***Original Research Article***

**Effects of spacing and nitrogen on castor (GAC 11) grown on heavy black soil**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**ABSTRACT**

 To find out the effect of spacing and nitrogen on castor (GAC 11) grown on heavy black soil of middle Gujarat experiment was carried out at Narmada Irrigation Research Project, Anand Agricultural University, Khandha,Vadodara (Gujarat) during the years 2019-20 to 2021-22. The experiment was laid out in split plot design with three replications. The results revealed that among spacing treatments, significantly the highest plant population was recorded under treatment S1 : 60-120-60 cm (Paired row). Growth and yield attributes of castor were remain unaffected due to the different spacing treatments, while, significantly the highest seed yield of castor was recorded under treatment S1 : 60-120-60 cm. Under nitrogen levels treatments, significantly the highest growth and yield attributes of castor like, plant height, number of branches per plant, number of spike per plant, main spike length and number of capsules per main spike and seed yield of castor were recorded under treatments N3: 100 kg/ha which was statistically at par with treatment N2: 75 kg/ha. Seed yield of castor was significantly influenced due to interactions between spacing and nitrogen levels in pooled results. Significantly the highest seed yield of castor was recorded under treatment S2N3 which was statistically at par with treatment S1N1, S1N2, S1N3, S2N2 & S3N3 ,while interactions effects were found non-significant with respect to growth and yield attributes. Maximum net realization and BCR were recorded under treatments S1N2, S1N3, S2N2 & S2N3, while, low cost of cultivation was found under treatment S1N1.

**Key words**: castor, plant population, paired row spacing, nitrogen, seed yield

**1. INTRODUCTION**

 Castor (*Ricinus communis* L.) is one of the most important non-edible oilseed crops of India. Because of its hardiness, castor plays an important role in the economy of arid and semi-arid regions of the country. Castor oil has great industrial utility as it is used for the manufacture of soaps, refined and perfumed hair oil, printing inks, varnishes, synthetic resins, carbon paper, lubricants, printers, ink, electrical insulation, ointments, cosmetics and processed leather. Castor cake is also a good source of nitrogen (4.3%) and is widely used as manure. In Gujarat castor is cultivated in an area of 7.25 lakh hactares and production of 15.95 lakh tones with productivity of 2201 kg/ha (Anon.2023).

 Optimizing plant spacing and plant population is a simple agronomic technique which may plays an important role in obtaining higher yield. Under black soil conditions, vegetative growth of crop is higher on account of more conservation of soil moisture. Under these circumstances, farmers of middle Gujarat growing castor under heavy black soil are generally preferred wider spacing and therefore, it is very necessary to quantify optimum plant population by adjusting the spacing.

 Fertilizers play a significant role in the modern crop production. They are key inputs contributing about 30 to 70 per cent increase in crop yield. Nitrogen is an essential nutrient needed by all plant to thrive. Efficient utilization of N fertilizers can increase the yield of castor. Enhanced production is possible mainly through appropriate agro techniques such as crop sown at optimum spacing, maintaining optimum plant population and efficient use of nutrients. The present study was, therefore, designed to obtain reasonably higher level of productivity of castor by selecting the suitable plant spacing and nitrogen level under black soil condition of the middle Gujarat region.

