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Optimizing Fertilizer Requirement for Newly Released Castor Hybrid YRCH 2 under Irrigated Condition

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Field experiment was conducted at Gopalapuram village of Salem district, Tamil Nadu during *Rabi,* 2017 under irrigated condition with an objective of optimizing the fertilizer dose and split application of N and K for obtaining higher productivity in castor hybrid YRCH 2. The experiment was conducted in randomized block design with three replications. The treatments consisted of two graded dose of fertilizers *viz*., 100 and 125% with the combination of 3 splits (basal, 30 and 60 DAS), 4 splits (basal, 30, 60 and 90 DAS) and 5 splits (basal, 30, 60, 90 and 120 DAS). The results of the field experimentation revealed that application of 125 per cent recommended dose of fertilizer with five split application at basal, 30, 60, 90 and 120 DAS had recorded the higher plant height (129.1 cm), higher dry matter production (6105 kg ha^{-1}) and LAI (1.107) at 150 DAS. Whereas, 125 per cent recommended dose of fertilizer with four split application at basal, 30, 60 and 90 DAS had produced more branches (14.60) at 150 DAS. With regard to floral phenology, crop attained fifty per cent flowering at 54.6 days under 125 per cent RDF along with five split application which was followed by 125 per cent RDF with four splits (56.3 days). The yield attributing characters such as productive branches plant^{-1}, length of primary spike, No. of capsules spike^{-1}, test weight and seed yield (3020 kg ha^{-1}) were higher in 125 per cent RDF with five split application which was followed by 125 per cent RDF with four split application which in turn resulted in realization of higher gross returns of 123820 Rs.ha^{-1}, net returns of 98621 Rs.ha^{-1} with benefit cost ratio of 4.91.

Key Words: Castor Hybrid, Fertilizer, Split application, Productivity.

Castor (*Ricinus communis* L.) is an important non-edible industrial oil seed crop belongs to the family Euphorbiaceae. It is monoecious in nature, favours cross-pollination up to the extent of 50 per cent. Castor is generally requires tropical type of climate for its growth and development. Therefore, castor is largely grown in most of the tropical countries in the world. Globally, castor is cultivated in more than 30 countries of which India, Brazil, China, Russia, Thailand and Philippines are the major castor producing countries. India is the lead producer of castor oil in the world and constitutes about 85 per cent of the total global production, has ample scope for castor oil trade and export. Thus, 95 percentage of the total domestic castor production is being exported to European Union and United State of America and generated 6000 crore rupees as foreign exchange annually. In India, it is cultivated in an area of 0.83 m ha with a production and productivity of 1.42 m tonnes and 1713 kg ha^{-1}, respectively (Anon., 2018). Gujarat, Rajasthan, Andhra Pradesh, Telangana, and Tamil Nadu are the major castor producing states in India. The area under castor cultivation in Tamil Nadu is about 50,000 ha with an average productivity of 3000 kg ha^{-1} under irrigated condition and 1875 kgha^{-1} under rainfed situation (AICRP (Castor) QRT Report, TCRS, Yethapur, 2018). In respect of castor hybrid, plant density and its nutrient management plays an important role in influencing the seed yield. The research evidences indicated that the castor seed yield could be improved further, if nitrogen and potassium are applied at the appropriate growth stages coinciding with its demand. Apart from nitrogen, top dressing with potassium may also be found to be effective especially under irrigated condition (Anon., 2016 a). Castor shows considerable plasticity to nutrient and available research data indicated that castor hybrid performs better in terms of bean yield and quality when sown under optimum plant density coupled with efficient nutrient management practices (Dodiya *et al.*, 2016).

More capsules spike^{-1}, lengthy spikes and higher test weight besides higher productivity were obtained when potassium was applied to the crop till formation of third order spike (Anon., 2016 b). The above obtained facts are in favour of split application of both N and K, but in depth studies were not carried out so far in newly released YRCH 2 castor hybrid. However, very few research workers did some excellent works on the split application of nitrogen and potassium in other castor hybrids. The application of entire dose of P and two split application of N and K nutrients at 30 and 60 days after sowing for castor hybrid recommendation (Crop Production Guide, 2012)

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which is reconsidered since the pattern of maximum uptake was between 90 and 120 days after sowing. Considering all these facts, an experiment was conducted to optimizing the fertilizer dose and split application of N and K for obtaining higher productivity in castor hybrid YRCH 2.

