Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 809-813
Received: 22-07-2019
Accepted: 24-08-2019

M Keerthana
Ph.D Scholar, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

S Manickam
Ph.D Scholar, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

P Kathirvelan
Ph.D Scholar, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

S Suganya
Ph.D Scholar, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

Correspondence
M Keerthana
Ph.D Scholar, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

Optimizing fertilizer requirement for new castor hybrid YRCH 2 under irrigated ecosystem

M Keerthana, S Manickam, P Kathirvelan and S Suganya

Abstract
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 3splits (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 drawn from partitioning efficiency revealed that the higher partitioning efficiency of root, stem, leaves and spikes were noticed with 125% of RDF along with five splits at basal, 30, 60, 90 and 120 DAS. In respect of physiological parameters *viz*., Chlorophyll 'a', 'b' and total chlorophyll, soluble protein and nitrate reductase were higher with 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) at 130 DAS. However, the lower soluble protein and nitrate reductase activity was observed under control. With regard to floral phenology, maleness and interspersed flowers were lower with application of 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) and control (T_1). Majority of the yield attributing characters *viz*., the number of spikes plant^{-1}, number of capsules primary spikes^{-1} and higher bean yield, the higher values were recorded in 125% RDF with five splits at basal, 30, 60, 90 and 120 DAS (T_7). Similar to bean yield, density of castor bean and shelling percentage were also higher in T_7 which resulted in higher gross return, net return and benefit cost ratio.

Keywords: Castor hybrid, fertilizer, split application, productivity

Introduction
Castor (*Ricinus communis* L.) is an important non-edible industrial oil seed crop belongs to the family Euphorbiaceae. Castor is largely grown in most of the tropical countries in the world. 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. India is the largest exporter of castor oil and has a market share of about 85-90%. Castor seed contains oil ranges from 46 to 50 per cent. It has wide range of uses in a variety of applications in the chemical industry including pharmaceuticals. Castor oil has multiple uses such as making dyes, detergents, cosmetics, soaps, ointments, polishes, greases, rubber, aircraft lubricants, wetting agents, paints and varnish etc.

Globally, castor is cultivated in an area of 14.48 lakh ha with a production of 19.48 lakh tonnes with an average productivity of 1345 kg ha^{-1} (Oilseeds Statistics, 2015) [7]. 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) [1]. Gujarat, Rajasthan, Andhra Pradesh, Telangana, and Tamil Nadu are the major castor producing states in India. Gujarat ranks first in castor acreage of 5.65 lakh ha with a production of 8.61 lakh tonnes and productivity of 1524 kg ha^{-1} (CSMAO, 2017) [3].

Looming water crisis, paucity of labourers, increased cost of production and fluctuating of market price of traditional crops drive the search for alternate crop for realizing higher remuneration. In recent past, hybrid castor cultivation has received much attention among the rainfed farmers owing to its low water requirement, less cost of cultivation and better price besides improving the soil fertility through addition of biomass. In recent past, steady and premium market price of castor has encouraged quite a good number of farmers to pursue castor cultivation particularly under irrigated situation.

The response of castor hybrid to nitrogen, phosphorus and potassium application had been found to be highly unpredictable and varied from place to place. At present, entire dose of nitrogen, phosphorus and potassium are applied as basal, research evidences indicated that castor bean 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.

More capsules spike^{-1}, lengthy spikes, higher test weight and oil content besides higher productivity were obtained when potassium was applied to the crop till formation of third order spike. 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.

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 required reconsideration, since the pattern of maximum uptake was between 90 and 120 days after sowing. Based on the above research capsulation, it could be stated with the confidence that the core objective of the present investigation was to optimize the fertilizer dose for newly released 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 11º67' N latitude, 78º16' 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 partitioning efficiency, chlorophyll a, chlorophyll b, total chlorophyll, NRase, soluble protein, days to 50 per cent flowering, days to maturity, number of capsules primary spike^{-1}, number of spikes plant^{-1}, shelling percentage, bean yield (kg ha^{-1}) 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) [4].