**2. MATERIALS AND METHODS**

 Research experiment was carried out to find out the optimum spacing and nitrogen level for castor (GAC 11) during semi *rabi* season of the consecutive three years 2019-20 to 2021-22 at Narmada Irrigation Research Project, Anand Agricultural University, Khandha (Gujarat) which represent Middle Gujarat Agroclimatic Zone III and Agro ecological situation IX of Gujarat. The soil of Khandha farm is montmorillonitic and vertisols which is characterized by very deep black clayey, imperfectly drained with low infiltration rate. The initial soil status showed that soil was high in organic carbon (0.88%), medium in available phosphorus (55.04 kg/ha), high in available potassium (981 kg/ha) and alkaline in reaction having pH of 8.44. The experiments were laid out in split plot design with three replications. There were twelve treatment combinations of two factors i.e., plant spacing and nitrogen levels. Spacing treatments comprised of four spacing *i.e.,* S1 : 60-120-60 cm (Paired row-18,519 plants/ha), S2 : 60-150-60 cm (Paired row-15,873 plants/ha), S3 : 60-180-60 cm (Paired row-13,888 plants/ha) and S4 : 180 x 60 cm (Farmer’s practice- 9,259 plants/ha) , while Nitrogen levels comprised of three treatments *i.e.,* N1 : 50 kg/ha, N2 : 75 kg/ha and N3 : 100 kg/ha. FYM @ 5 t/ha was applied during land preparation. Improved selection variety Gujarat Anand Castor 11 (GAC 11) was used in the experiment, which is recommended for castor growing areas of middle Gujarat under irrigated and rainfed conditions. Castor seeds were dibbled as per the spacing treatments in paired row and without paired row. Gap filling operations were undertaken at 15 days after sowing to maintain uniform plant population. Common dose of Phosphorus @ 50 kg/ha was applied as a basal to all plots. Nitrogen was applied as per the treatments in three splits *i.e.,* 25 % N as a basal, 50 % N at 30 DAS and 25 % N at 60 DAS. Urea and Single super phosphate were used as source for supplying N and P2O5 nutrients respectively. Besides spacing and nutrient management practices, the crop was raised with recommended package of practices. The treatment effects were evaluated in terms of growth, yield attributing parameters, yield and economics. Observations on plant population, plant height, number of branches per plant, number of spike per plant, main spike length and number of capsules per main spike, seed index and seed yield were recorded as per the procedure. Soil analysis at initial and after harvest of crop was done to assess the nutrient content in the soil. Data was analyzed statistically using Fisher’s analysis of variance technique and treatment means were compared using least significant difference test at 5 percent level of probability.

**3. RESULTS AND DISCUSSION**

 The pooled results of three years experimental findings on effect of row spacing and nitrogen on growth, yield attributes, yield and economics of castor have been discussed under different heads.

**3.1 Effect of plant spacing:**

 Plant populations/net plot was significantly increased under paired row spacing treatment S1 : 60-120-60 cm (46.5) over other spacing treatments i.e., S2 : 60-150-60 cm (31.2), S3 : 60-180-60 cm (31.0 ) and S4 : 180 x 60 cm (23.2). This was attributed to more plants were sown per unit area under closer spacing of paired row as compared to normal spacing of farmer’s practices. Porwal *et al.* (2006) and Patel *et al*. (2010) reported the similar results. The pooled results of three years experiment findings showed that growth and yield attributes like, plant height, number of branches per plant, number of spike per plant, main spike length, number of capsules per main spike and seed index of castor (GAC 11) were remain unaffected due to the different spacing treatments. This exhibited that inter row competition was not so severe due to the different paired row spacing and normal spacing. Similar results was reported by Dhimmar (2009).

 Seed yield of castor was significantly influenced due to the spacing treatments. Significantly the highest seed yield (1069 kg/ha) was recorded under treatment S1 : 60-120-60 cm (Paired row) over normal sowing treatment S4: 180 x 60 cm (farmer’s practice) and it was statistically at par with treatment S2 : 60-150-60 cm (Paired row) in pooled results. This can be attributed to more number of plants per unit area under closer spacing of paired row which resulted in higher yield. These findings corroborates the results of Porwal *et al.* (2006), Patel *et al.* (2009), Patel *et.al*. (2010), Dodiya *et al.* (2016),Shinde *et al.* (2018) and Kowser *et al*. (2021).

 Different soil parameters like Organic carbon, Av. P2O5 ,Av. K2O, Soil pH and Soil EC were not significantly influenced by the spacing treatments.

**3.2 Effect of nitrogen levels:**

 Growth and yield attributes were found significant due to the different nitrogen levels treatments. Significantly the highest growth and yield attributes like, plant height (91.0 cm), number of branches per plant (4.27), number of spike per plant (5.51), main spike length (55.1 cm) and number of capsules per main spike (63.8) were recorded under treatments N3: 100 kg/ha which was statistically at par with treatment N2: 75 kg/ha. This improvement in crop growth might be because of the increased availability and uptake of nitrogen at higher N levels. More number of branches per plant coupled with better nutrition would have resulted in production of more number of spikes/ plant and capsules/ spike. These results are in agreement with Mathukia and Modhwadia (1993),Venugopal *et al.* (2007), Patel *et al.* (2009),Patel *et al.* (2010) and Man *et al.* (2017).