Material and Methods

The field experiment was conducted at farmer's holding in Gopalapuram village of Salem district under irrigated condition during *Rabi* 2017. The experiment area falls under North- Western agro climatic zone of Tamil Nadu and situated at 11°67' N latitude, 78°16' E longitude and at an altitude of 262 m above the mean sea level (MSL). The soil was sandy clay loam in texture, neutral in reaction (pH 6.9), having 0.4% organic carbon, 315 kg ha^{-1} available nitrogen, 21.5 kg ha^{-1} available P_2O_5 and 362.5 kg ha^{-1} available K_2O. Sowing of castor hybrid YRCH 2 was done at the spacing of 150 x150 cm. The experiment laid out in randomized block design and replicate thrice with seven treatments *viz*., **T_1-**Control (No NPK), **T_2-**100% RDF with 3 split application of N and K at basal, 30 and 60 DAS (100% P as basal , 33.3 % N and K in each split) , **T_3-**125% RDF with 3 split application of N and K at basal, 30 and 60 DAS (100% P as basal , 33.3 % N and K in each split), **T_4-**100% RDF with 4 split application of N and K at basal, 30, 60 and 90 DAS (100% P as basal , 25 % N and K in each split), **T_5-**125% RDF with 4 split application of N and K at basal, 30, 60 and 90 DAS (100% P as basal , 25 % N and K in each split), **T_6-**100% RDF with 5 split application of N and K at basal, 30, 60, 90 and 120 DAS (100% P as basal , 20 % N and K in each split) and **T_7-**125% RDF with 5 split application of N and K at basal, 30, 60, 90 and 120 DAS (100% P as basal , 20 % N and K in each split). Entire dose of phosphorus was applied as basal in respective experimental plot. Regarding split application of N and K, the required quantity of urea and potash were arrived and divided into three, four and five equal parts and applied in the respective treatment plot as basal, 30, 60, 90 and 120 DAS. Fertilizer was applied as placement method at stipulated days along with planting row by keeping a distance of 15 cm away from the main stem and gently covered with top soil with the help of hand hoe. Soon after application of fertilizer, irrigation was done. A total of 10 irrigations were given during the cropping period. Besides nutrient management practices, the crop was raised with recommended package of practices. The observation recorded during crop period were plant height (cm), number of branches plant $^{-1}$, dry matter production (kg ha^{-1}), leaf area index, floral phenology, length of primary spike (cm) at 110 DAS, number of capsules primary spike^{-1}, number of spikes plant^{-1}, test weight (g), shelling percentage, seed yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}). The experimental data were statistically analysed by adopting Fischer's method of "Analysis of variance" as per Gomez and Gomez (1984).

Results and Discussion

Growth attributes

Increase in fertilizer dose with split application was significantly increased the growth parameters *viz*., plant height, number of branches, LAI and dry matter production. Increase in nitrogen dose from 90 to 115 kg ha^{-1}, phosphorus and potassium from 45 to 60 kg ha^{-1}greatly influenced the growth attributing characters of the crop under irrigated ecosystem. This was mainly due to favourable effect of nitrogen in increasing cell wall material, as a result increase the size of cell and meristematic tissue which has very active protein metabolism and photosynthetic transport to site of growth which is used predominantly in synthesis of nucleic acid and protein. Phosphorus plays an important role in metabolism and main constituents of structural element of certain co-enzymes like NADP, ATP and ADP which act as energy transfer currency and thus improves photosynthesis. Whereas, potash is known to augment cell division and cell expansion resulting in positive effect on growth parameters (Dodiya *et al.*, 2016)