Results and Discussion

Partitioning efficiency

The mean data on partitioning efficiency of castor hybrid computed for various plant parts are furnished in Table 1.

Significant differences among the graded dose of fertilizers and split application were observed on all the plant parts studied. The higher partitioning efficiency of root, stem, leaves and spikes were noticed with application of 125% of RDF along with five split application at basal, 30, 60, 90 and 120 DAS (T_7). The next best treatment was 125% RDF with four split application (T_5) which was observed to be at par with 100% RDF + five split application (T_6). The lower values of these parameters were observed with control (T_1).

Physiological parameters

The maximum chlorophyll a content of 2.40 mg g^{-1} at 110 DAS was noticed in 125% RDF with four split application at basal, 30, 60 and 90 DAS (T_5) and it was on par with T_7 and T_4 which registered 2.32 and 2.30 mg g^{-1}, respectively (Table 2). At 130 DAS, the higher chlorophyll a content of 2.94 mg g^{-1} was registered under application of 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) and it was on par with T_6, T_5 and T_4 which recorded 2.86, 2.84 and 2.78 mg g^{-1}, respectively. The lower chlorophyll a content of 2.16 mg g^{-1} was noticed in control (T_1). At 130 DAS maximum chlorophyll b content of 1.067 mg g^{-1} was noticed under 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7). Higher total chlorophyll content (3.89 mg g^{-1}) at 130 DAS was recorded in 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) and it was on par with T_6, T_5 and T_4 which recorded 3.68, 3.65 and 3.63 mg g^{-1}, respectively. Since, nitrogen is a constituent of nucleic acid, protein, protoplasm and chlorophyll and application of nitrogen at optimum dose at regular interval had greater influence on chlorophyll content of leaves.

Higher NRase activity of 151.54 µg NO_2 g-1hr-1 at 110 DAS was recorded in 125% RDF with four split application at basal, 30, 60 and 90 DAS (T_5) and it was on par with T_7 which registered 145.76 µg NO_2 g^{-1}hr^{-1} and the lower NRase activity (117.32 µg NO_2 g^{-1}hr^{-1}) was registered under control (T_1) (Table 2). At 130 DAS the higher soluble protein content (21.87 mg g^{-1}) was recorded in 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) followed by T_6 and T_5 which registered 19.56 and 18.90 mg g^{-1}, respectively. The availability of substrate would favour the synthesis of amino acid which inturn increased the soluble protein content by the enzyme nitrate reductase.

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 (Table 3). 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. While, the treatment control took 78.3 days to attain 50% flowering stage. 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.

Yield parameters

Nutrient management highly influenced the castor yield attributing characters. Maximum number of capsules primary spike^{-1}, shelling percentage, and bean 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 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 [2].

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) [8] 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 [9], Aruna and Karuna Sagar, 2016 [2] and Jamil *et al.*, 2017 [5]. The higher shelling percentage (71.5) was 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) [6].

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 bean 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) (Table 4).

Density of castor bean of different treatments were significantly varied due to graded dose of fertilizer and split application. The treatment 125% RDF with five split application on basal, 30, 60, 90 and 120 DAS (T_7) was statistically on par with each other except T_2 and control. Numerically higher value of 990 kg m^{-3} was registered under T_7. While the lower density of castor bean (760 kg m^{-3}) was noticed under 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 5) 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.

Table 1: Partitioning efficiency of castor hybrid YRCH 2 as influenced by graded dose and split application of fertilizer during *Rabi* 2017