 Significantly the highest seed yield of castor (1069 kg/ha) was recorded under treatment N3: 100 kg/ha which was statistically at par with treatment N2: 75 kg/ha. The probable reason for such a positive response due to addition of higher rate of nitrogen might be resulted in efficient photosynthesis and finally produced more seed yield. These results are analogous to those reported by Patel *et al.* (2009),Patel *et al.* (2010) and Man *et al.* (2017).

 The seed index and different soil parameters like, Organic carbon, Av. P2O5 ,Av. K2O, Soil pH and Soil EC were found non significant.

**Table 1**: **Effect of spacing and nitrogen on plant population, growth attributes, yield attributes,**

 **yield and seed index of castor (GAC 11)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant population/ Net plot** | **Plant height (cm)** | **No. of branches /plant** | **No. of spikes/plant** | **Main spike length (cm)** | **No. of capsule/main spike** | **Seed yield (kg/ha)** | **Seed index** |
| **Main plot : Spacing (S)** |
| S1 : 60-120-60 cm (Paired row) | **46.5** | 89.6 | 4.07 | 5.30 | 53.4 | 61.1 | **1069** | 32.3 |
| S2 : 60-150-60 cm (Paired row) | 30.9 | 89.7 | 4.13 | 5.22 | 53.0 | 60.7 | 1023 | 32.5 |
| S3 : 60-180-60 cm (Paired row) | 30.7 | 87.9 | 3.92 | 5.18 | 52.3 | 60.5 | 991 | 32.3 |
| S4 : 180 x 60 cm (Farmer’s practice) | 22.9 | 85.3 | 3.98 | 5.11 | 50.8 | 60.4 | 871 | 32.3 |
| **S.Em±** | **0.123** | **1.49** | **0.081** | **0.101** | **0.888** | **1.15** | **20.4** | **0.317** |
| **C.D. at 5 %** | **0.365** | **NS** | **NS** | **NS** | **NS** | **NS** | **60.5** | **NS** |
| **C.V. (%)** | **1.95** | **8.79** | **10.4** | **10.0** | **8.81** | **9.82** | **10.7** | **5.09** |
| **Sub plot : Nitrogen levels(N)** |
| N1 : 50 kg/ha | 32.9 | 84.2 | 3.73 | 4.78 | 48.5 | 56.3 | 932 | 32.3 |
| N2 : 75 kg/ha | 32.6 | 89.2 | 4.08 | 5.33 | 53.6 | 62.0 | 1009 | 32.4 |
| N3 : 100 kg/ha | 32.8 | **91.0** | **4.27** | **5.51** | **55.1** | 63.8 | **1024** | 32.3 |
| **S.Em±** | **0.136** | **1.21** | **0.076** | **0.083** | **0.697** | **0.826** | **11.5** | **0.316** |
| **C.D. at 5 %** | **NS** | **3.43** | **0.216** | **0.237** | **1.98** | **2.35** | **32.6** | **NS** |
| **C.V. (%)** | **2.48** | **8.21** | **11.3** | **9.62** | **7.99** | **8.17** | **6.97** | **5.86** |
| **INTERACTION**  |
| **S X N** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **Sig.** | **NS** |