Table 1. Influence of graded dose of fertilizers on castor hybrid YRCH 2

Treatments	Plant height (cm)	No. of branches	LAI	DMP (kg ha^{-1})	Length of primary spike (cm)	No. of spike plant^{-1}	No. of capsules primary spike $^{-1}$	Shelling Per cent	Test Weight (g)	Seed Yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
T_1-Control (No NPK)	103.3	9.47	0.503	2687	55.5	21.5	64.2	60.1	21.3	1250	44.68	558
T_2-100% RDF with 3 splits	116.0	11.30	0.673	4139	61.7	40.3	111.3	65.6	26.5	2029	46.85	950
T_3-125% RDF with 3 splits	126.1	12.90	0.733	4825	64.3	48.9	126K.5	67.8	28.9	2377	49.56	1178
T_4-100% RDF with 4 splits	124.9	14.00	0.817	4567	63.7	42.5	115.5	66.8	28.7	2175	44.85	975
T_5-125% RDF with 4 splits	127.7	14.60	0.890	5471	68.3	51.2	134.1	68.7	29.7	2643	47.00	1242
T_6-100% RDF with 5 splits	116.1	11.60	0.887	5201	62.7	46.9	110.2	66.8	28.8	2465	46.70	1151
T_7-125% RDF with 5 splits	129.1	12.40	1.107	6105	76.3	55.9	143.8	71.5	29.8	3020	48.06	1451
SEd	6.7	1.37	0.129	144	2.0	1.4	3.6	2.0	0.8	70	0.030	**34**
CD (P=0.05)	14.6	2.99	0.280	314	4.2	3.0	7.7	4.3	1.8	153	0.060	**73**

100% RDF- 90:45:45 kg NPK ha^{-1}; 125% RDF- 115:60:60 kg NPK ha^{-1}; entire P as basal, N and K in splits.

Application of 125 per cent recommended dose of fertilizer with five split application at basal, 30, 60, 90 and 120 DAS had recorded the higher plant height (129.1 cm), higher dry matter production (6105 kg ha^{-1}) and LAI (1.107) at 150 DAS. Whereas, 125 per cent recommended dose of fertilizer with four split application at basal, 30, 60 and 90 DAS had produced more branches (14.60) at 150 DAS and it was observed to be on par with T_4, T_3 and T_7. This might be due to optimum dose of nitrogen hastens the metabolic activities in the plant body by synthesizing the tryptophan, a precursor, for the auxins, which in turn increased number of branches plant^{-1} (Mukesh Kumar Man *et al*., 2017).

Table 2. Floral phenology of castor hybrid YRCH 2 as influenced by graded dose and split application of fertilizer during *Rabi* 2017

Treatments	Days to 50% flowering	Days to maturity	Maleness (%)	Interspersed flower	Spike compactness
T_1-Control (No NPK)	78.3	122.3	7.38	8.7	LS
T_2-100% RDF with 3 splits	75.3	120.3	8.91	14.4	SCS
T_3-125% RDF with 3 splits	65.3	113.7	9.72	15.9	SCS
T_4-100% RDF with 4 splits	55.7	106.7	8.01	12.1	SCS
T_5-125% RDF with 4 splits	56.3	102.3	8.19	12.3	SCS
T_6-100% RDF with 5 splits	56.7	109.7	7.81	10.6	SCS
T_7-125% RDF with 5 splits	54.7	103.7	7.18	10.8	SCS
SEd	2.00	3.30	0.250	0.40	-
CD (P=0.05)	4.30	7.30	0.540	0.80	-

100% RDF- 90:45:45 kg NPK ha^{-1}; 125% RDF- 115:60:60 kg NPK ha^{-1}; entire P as basal, N and K in splits. LS- Loose Spike; SCS- Semi- Compact Spike

Parameters on floral phenology

The crop raised under the treatment consisted of 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) had attained 50% flowering earlier (54.7 days) than other treatments though it was observed to be at par with T_4, T_5 and T_6 wherein, castor hybrid YRCH 2 reached 50% flowering at 55.7, 56.3 and 56.7 days, respectively. While, the treatment control took 78.3 days to attain 50% flowering stage.

There was advancement in first flower bud appearance in the treatment T_7 involving 125 per cent recommended dose of fertilizer with five split application at basal, 30, 60, 90 and 120 DAS which was earlier by 23.6 days as compared to control. The earliness in 50 per cent flowering might be attributed to graded levels of 125 per cent recommended dose of fertilizers with five split application which might have consistently lead to early flower bud initiation. This might be due to the better stem girth which would have helped the translocation of synthesized cytokinin as well as more quantity of available phosphorus through the xylem vessels. The accumulation of cytokinins and phosphorus in these auxillary buds would have favoured the plants to enter reproductive phase early and also this might be due to the partitioning efficiency *viz*., increased allocation of photosynthates towards the economic part and also hormonal balance in the plant system. The delayed flowering in T_2 and T_3 could be related to the presence of higher amount of nitrogen which might have helped in prolonging the vegetative phase and shortening the reproductive cum maturation phase. 125 per cent recommended dose of fertilizer provide optimum dose of nutrition for flowering due to the accumulation of cytokinins than 100% recommended dose fertilizer.