Partitioning efficiency				
Treatments	**Leaves and Stem**	**Root**	**Spike**	**Total**
T_1-Control (No NPK)	0.23 (38.11)	0.15 (24.61)	0.22 (37.27)	0.59 (100)
T_2-100% RDF with 3 split application at basal, 30 and 60 DAS	0.33 (34.98)	0.24 (24.82)	0.38 (40.19)	0.95 (100)
T_3-125% RDF with 3 split application at basal, 30 and 60 DAS	0.38 (34.48)	0.28 (25.09)	0.45 (40.42)	1.11 (100)
T_4-100% RDF with 4 split application at basal, 30, 60 and 90 DAS	0.36 (33.85)	0.27 (25.35)	0.42 (40.39)	1.05 (100)
T_5-125% RDF with 4 split application at basal, 30, 60 and 90 DAS	0.42 (33.35)	0.32 (25.53)	0.52 (41.11)	1.27 (100)
T_6-100% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	0.40 (33.55)	0.31 (25.54)	0.49 (40.99)	1.20 (100)
T_7-125% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	0.49 (32.60)	0.39 (25.82)	0.62 (41.57)	1.50 (100)
SEd	0.01	0.01	0.01	0.03
CD (P=0.05)	0.03	0.02	0.03	0.07

Values in the parenthesis indicate per cent contribution

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.

Table 2: Physiological parameters of castor hybrid YRCH 2 as influenced by graded dose and split application of fertilizer during *Rabi* 2017

Treatments	**Chlorophyll a(mg g^{-1}FW)**		**Chlorophyll b(mg g^{-1}FW)**		**Total chlorophyll (mg g^{-1}FW)**		**NRase (µg NO_2 g^{-1}hr^{-1})**		**Soluble protein (mg g^{-1}FW)**	
	110 DAS	**130 DAS**	**110 DAS**	**130 DAS**	**110 DAS**	**130 DAS**	**110 DAS**	**130 DAS**	**110 DAS**	**130 DAS**
T_1-Control (No NPK)	1.86	2.16	0.734	0.831	2.56	3.23	117.32	109.98	12.03	10.56
T_2-100% RDF with 3 split application at basal, 30 and 60 DAS	1.88	2.40	0.741	0.838	2.61	3.28	124.55	118.70	14.32	13.65
T_3-125% RDF with 3 split application at basal, 30 and 60 DAS	1.93	2.42	0.781	0.878	2.71	3.38	128.71	131.56	14.67	15.43

T_4-100% RDF with 4 split application at basal, 30, 60 and 90 DAS	2.30	2.78	0.891	0.986	2.98	3.63	140.24	137.35	17.64	15.78
T_5-125% RDF with 4 split application at basal, 30, 60 and 90 DAS	2.40	2.84	0.978	0.988	3.22	3.65	151.54	146.75	19.34	18.90
T_6-100% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	2.24	2.86	0.889	0.994	2.96	3.68	135.64	148.65	16.44	19.56
T_7-125% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	2.32	2.94	0.897	1.067	3.01	3.89	145.76	158.17	18.03	21.87
SEd	0.06	0.08	0.030	0.030	0.09	0.10	4.00	4.02	0.48	0.50
CD (P=0.05)	0.14	0.17	0.050	0.060	0.18	0.28	8.71	8.76	1.03	1.09

Table 3: Floral phenology of castor hybrid YRCH 2 as influenced by graded dose and split application of fertilizer during *Rabi* 2017

Floral phenology of castor					
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 split application at basal, 30 and 60 DAS	75.3	120.3	8.91	14.4	SCS
T_3-125% RDF with 3 split application at basal, 30 and 60 DAS	65.3	113.7	9.72	15.9	SCS
T_4-100% RDF with 4 split application at basal, 30, 60 and 90 DAS	55.7	106.7	8.01	12.1	SCS
T_5-125% RDF with 4 split application at basal, 30, 60 and 90 DAS	56.3	102.3	8.19	12.3	SCS
T_6-100% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	56.7	109.7	7.81	10.6	SCS
T_7-125% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	54.7	103.7	7.18	10.8	SCS
SEd	2.0	3.3	0.25	0.4	-
CD (P=0.05)	4.3	7.3	0.54	0.8	-

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

Table 4: Yield attributes of castor hybrid YRCH 2 as influenced by graded dose and split application of fertilizer during *Rabi* 2017

