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Research Paper

Intra-row spacing and nitrogen management in wide–spaced winter castor (*Ricinus communis*) in heavy rainfall zone of south Gujarat

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ABSTRACT

An experiment was conducted for 3 consecutive winter (*rabi*) seasons of 2011–12, 2012–13 and 2013–14 on clayey soil of the Soil and Water Management Research Farm, Navsari, Gujarat, to study the response of wide-spaced (2.4 m), drip-irrigated winter (*rabi*) castor (*Ricinus communis* L.) to intra-row spacing under varying nitrogen (N) levels. In all, 10 treatments comprising 3 intra-row spacings (60, 90 and 120 cm) and 3 N levels (80, 120 and 160 kg N/ha) besides, 1 paired row control [0.6 m × 0.6 m × 1.2 m paired row + recommended dose of fertilizer (RDF)] treatment outside the experimental plot. Intra-row spacing of 120 cm resulted in significantly higher number of branches, leaves, spikes and seed yield/plant. However, intra-row spacing of 60 cm remained superior in respect of plant height, seed, stalk and oil yields and nutrient uptake. Improvement in seed yield under 0.6 m intra-row spacing was 12.68 and 4.18% over 1.2 and 0.9 m respectively. Among the N levels, an application of 160 kg N/ha recorded significantly higher plant height, number of branches, leaves, spikes, seed yield/plant and also resulted in higher seed, stalk and oil yields. On pooled data basis, the magnitude of increase in seed yield under 160 kg N/ha was 5.84 and 2.11% over 80 and 120 kg N/ha respectively.

Key words : Castor, Intra-row spacing, Nitrogen, Yield

In south Gujarat heavy rainfall zone, the predominant crop sequence is rice-rice and paddy-sugarcane, which is the main cause for waterlogging and salinity problems in these areas. Also this system proves uneconomical day by day due to increased cost of cultivation as well as decreases in yield trend of sugarcane. Hence there is an urgent need to find out an alternate crop sequence with low water requirement and higher economic returns to overcome these problems. As the south Gujarat lies in heavy rainfall zone with heavy black clay soil, castor is sown during late rainy (*kharif*) or *rabi* season. To fill up the gap between onset of monsoon and sowing time of castor, farmer can grow crops like rice, mungbean, urdbean, cowpea, sesame, mothbean etc., in *kharif* season and thus, the farmer can be benefited from short-duration crop. When pulses are grown in crop sequence it provides residual nitrogen. Inclusion of castor in a crop sequence reduces inputs requirement with its low cost production technology, less water requirement which also minimizes salinity problems and improves soil health. Now-a-days, with increasing demand of castor oil for industrial purpose, castor fetches good market price and higher economic returns over existing addy-sugar cane cropping system in shorter duration. Optimum plant stand is essential for an interception of sunlight and consequently increases the uptake of water and nutrients thereby higher dry-matter production. An adequate supply of nitrogen is associated with vigorous plant growth and deep green colour of plant. Since castor, being indeterminate in growth habit, shows response to the space and N, there is need to evaluate its performance under wider spacing and higher levels of nitrogen.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of 2011–12, 2012–13 and 2013–14 at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari, Gujarat. The soil of experimental plot was clayey in texture and slightly alkaline. The soil was low in available N, medium in available P and high in available K. The experiment was laid out in a randomized block design with factorial concept with 3 replications. There were 10 treatments, comprising combinations, of 3

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intra-row spacings (S_1: 60 cm, S_2: 90 cm and S_3: 120 cm) and 3 N levels (N_1: 80 kg N/ha, N_2: 120 kg N/ha and 160 kg N/ha) besides 1 paired row control [0.6 m × 0.6 m × 1.2 m paired row + recommended dose of fertilizer (RDF)] outside the experimental plot. The common wide inter-row spacing of 2.4 m was mentained for all plots except paired row control. The recommended dose of fertilizer (80 : 40 : 0, N : P : K) was given to the control plots, while other plots fertilized with various levels of nitrogen as per treatment and common phosphorus of 40 kg/ha. The crop was fertilized with basal dose of 40 kg/ha P and 10% of N level, while remaining 90% N was given in equal 9 splits at 10-day intervals, starting from 20 DAS (days after sowing) up to 100 days through fertigation. The crop was raised with agronomic package of practices, and observations were made periodically.