**Table 2**: **Effect of spacing and nitrogen on soil parameters of castor (GAC 11)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Organic carbon (%)** | **Av. P2O5 (kg/ha)** | **Av. K2O (kg/ha)** | **PH** | **EC (dsm-1)** |
| **Main plot : Spacing (S)** |
| S1 : 60-120-60 cm (Paired row) | 0.88 | 53.1 | 800 | 8.22 | 0.48 |
| S2 : 60-150-60 cm (Paired row) | 0.86 | 51.7 | 802 | 8.06 | 0.49 |
| S3 : 60-180-60 cm (Paired row) | 0.86 | 53.3 | 819 | 8.09 | 0.46 |
| S4 : 180 x 60 cm (Farmer’s practice) | 0.86 | 53.4 | 821 | 8.13 | 0.49 |
| **S.Em±** | **0.011** | **1.04** | **7.42** | **0.046** | **0.01** |
| **C.D. at 5 %** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **C.V. (%)** | **6.83** | **10.2** | **4.76** | **2.93** | **13.4** |
| **Sub plot : Nitrogen levels(N)** |
| N1 : 50 kg/ha | 0.85 | 53.4 | 808 | 8.15 | 0.48 |
| N2 : 75 kg/ha | 0.86 | 52.6 | 810 | 8.10 | 0.48 |
| N3 : 100 kg/ha | 0.89 | 52.8 | 814 | 8.13 | 0.47 |
| **S.Em±** | **0.014** | **1.08** | **8.15** | **0.044** | **0.010** |
| **C.D. at 5 %** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **C.V. (%)** | **9.60** | **12.22** | **6.03** | **3.28** | **12.0** |
| **INTERACTION**  |
| **S X N** | **NS** | **NS** | **NS** | **NS** | **NS** |

**3.3. Interaction effects of spacing and nitrogen levels:**

 The interaction effects between spacing and nitrogen levels with respect to growth & yield attributes and soil parameters of castor was found non-significant. However, the interactions between spacing and nitrogen levels were found significant in pooled results with respect to seed yield of castor. Significantly the highest seed yield of castor was recorded under treatment S2N3 (60-150-60 cm, Paired row + 100 kg N/ha) which was statistically at par with treatment S1N1 (60-120-60 cm, Paired row + 50 kg N/ha), S1N2 (60-120-60 cm, Paired row + 75 kg N/ha), S1N3 (60-120-60 cm, Paired row + 100 kg N/ha), S2N2 (60-150-60 cm, Paired row + 75 kg N/ha), S3N3 (60-180-60 cm, Paired row + 100 kg N/ha). The findings are in accordance with the results reported by Narkhede *et al.* (1984) and Patel *et al.* (2010).

**Table 3**: **Interaction effect of row spacing and nitrogen on seed yield of castor (GAC 11)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S X N** | **N1** | **N2** | **N3** |
| **S1** | 1054 | 1074 | 1080 |
| **S2** | 911 | 1077 | **1081** |
| **S3** | 936 | 999 | 1037 |
| **S4** | 829 | 886 | 898 |
| **S.Em±** | **23.0** |
| **C.D. at 5 %** | **65.3** |
| **C.V. (%)** | **8.83** |

**3.4 Economics**

 The results revealed that maximum net realization and BCR were recorded under treatments S1N2 (60-120-60 cm, Paired row + 75 kg N/ha), S1N3 (60-120-60 cm, Paired row + 100 kg N/ha), S2N2 (60-150-60 cm, Paired row + 75 kg N/ha) & S2N3 (60-120-60 cm, Paired row + 75 kg N/ha) while, low cost of cultivation was found under treatment S1N1 (60-120-60 cm, Paired row + 50 kg N/ha).

**Table 4**: **Effect of row spacing and nitrogen on economics of castor GAC 11)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Yield (kg/ha)** | **Gross realization (`/ha)** | **Treatment cost (`/ha)** | **Common cost****(`/ha)** | **Total cost of cultivation (`/ha)** | **Net Realization (`/ha)** | **BCR** |
| S1N1 | 1054 | 74307 | **2327** | 55947 | **58274** | 16033 | 1.28 |
| S1N2 | 1074 | 75717 | 2705 | 55947 | 58652 | 17065 | 1.29 |
| S1N3 | 1080 | 76140 | 3082 | 55947 | 59029 | 17111 | 1.29 |
| S2N1 | 911 | 64226 | 2327 | 55947 | 58274 | 5951 | 1.10 |
| S2N2 | 1077 | 75929 | 2705 | 55947 | 58652 | 17277 | 1.29 |
| S2N3 | 1081 | 76211 | 3082 | 55947 | 59029 | 17181 | 1.29 |
| S3N1 | 936 | 65988 | 2327 | 55947 | 58274 | 7714 | 1.13 |
| S3N2 | 999 | 70430 | 2705 | 55947 | 58652 | 11778 | 1.20 |
| S3N3 | 1037 | 73109 | 3082 | 55947 | 59029 | 14079 | 1.24 |
| S4N1 | 829 | 58445 | 2327 | 55947 | 58274 | 170 | 1.00 |
| S4N2 | 886 | 62463 | 2705 | 55947 | 58652 | 3811 | 1.06 |
| S4N3 | 898 | 63309 | 3082 | 55947 | 59029 | 4280 | 1.07 |