Treatments	**No. of spikes $plant^{-1}$**	**No. of capsules primary $spike^{-1}$**	**Bean yield (kg ha^{-1})**	**Density of castor bean (kg m^{-3})**	**Shelling percentage**
T_1-Control (No NPK)	21.5	64.2	1250^{e}	760	60.1
T_2-100% RDF with 3 split application at basal, 30 and 60 DAS	40.3	111.3	2029^{d}	883	65.6
T_3-125% RDF with 3 split application at basal, 30 and 60 DAS	48.9	126.5	2377^{c}	963	67.8
T_4-100% RDF with 4 split application at basal, 30, 60 and 90 DAS	42.5	115.5	2175^{d}	963	66.8
T_5-125% RDF with 4 split application at basal, 30, 60 and 90 DAS	51.2	134.1	2643^{b}	963	68.7
T_6-100% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	46.9	110.2	2465^{c}	961	66.8
T_7-125% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	55.9	143.8	3020^{a}	990	71.5
SEd	1.4	3.6	70	27	2.0
CD (P=0.05)	3.0	7.7	153	60	4.3

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.

Table 5: Economics of castor hybrid YRCH 2 as influenced by graded dose and 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 split application at basal, 30 and 60 DAS	23276	83189	59913	3.57
T_3- 125% RDF with 3 split application at basal, 30 and 60 DAS	24599	97457	72858	3.96
T_4- 100% RDF with 4 split application at basal, 30, 60 and 90 DAS	23576	89175	65599	3.78
T_5- 125% RDF with 4 split application at basal, 30, 60 and 90 DAS	24899	108363	83464	4.35
T_6- 100% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	23876	101065	77189	4.23
T_7- 125% RDF with 5 split application at basal, 30, 60, 90 and 120 DAS	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.

Conclusion

From the experiment, it could be concluded that among the different treatments, Application of 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) registered highest seed yield of castor hybrid YRCH 2. That treatment also provides higher gross return, net return and benefit cost ratio compare to other treatments. YRCH 2 was medium duration and high biomass producing hybrid, so it need nutrients at critical growth period. The treatment T_7 pro vide nutrients at five split application, hence it fulfil the need of castor hybrid YRCH 2 Therefore, application of fertilizer at 125% RDF with five split application at basal, 30, 60, 90 and 120 DAS (T_7) registered highest seed yield and net return to the castor hybrid YRCH 2 when raised during *Rabi* season under irrigated condition.

Acknowledgement

I feel glad to convey my sincere thanks to Dr. S. Manickam, Professor in Agronomy and Members of the Advisory Committee for their proper guidance, constant help and advice during the course of experimentation.

References

1. Anonymous. Annual Group Meeting on Oil seeds, ICAR-Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad, 2018, 34.
2. Aruna E, Karuna Sagar G. Productivity of rainfed castor as influenced by plant geometry and nitrogen levels. IRA- International journal of applied sciences, 2016, 4(1).
3. CSMAO. Castor Seed Market Analysis and Outlook, 2017, 2-3.

4. Gomez KA, Gomez CA. Statistical Procedure for Agricultural Research. IRRI Book, Pub. John Wiley and Sons, New York, USA, 1984.
5. Jamil M, Hussain SS, Amjad Qureshi M, Mehdi SM, Nawas MQ. Impact of sowing techniques and nitrogen fertilization on castor bean yield in salt affected soils. The Journal of Animal and Plant Sciences. 2017; 27(2):451-456.
6. Mathukia RK, Shekh MA, Sagarka BK. Irrigation and integrated nutrient management in castor (*Ricinus communis* L.). Innovare Journal of Agricultural Sciences. 2014; 2(2):3-4.
7. Oilseeds Statistics: A Compendium. ICAR-Indian Institute of Oilseeds Research, Hyderabad, 2015, 373.
8. Patel KS, Patel GN, Patel MK, Pathak HC, Patel JK. Nitrogen requirement of rabi castor, *Ricinus communis* L. under different crop sequences. J. Oilseeds Res. 2005; 22(1):209-210.
9. Sandhya Rani B, Munirathnam P, Gayathri NK. Effect of time of sowing and nitrogen fertilization on growth and yield of castor in vertisols under rainfed conditions. Indian J Agric. Res. 2014; 48(3):241-244.