RESULTS AND DISCUSSION

Intra-row spacing

The intra-row spacing failed to show significant effect on plant height, no. of spikes/plant, capsules/spike and 100-seed weight (Table 1). Though higher seed yield/plant was registered with wider intra-row spacing (120 cm), significantly higher seed (2,941 kg/ha) and stalk yield (4,737 kg/ha) were realised owing to closer intra-row spacing because of significantly more plant population (6,818/ha). Increase in intra-row spacing decreased the seed and stalk yields to 2,823 kg/ha and 4,345 kg/ha (90 cm) and 2,618 kg/ha and 4,037 kg/ha (120 cm) respectively. The mean seed yield advantage under 0.6 m intra-row spacing was 12.68 and 4.18% over 1.2 and 0.9 m respectively. Similar results were also reported by Rana *et al.* (2006).

Varying intra-row spacings did not significantly influence available soil N, P, K and oil content in castor seed (Table 2). However, significantly higher oil yield was obtained under treatment receiving 0.6 m intra-row spacing over 1.2 m, but remained statistically at par with 0.9 m. Sardana *et al.* (2008) in castor also reported the non significant response of oil content to various spacings. Intra-row spacing of 0.6 m accrued maximum net returns of ₹68,986/ha with benefit: cost ratio of 1.73 (Table 2). This treatment increased the net returns to ₹11,401/ha and 4,016/ha over 1.2 and 0.9 m respectively. The increase in net profit was attributed to large yield differences with very minute differences in cost of production under different intra-row spacings. Closer intra-row spacing was found superior to wider ones. Singh (2003) and Tank *et al.* (2007) also reported similar pattern.

Nitrogen

Though positive effect of N on growth and yield-attributing characters were reported earlier by Paida and Parmar (1980), Patel *et al.* (2005) and Rana *et al.* (2006) none of growth and yield attributes of castor were significantly influenced by application of graded levels 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

Table 1. Influenced of intra-row spacings and nitrogen levels on growth, yield parameters and yield of castor (mean data of 3 years)

Treatment	Plant population/ ha	Plant height (cm)	Branches/ plant	Spikes/ plant	Length of primary spike (cm)	Capsules on primary spike	Seed yield (g/plant)	100-seed weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)
Intra-row spacing (cm)										
S_1, 60	6,818	59.2	24.5	20.4	71.0	63.1	458.9	29.77	2,941	4,737
S_2, 90	4,572	57.2	27.1	21.0	72.7	63.7	656.5	30.25	2,823	4,345
S_3, 120	3,431	59.0	27.6	21.1	71.1	62.0	834.2	30.48	2,618	4,037
SEm±	38.5	0.79	0.55	0.24	0.86	1.12	10.9	0.17	39.06	132.8
CD (P=0.05)	109.4	NS	1.55	0.67	NS	NS	30.9	NS	110.1	377.8
N level (kg/ha)										
N_1, 80	4,921	58.3	25.1	19.8	70.6	61.5	632.7	29.73	2,634	3,924
N_2, 120	4,920	58.8	26.8	20.9	72.1	63.8	658.0	30.26	2,772	4,405
N_3, 160	4,979	58.2	27.3	21.8	72.0	63.4	658.9	30.51	2,977	4790
SEm±	38.5	0.79	0.55	0.24	0.86	1.12	10.9	0.17	39.06	132.8
CD (P=0.05)	NS	NS	1.55	NS	NS	NS	NS	0.48	110.1	377.8
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Control vs rest										
Intra-row spacing (Normal)	4,940	58.4	26.4	20.8	71.6	62.9	649.9	30.17	2,794	4,373
Paired row (Control)	16,999	64.2	11.0	9.3	59.1	50.7	158.0	29.54	2,404	4,023
SEm±	41.2	1.48	0.91	0.40	1.49	1.95	8.0	0.13	49.4	97.7
CD (P=0.05)	116.8	4.16	2.56	1.13	4.19	5.48	22.8	NS	139.0	NS

significant impact on plant stand, it indicates the uniformity of plants/unit area in all the treatments (Table 1). Similarly, N levels also failed to exert any significant impact on plant height at harvesting, but numerically it was found to be increased with increase in N levels. Among the N levels, castor fertilized with 160 kg N/ha recorded significantly higher number of branches/plant at harvesting than 80 kg N/ha but remained statistically at par with 120 kg N/ha. Though various yield-attributing characters were failed to show significant influence of N, 100-seed weight was found significantly affected with varying N levels (Table 1). Application of 160 kg N/ha remarkably increased the number of spikes/plant 100-seed weight with 160 kg N/ha over 80 kg N/ha, but closely followed by 120 kg N/ha.

