largest castor growing state of India where it is cultivated intensively in arid and semi-arid region over an area of 7.36 lakh ha with the annual production of 14.32 lakh ton with an average productivity of about 1944 kg ha^{-1} (Anonymous, 2020). Whilst, castor is drought tolerant plant and can be grown on wide climatic regimes and is an ideal crop for arid and semi-arid zones with humid climate (Falasca *et al.*, 2012), the availability of balanced nutrients is very necessary for getting high yield. The productivity of castor is low due to poor crop management practices and low resource allocation parallel to lack of high yielding improved hybrids adaptive under diverse environmental condition and wilt disease (Patel *et al.*, 2020). However, response of different genotypes may differ with different fertility levels in a particular

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environment. The evaluation of consistency and adaptability of the genotypes is an important component of natural recourse management, because in the eve of elevated agro inputs prices and depleting natural resource, the venture of crop production must explore the resources judiciously (Mohan Kumar and Yamanura, 2020). Hence, genotype used in crop production process must have higher resource use efficiency. Hybrids are cultivated mainly as pure crop both under rainfed and irrigated systems. A particular genotype does not exhibit the same phenotypic expression under different environments and different genotypes respond differently to a particular environment and particular nutrition as well as management practices. This variation arising from lack of correspondence between the genetic and non-genetic effects is known as genotype × management interaction. The crop yield is dependent on the genotype, environments, management and their interaction. The productivity of castor genotypes is low because of poor management and low resource allocation. Imbalance and indiscriminately application of fertilizers hinders the crop performance and pollutes environment (Jat and Desai, 2020). Hence, optimum nutrient supply is a key factor for achieving higher yield and remuneration with sustaining environment (Chongtham *et al*., 2018). Keeping in view the potential of crop, in terms of industrial uses and ever growing demand for castor oil and derivatives across the world, there is need to improve castor productivity in India. Therefore, present investigation was conducted to find out the balance fertilizer level for different castor genotypes under North Gujarat Agro-climatic condition.

Materials and Methods

Experimental site and weather

A field experiment was undertaken at Castor-Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar, Dantiwara, Gujarat during kharif season (2017-2018). The soil of the experimental field was loamy sand in texture, organic carbon (0.12%), pH (7.2), low in available nitrogen (97 kg ha^{-1}), medium in available phosphorus (51 kg ha^{-1}), available potassium (232 kg ha^{-1}) and sulphur (13 ppm). The experimental site has semi-arid and sub-tropical climate with hot dry summer and slightly cold winter. A total rainfall of 2082.6 mm received in 38 rainy days was recorded with maximum intensity in second fortnight of July, 2017. The weekly mean maximum temperature varied from 23.8 to 41.8°C (average 33.0°C) along with minimum temperature ranged from 6.2 to 27.1°C (average 17.9°C), respectively.

Experimental details

The experiment comprised of sixteen treatment combinations which consisted eight castor hybrids (JHB 1018, SHB 974, SLCH 158, ICH 66, ICH 68, Maharaja 9, DCH 519 and GCH 7) and two fertility levels (100% recommended dose of fertilizer (RDF) and 125% RDF). The experiment was laid out in factorial randomized block design with three replications.

Crop management and observations

Castor hybrids were sown in rows 150 cm apart with keeping plant to plant distance 120 cm on 12 August, 2017. Recommended dose of fertilizer (RDF) i.e. 180-37.5-00-20 kg N-P-K-S ha^{-1} for castor was applied as per treatments. Full dose of phosphorus, sulphur and ¼th part of nitrogen were made as per treatments to earmarked plots as basal. Remaining ¾th dose of nitrogen was applied in 3 equal instalments at 30-35, 60-65 and 90-95 DAS. Nitrogen, phosphorus and sulphur were supplied through urea, diammonium phosphate and elemental sulphur, respectively. Weed management operations were carried out manually as well as inter-culturing by tractor operated cultivator. Six irrigations were applied during cropping period. Other management practices were adopted as per package of the crop under irrigated condition. Harvesting of spike was done as per maturity and all pickings were completed up to last week of March.

