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Research Paper

Influence of date of sowing and irrigation scheduling on *rabi* castor (*Ricinus communis*) in Peninsular India

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ABSTRACT

A field experiment was conducted during *rabi* seasons of 2007-2010 at Regional Agricultural Research Station, Palem, Andhra Pradesh in order to study the performance of *rabi* castor (*Ricinus communis L.*) in relation to four dates of sowing (October 1, October 15, November 1 and November 15) and scheduling of irrigation at three CPE levels (50, 75 and 100 mm). Pooled data of three years revealed that sowing on October 1 significantly outyielded (2.32 t/ha) other three dates of sowing. With delay in sowing from October 1 to October 15, November 1 and November 15, bean yield of castor declined by 21.5% (1.91 t/ha), 24.1 (1.87 t/ha) and 44.1% (1.61 t/ha), respectively. Sowing on October 1 was found to be superior in respect of water use efficiency (3.73 kg/ha-mm), net returns (₹38.65 × 10^3/ha) and B:C ratio (2.67). Among irrigation levels, scheduling of irrigation at 50 mm CPE resulted in higher bean yield of castor (2.00 t/ha) but found on par with 75 mm CPE (1.91 t/ha). Scheduling of irrigation at 50 mm CPE was found to be superior in terms of net returns (₹30.82 × 10^3/ha) but B:C ratio was higher in case of 75 mm CPE (2.39). Higher water use efficiency was observed with 100 mm CPE (3.53 kg/ha-mm) followed by 75 mm CPE (3.50 kg/ha-mm) and the lowest was with wet regime (2.90 kg/ha-mm).

Key words **:** Castor bean yield, Irrigation scheduling, *Rabi* castor, Sowing date

Among nine cultivated oilseeds, castor is an important commercially grown non-edible oilseed crop of arid and semi-arid regions of the world, having wide range of industrial uses. India is the largest producer of castor seeds and oil contributing nearly 65% of total global production and meeting 80-90% of world requirement of castor oil. In India, it is mainly grown in Gujarat, Andhra Pradesh, Rajasthan, Chhattisgarh, Karnataka, Orissa and Tamil Nadu.

Castor crop during *Kharif* season is often caught by vagaries of monsoon namely delay in onset of monsoon or prolonged dry spell during critical stages of crop growth. The crop is severely affected by botrytis grey rot (*Botrytis ricini*) due to rains associated with low temperature, fog and more than 90% relative humidity during flowering/capsule development stage (Sudhakar *et al*., 2010). Botrytis is very serious in its infestation in Peninsular India in general and Andhra Pradesh and Tamil Nadu in particular, where it has virtually threatened castor cultivation. As cyclonic rain predisposes the onset and spread of the disease, its incidence varies in different years leading to yield loss ranging from 80-90% (Moses and Reddy, 1989 and Janila *et al*., 2006). Unfortunately, neither resistant varieties nor effective management practices against this dreaded disease are available. Consequently, the realized productivity is only 30-40% of actual potential yield. Thus, castor productivity during *Kharif* season in traditional rainfed tracts of peninsular India is very low (400-500 kg/ha), which is a great cause of concern for growers, scientists, industrialists and policy makers. Earlier, farmers preferred this crop owing to its excellent rejuvenating capacity and genetic potential to give some yield even under adverse edaphic and climatic conditions. However, these days, peasants of this region are shifting to alternate, competitive and profitable crops like Bt Cotton and maize during *kharif* season.

Cultivation of castor as an irrigated dry crop during *rabi* season is a new dimension. This experiment was conducted to find out an optimum date of sowing, irrigation interval and amount of irrigation water required for higher yield of castor during *rabi* season.