**4. CONCLUSION**

 Looking to the above results of interactions between spacing and nitrogen with respect to seed yield of castor and cost of cultivation, castor (GAC 11) crop should be sown in paired row at the spacing of 60-120-60 cm and fertilize the crop with 5 t FYM/ha and 50 kg P2O5/ha as basal, while 50 kg N/ha should be applied in three splits i.e., 12.5 kg N/ha as a basal, 25 kg N/ha at 30 DAS and 12.5 kg N/ha at 60 DAS for getting better yield with low cost of cultivation on heavy lack soil of middle Gujarat (AES IX).

**REFERENCES:**

Anonymous (2023). Final advance estimate of Area, Production and Yield of major Kharif/Rabi/Summer crop of Gujarat state. Director of Agriculture (Gujarat state).

Dhimmar S.K. (2009). Effect on growth and yield of *rabi* castor in pulses intercropping under varying planting geometry. *American-Eurasian J. of Scientific Res.* **4**(3): 165-168.

Dodiya C. J., Solanki R. M., Modhavadia J. M., Chatrabhuji B. J. and Barad B. B. (2016). Influence of plant geometry and fertility levels on growth and yields of *rabi* castor (*ricinus communis* L.). *The Bioscan* **11**(1): 445-448.

Kowser T., Halepyati A. S., Chittapur B. M., Channabasavanna A. S., I. Shanker Goud and Gowda B. (2018). Effect of genotypes on spacing and nipping with different levels of nutrients on growth and yield of castor (*Ricinus communis* L.). *Int. j. of pure and applied bioscience* **6** (1): 1259-1265.

Mathukia R. *K.* and Modhwadia M. M. (1993). Response of castor *(Ricinus communis)* to nitrogen and phosphorus. *Indian J. Agron.* **38** (1) : 152-153.

 Man M.K.\*, Amin A.U., Choudhary K.M. and Annu Devi Gora (2017). Response of castor (*Ricinus communis* L.) to varying weather variables and crop geometry with levels of nitrogen under *rabi* season. *Int.J.Curr.Microbiol.App.Sci.* **6**(5): 2409-2418.

Narkhede B. N., Patil, A. B. and Deokar, A. B. (1984).Varietal response to plant densities and nitrogen application in castor. *Journal of Oilseeds Research* **1**(2) : 109-114.

Patel R.A., Patel J.J. and Patel A.S. (2010). Seed yield and net returns of drip irrigated late *Kharif* castor (*Ricinus communis* L.) as influenced by plant geometry and nitrogen levels. *Int. J. of Agric. Sci.*  **6**(2) : 449-452.

Patel R.M., Patel M.M. and Patel G.N. (2009). Effect of spacing and nitrogen levels on *rabi* castor, *Ricinus communis* Linn, grown under different cropping sequences in North Gujarat agro-climatic conditions. *J. Oilseeds Res.* 26(2) : 123-125.

Porwal, M.K., Agarwal, S.K. and Khokhar, A.K. (2006). Effect of planting methods and intercrops on productivity and economics of castor (*Ricinus communis* L*.*) based intercropping systems. *Indian J. Agron.* **51**(4): 274-277.

Shinde R.S., Kalegore N.K. and Gagare Y. M. (2018). Effect of plant spacing and fertilizer levels on yield and yield attributes of castor (*Ricinus communis* L.). *Int.J.Curr.Microbiol.App.Sci.* Special Issue-**6**: 1738-1743.

Venugopal, C. and Krishna Reddy, G. (2007). Yield attributes, seed yield and net returns of rainfed castor as influenced by plant geometry and nitrogen levels. *Internat. J. Agric. Sci.* **3** (2): 138-140.