Crop productivity was calculated by using the formula:

$$\text{Crop productivity (kg ha}^{-1}\text{ day}^{-1}) = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Crop duration (days)}}$$

Economics like cost of cultivation and net return were worked out by considering prevailing local market prices of inputs during the period of investigation. Net return was estimated by subtracting total cost of cultivation from gross return. Benefit:cost ratio (BCR) was worked out through dividing gross return by total cost of cultivation. Crop productivity of castor was calculated by using the following formula:

$$\text{Crop profitability } (\text{Rs ha}^{-1}\text{ day}^{-1}) = \frac{\text{Net return (Rs ha}^{-1})}{\text{Crop duration (days)}}$$

Partial factor productivity (PFP) was calculated for different nutrients viz. N, P and S in terms of seed yield production per unit application of that particular nutrient as:

$$\text{Partial factor productivity of N or P or S (kg seed yield kg}^{-1}\text{ nutrient applied)} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{N or P or S applied (kg ha}^{-1})}$$

Statistical analysis

All the observed data were statistically analysed as per the procedure of analysis of variance and significance of a factorial randomized block design was tested by "F" test (Gomez and Gomez, 1984). Standard error of means (SEm±) and least significant difference (LSD) at 5% level of significance were worked out for mean values of each parameter to draw a valid conclusion and logical interference.

Results and Discussion

Genotypes

Among all genotypes, Maharaja 9 registered significantly higher plant height (92.2 cm) and number of nodes plant^{-1} (21.5) as compared to remaining hybrids (Table 1). However, in case of length of primary spike (80.5 cm) and number of capsules on primary spike (131.3) was recorded significantly higher with SLCH 158, whereas number of effective branches plant^{-1} (18.8) was proved significantly higher under JHB 1018 and maximum 100 seed weight was obtained from ICH 66. Significantly higher seed yield (3418 kg ha^{-1}) of castor was recorded with hybrid ICH 68 to the tune of 19.46% higher yield over SHB 974 which was produced minimum seed yield (2861 kg ha^{-1}). Variation in genetic constituent of different cultivars may be the reason for their differential growth response. These results are in accordance with the earlier findings of Lavanya and Solanki, 2010; Severino *et al*., 2012; Anjani, 2014; Jat and Desai, 2020. Maximum oil content (49.0%) was found in castor cultivar SHB 974 (Table 1). Significantly higher oil yield (1600 kg ha^{-1}), crop productivity (14.8 kg ha^{-1} day^{-1}), net returns (Rs. 97689 ha^{-1}) B:C ratio (3.50) and crop profitability (Rs. 423 ha^{-1} day^{-1}) was recorded with ICH 68. The economic benefits accrued could be attributed to better growth and yield of this hybrid under optimum fertility level. Several researchers have also been observed the variation among the genotypes of castor yield and growth characteristics. Similar findings were also reported by Senthil Kumar and Venkatachalam, 2017; Chongtham *et al*., 2018;

Table 1. Effect of fertility levels on growth and yield characters of castor genotypes

Treatments	Plant height (cm)	No. of nodes plant^{-1}	No. of effective branches plant^{-1}	Length of primary spike (cm)	Number of capsules on main spike	100 seed weight (g)	Seed yield (kg ha^{-1})	Oil content (%)
Castor genotypes								
JHB 1018	66.10	17.60	18.80	53.00	71.40	27.20	3168.0	47.20
SHB 974	64.10	16.20	14.30	50.90	85.40	29.60	2861.0	49.00
SLCH 158	65.00	18.60	9.90	80.50	131.30	32.50	3305.0	47.20
ICH 66	67.00	19.10	12.70	73.00	116.20	33.60	2943.0	48.10
ICH 68	78.50	19.00	17.80	69.60	96.80	33.10	3418.0	46.80
Maharaja 9	92.20	21.50	13.90	78.20	112.10	32.10	3076.0	48.60
DCH 519	80.70	18.30	12.50	72.70	121.20	30.50	2988.0	46.40
GCH 7	81.60	19.50	14.70	65.40	88.90	32.80	3321.0	47.70
SEm±	3.23	0.36	0.78	1.97	4.51	0.55	130.2	0.56
CD (P=0.05)	9.32	1.04	2.26	5.70	13.02	1.60	376.1	1.60
Fertility levels								
100% RDF	75.20	18.90	14.50	68.70	102.40	31.50	3108.0	48.00
125% RDF	73.70	18.50	14.20	67.20	103.50	31.40	3162.0	47.20
SEm±	1.61	0.18	0.39	0.99	2.25	0.28	65.1	0.28
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of fertility levels on quality, productivity, economics, profitability and partial factor productivity of castor genotypes