The treatment T_5 has taken 102.3 days to attain physiological maturity of primary spike and matured twenty days earlier than control treatment and it was comparable with T_7 and T_4, which registered 103.7 and 106.7 days, respectively. Whereas, control treatment took 122.3 days to reach physiological maturity of primary spike and it was on par with T_2 and T_3 (120.3 and 113.7 days, respectively).

The different graded dose and split application of fertilizer did affect the percentage of maleness in castor hybrid YRCH 2. The maximum maleness per cent of 9.72 was recorded in 125% RDF with three split application at basal, 30 and 60 DAS (T_3), followed by T_2 (8.91). While the minimum maleness per cent (7.18) was noticed in T_7 followed by T_1 (7.38).

Ratio between female and male flowers raceme^{-1} is another important yield attributing character in castor, as it renders number of capsules and compactness of the spike. Maximum number of female flower raceme^{-1} was recorded in T_7. This could be due to enhanced levels of NRase and soluble protein which diverts the photo assimilates to the developing female flower buds, resulting in increased proportion of female and male flower. Whereas, maximum maleness was noticed under the treatment received 125 per cent RDF with three split application (T_3) and this might be due to application of excess dose of nitrogenous fertilizer with minimum interval and higher dose of nitrogenous fertilizer had encouraged more male flower rather than female. Similar observation was also noticed by Krarup *et al*., (2001).

Higher number of interspersed flowers of 15.9 was noticed in 125% RDF with three split application at basal, 30 and 60 DAS (T_3) followed by T_2 (14.4). Whereas, the lower interspersed flowers of 8.7 were recorded in control (T_1) which was followed by T_6 (10.6).

Though presence of interspersed flowers in the spike is mainly influenced by abiotic factors such as high temperature coupled with low rainfall and

relative humidity, imbalanced nutrition *viz*., excess dosage of nitrogenous fertilizer during the vegetative and flowering period might have influenced the male flower. This was happened in the present investigation that the higher interspersed flower was in the treatment T_3 and T_2 while the lower interspersed flowers was registered under treatment T_1 and T_6.

Table 3. Economics of castor hybrid YRCH 2 as influenced by graded dose with split application of fertilizer during *Rabi* 2017

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
T_1-Control (No NPK)	19700	51250	31550	2.60
T_2-100% RDF with 3 splits	23276	83189	59913	3.57
T_3-125% RDF with 3 splits	24599	97457	72858	3.96
T_4-100% RDF with 4 splits	23576	89175	65599	3.78
T_5-125% RDF with 4 splits	24899	108363	83464	4.35
T_6-100% RDF with 5 splits	23876	101065	77189	4.23
T_7-125% RDF with 5 splits	25199	123820	98621	4.91

100% RDF- 90:45:45 kg NPK ha^{-1}; 125% RDF- 115:60:60 kg NPK ha^{-1}; entire P as basal, N and K in splits.

The results on compactness of the primary spike revealed that all the treatments have semi compact type of spike. Whereas, loose type of spike was noticed under control treatment.

Lower maleness (high proportion of female and male ratio of 90:10), less interspersed flower coupled with earliness of flowering resulted in semi- compact type of spike which was observed in the present investigation mainly owing to adequate quantity of fertilization at appropriate interval might have helped in progressive mineralization of nutrients which in turn was available constantly throughout the crop growth.

Yield attributes

Nutrient management highly influenced the castor yield attributing characters. Higher length of primary spike, more number of spike plant^{-1}, maximum number of capsules primary spike^{-1}, shelling percentage, test weight (g) and seed yield (kg ha^{-1}) were highest in 125 per cent with five split application at basal, 30, 60, 90 and 120 DAS (T_7).