Soil-available P, K after crop harvesting, oil content and oil yield were not affected significantly due N levels, except N content in soil. Oil content in castor seed followed decreasing trend with increase in N level. So far economic assessment is concerned, the maximum net returns of 69,738/ha and benefit: cost ratio of 1.73 were accrued with the application of N @ 160 kg/ha, which was followed by N @ 120 kg/ha (63,031/ha and 1.59 respectively).

Interaction effect and control vs rest analysis

The interaction between intra-row spacing and N levels was found non-significant for almost all parameters studied. However, treatment combination of 1.2 m intra-row spacing with 160 kg N/ha resulted in higher values of number of branches, spikes, seed yield/plant and 100-seed weight. However, treatment combination of 0.6 m intra-row spacing with 160 kg N/ha resulted in higher seed, stalk and husk yields of castor. Soil-available N, P, K after crop harvesting and oil content were not affected significantly due to interaction of intra-row spacing and N levels. However, treatment combination of S_1N_3, i.e. 0.6 m intra-row spacing and 160 kg N/ha, accrued the maximum net returns (₹69,362/ha) and benfit: cost ratio (1.73).

The control *vs* rest analysis showed significant variation in almost all the parameters studied. Pair row control treatment significantly increased the plant population to the tune of 244.11% over wider row planting. However, other characters like, number of branches, spikes, spike length, capsules/spike and seed yield/plant were significantly improved under wider row spacing. Consequently, wider row-planted castor gave significantly higher seed and stalk yields over paired row control to the extent of 16.22 and 8.70% respectively. Similar results were also reported by Tank *et al.* (2007). Nutritional study showed that soil-available N, P, K after crop harvesting and oil content were not differed significantly in the control vs rest analysis, except in case of oil yield. Similarly, in the control vs rest analysis, wider intra-row planting of castor showed higher net returns (₹63,846/ha) and benefit: cost (1.62) ratio as compare to paired row control (₹45,165/ha and 1.03 respectively). The increase in net returns by castor for normal wider inter-row spacing over paired row planting was to the tune of about ₹18,681/ha.

From the forgoing discussion, it be concluded that drip irrigated *rabi* castor has to be grown at 60 cm intra-row

Table 2. Influence of intra-row spacing and N levels on oil content, yield, soil nutrient status and economics in castor (mean data of 3 years)

Treatment	Oil content (%)	Oil yield (kg/ha)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Net returns (₹/ha)	Benefit: cost ratio
Intra-row spacing (cm)							
S_1, 60	50.4	1,560	238.0	49.2	512.5	68,986	1.73
S_2, 90	50.6	1,505	244.1	49.6	521.7	64,970	1.65
S_3, 120	50.3	1,428	247.6	50.3	527.4	57,585	1.47
SEm±	0.37	17.44	4.14	1.18	12.40	–	–
CD (P=0.05)	NS	49.58	NS	NS	NS	–	–
N levels (kg/ha)							
N_1, 80	50.6	1,457	230.6	50.9	528.1	58,802	1.52
N_2, 120	50.5	1,505	245.5	50.1	519.6	63,031	1.59
N_3, 160	50.3	1,532	253.7	48.1	513.7	69,738	1.73
SEm±	0.37	17.44	4.14	1.18	12.40	–	–
CD (P=0.05)	NS	NS	11.76	NS	NS	–	–
Interaction	NS	NS	NS	NS	NS	–	–
Control vs rest							
Intra-row spacing (Normal)	50.5	1,498	243.3	49.7	520.5	63,846	1.62
Paired row (Control)	50.4	1,364	227.0	47.1	498.8	45,165	1.03
SEm±	0.28	12.95	3.04	0.87	9.34	–	–
CD (P=0.05)	NS	36.72	NS	NS	NS	–	–

spacing and by applying 160 kg N/ha for higher yield and net returns, in heavy rainfall zone of south Gujarat.

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