Treatments	Oil yield (kg ha^{-1})	Crop productivity (kg ha^{-1} day^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio	Crop profitability (Rs ha^{-1} day^{-1})	Partial factor productivity (kg seed yield kg^{-1} nutrient applied)		
							Nitrogen	Phosphorus	Sulphur
Castor genotypes									
JHB 1018	1497	13.7	126708	87677	3.25	380	15.8	76.1	142.6
SHB 974	1402	12.4	114440	75409	2.93	326	14.2	68.3	128.0
SLCH 158	1562	14.3	132197	93165	3.38	403	16.4	78.8	147.8
ICH 66	1416	12.7	117713	78682	3.02	341	14.8	71.0	133.1
ICH 68	1600	14.8	136720	97689	3.50	423	17.1	82.3	154.2
Maharaja 9	1493	13.3	123032	84001	3.15	364	15.3	73.5	137.8
DCH 519	1385	12.9	119532	80501	3.06	348	15.0	71.8	134.7
GCH 7	1574	14.4	132822	93790	3.40	406	16.6	79.6	149.3
SEm±	59.69	0.56	5209.0	5209.0	0.13	22.5	0.68	3.29	6.16
CD (P=0.05)	NS	1.63	15044.6	15044.6	0.39	65.1	NS	NS	NS
Fertility levels									
100% RDF	1490	13.5	124317	85879	3.23	372	17.3	82.9	155.4
125% RDF	1492	13.7	126474	86850	3.19	376	14.1	67.5	126.5
SEm±	29.85	0.282	2604.5	2604.5	0.067	11.3	0.342	1.643	3.081
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.99	4.75	8.90

1US$=INR (73.1486)

Mohan Kumar and Yamanura, 2020; Jat and Desai, 2020.

Partial factor productivity of nitrogen, phosphorus and sulphur was not influenced significantly due to various castor genotypes but it was registered numerically higher with ICH 68 (Table 2). Similar results have also been reported by Ramanjaneyulu *et al*., 2013; Kalhapure *et al*., 2020; Jat and Desai, 2020.

Fertility levels

Growth and yield characters such as plant height, number of nodes plant^{-1}, number of effective branches plant^{-1}, length of primary spike, number of capsule on primary spike, 100 seed weight and seed yield was recorded numerically higher under 125% RDF but it was failed to showed significant variation (Table 1). Stunted plant height may be observed in presence of insufficient supply of nitrogen. Increasing nitrogen levels concomitantly increases number of capsules per spike was also reported by Jamil *et al*., 2017. Similarly, marginally higher oil content, oil yield, crop productivity, net returns, B:C ratio and crop profitability was registered under 125% RDF. Sufficient supply of nutrients might have enhanced growth promoting substances, which led to accelerated cell division and elongation, and ultimately resulted in luxuriant vegetative and reproductive growth in terms of growth and yield parameters (Rana *et al*., 2006; Malik *et al*., 2018). These results are in agreement with the finding of Chongtham *et al*., 2018 reported in forage sorghum.

Partial factor productivity of nitrogen, phosphorus and sulphur was decreasing with increasing levels of fertility. Significantly higher partial factor productivity of nitrogen (17.3), phosphorus (82.9) and sulphur (155.4) was recorded with application of 100% RDF (Table 2). Kalhapure *et al*., 2020 also reported this kind of results in wheat as well as Jat and Desai, 2020 also observed in castor.

Conclusion

Application of 125% RDF to castor genotypes ICH 68, GCH 7, ICH 66 and Maharaja 9 is considered for high yield, productivity and profitability under irrigated condition of the Northern Gujarat.

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