The highest value of length of primary spike (76.3 cm) was observed in application of 115 kg ha^{-1} of nitrogen and lowest length (55.5 cm) was noticed under control. The results were in corroborates with the finding of Sandhya Rani *et al*., (2014). The main yield attributing characters such as number of spikes plant^{-1} is encouragingly associated with number of branches plant^{-1} and more number of productive branches plant^{-1} which in turn produces more number of spikes plant^{-1} and in the present investigation, the highest number of spikes plant^{-1}(55.9) was noticed in 125 per cent RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7). These results were in line with the findings of Aruna and Karuna Sagar, 2016.

The highest number of capsules primary spike^{-1} (143.8) was registered in 125 per cent RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7). Similarly, Patel *et al.* (2005) reported that overall improvement in vegetative growth at higher fertility level favourably influenced flowering and fruiting which ultimately increased number of capsules spike^{-1} and increase in number of capsules primary spike^{-1} was noticed with increase in level of nitrogen. This finding was in accordance with the findings of Sandhya Rani *et al*., 2014, Aruna and Karuna Sagar, 2016 and Jamil *et al*., 2017. The higher shelling percentage (71.5) and test weight (29.8 g) were registered under the treatment 125 per cent RDF with five split applications at basal, 30, 60, 90 and 120 DAS (T_7) over rest of the treatments. The results are in lines with the findings of Mathukia *et al.* (2014).

In the present study, higher dose (115:60:60 kg NPK ha^{-1}) where phosphorus as basal along with split application of nitrogen and potassium at basal, 30, 60, 90 and 120 DAS had resulted in significantly higher seed yield as compared to other treatments. There might be leaching and other losses of nutrients under constricted split application interval. But such losses might be avoided under wider split application interval at basal, 30, 60, 90 and 120 DAS which resulted in prolonged the life of leaves in spite of heavy sink demand and overcoming the effects of ageing and thus higher seed yield of 3020 kg ha^{-1} was obtained in 125 per cent RDF with five split applications at basal, 30, 60, 90 and 120 DAS (T_7).

Quality parameters

The oil content of castor hybrid was significantly influenced by varied graded dose of fertilizer with split application. Higher oil content (49.56%) was recorded in 125% RDF with three split application at basal, 30 and 60 DAS (T_3) as compared to other treatments which was followed by 125% RDF with five split application (T_7) which registered oil content of 48.06%. The lower oil content of 44.68% was noted under control (T_1).

In oilseed crops, balanced application of N with S improves seed quality by enabling complete protein and enzyme synthesis as well as minimizing toxic effects of accumulation of non-protein N in plants. Nitrogenous fertilizer has been reported to influence the response to sulphur application. Hence, critical nutrient balance between N and S is thus essential, as

too much N with too little S in the plant can lead to an imbalance, which can impair protein production and reduce bean yield. The oil content was significantly increased with the increasing doses of sulphur with optimum dose of N fertilizer (Rehman *et al*., 2013).

In this experiment, the treatment consisting of 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) received the higher oil yield of 1451 kg ha^{-1} followed by the application of 125% RDF with four split application at basal, 30, 60 and 90 DAS (T_5) (1242 kg ha^{-1}) which was on par with 125% RDF with three split application at basal, 30 and 60 DAS (T_3) (1178 kg ha^{-1}) . The lower oil yield of 558 kg ha^{-1} was enumerated in control (T_1).

Economics

The economic feasibility was worked out for different treatments on graded dose of fertilizers with split application as well as for other component technologies on hybrid castor (YRCH 2) cultivation. There was significant improvement in seed yield of castor hybrid YRCH 2 due to varied dose of fertilizer and split application and this was observed during the course of study. Application of 125 per cent RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) gave gross return (Rs. 123820 ha^{-1}), net return (Rs. 98621 ha^{-1}) and benefit cost ratio (4.91) (Table 3) as compared to other treatments. This may also be due to better source and sink relation and faster mobilization of photosynthates, which might have resulted in increased seed yield which inturn pave the way for realizing higher economic returns over rest of the treatment.

Based on the above findings, it could be concluded that for newly realised castor hybrid YRCH 2 under irrigated situation, application of fertilizer at 125 per cent RDF with five split at basal, 30, 60, 90 and 120 DAS (T_7) had recorded significantly higher seed yield and net return besides improved the soil fertility through addition of biomass.

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