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MATERIALS AND METHODS

The field investigation was carried out for three consecutive years (2007-08, 2008-09 and 2009-10) during *rabi* season at the research farm of Regional Agricultural Research Station (Acharya N.G. Ranga Agricultural University), Palem, Mahabubnagar district of Andhra Pradesh. The soil (alfisols) at the experimental site was low in organic carbon (0.45%), available N (210 kg N/ha), medium in available P (42.1 kg P_2O_5/ha) and available K (330.6 kg K_2O/ha) with slightly acidic (pH 6.5) in reaction. The experiment was laid out in a split-plot design with three main plots (Irrigation levels – 50mm, 75 mm and 100 mm CPE) and 4 sub plots (Dates of sowing - October 1, October 15, November 1 and November 15) with three replications. The size of the gross plot was 5.4 × 7.2 m and net plot was 3.6 × 6.0 m. Castor seeds were sown at a spacing of 90 cm x 60 cm. Extra care was taken to avoid water flow from one treatment to another by giving irrigation in the middle channel leaving buffer channels on both the sides unirrigated. Castor hybrid 'DCH-177' during 2007-08 and 'PCH-111' during 2008-09 and 2009-10 were used as test hybrids. The sowing was done as per the treatment on October 1, October 15, November 1 and November 15. The details of evaporation and rainfall recorded from meteorological observatory of RARS, Palem were considered for arriving at cumulative pan evaporation (CPE). The irrigation treatments were imposed as and when cumulative pan evaporation reached 50mm, 75mm or 100 mm CPE. Irrigation was scheduled to a depth of 5 cm. A recommended dose of fertilizer was 80:40:30 kg N, P_2O_5 and K_2O/ha. Half of N and full dose of phosphorus and potash was given as basal, while the remaining half of N was applied in three equal splits at 30, 60 and 90 DAS. The growth parameters and yield attributes were recorded at the time of harvesting of primary spike at 120 DAS (days after sowing) on randomly tagged five plants in net plot. A total of three pickings were done during January, February and March months. Seed yield from all the three pickings was pooled for arriving at final seed yield. The data were statistically analysed in a split plot design using AGRISTAT. Amount of irrigation water given to each treatment was measured by using water meter installed at the site of experimentation. Year-wise water use was calculated and then mean of three years was used for calculating water use efficiency (WUE). WUE was calculated by dividing the seed yield of castor by total water use. Total rainfall of 101 mm (in 5 days), 92.7mm (5 days) and 216.8mm (in 8 days) was received during 2007-08, 2008-09 and 2009-10, respectively. Plant samples were analysed for determination of total nutrients (N,P,K) uptake. Partial factor productivity of N (PFP-N) was computed by dividing the seed yield with an amount of N applied (Baligar *et al*. 2001). The oil content was determined using NMR facility at Directorate of Oilseeds Research, Hyderabad. The oil yield was computed by multiplying oil content with bean yield of castor. Harvest index was calculated by dividing the bean yield with biological yield (Singh and Stoskopt, 1971).

RESULTS AND DISCUSSION

Growth attributes

The parameters like plant population and no. of nodes upto primary raceme were not significantly influenced by irrigation regimes. However, date of sowing had shown significant effect on plant population and no. of nodes upto primary raceme (Table 1). Plant stand in the crop sown on October 1 was significantly higher (16,841/ha) than crop sown on November 1 (15,809/ha) and November 15 (15,752/ha) barring 15th October (16,391/ha). It was mainly because of the fact that minimum temperature which started declining from 20.3^{0}c during October to 17.0^{0}c during November month thus might have affected the germination and subsequent establishment of the crop. This result is in accordance with that of Ramanjaneyulu *et al*., (2013). The crop on October 1 sown has produced more nodes/plant than rest of the dates of sowing.

Yield attributes, yield and water use efficiency

A perusal of data presented in Table 1 revealed that total spike length, total and effective number of spikes/plant were significantly affected by irrigation levels. Scheduling of irrigation at 50 mm CPE resulted in significantly longer spikes (48.8 cm), more number of total (7) and effective spikes/plant (6) compared to that of 100 mm CPE but it was found to be on par with that of 75 mm CPE. Total and effective spike length, total and effective number of spikes/plant were significantly influenced by time of sowing. Sowing during first week of October being at par with October 15 and November 1 was found to be significantly superior to the crop sown on November 15 in respect of total spike length. While significantly more effective spike length was observed in case of October 15 sown crop as compared to that of November 15 sown crop, however, at par with October 1 and November 1 sown crop. Early sowing (October 1 and October 15) was proved to be better than late sowing (November 1 and 15) for significantly more no. of total as well as effective spikes. Such kind of results were earlier published by Ramanjaneyulu *et al*. (2010) in Andhra Pradesh and Srivastava and Chandra (2010) in central Uttar Pradesh who reported that each successive delay in sowing caused severe reduction in seed yield, gross returns, net returns and B:C ratio.

Irrigation regimes and sowing date exerted significant effect on castor bean yield (Table 2). Wet regime (50 mm

CPE) was found to have significantly out yielded dry regime (100 mm CPE: 1.75 t/ha) by registering bean yield of 2.00 t/ha. This might be because of more dry matter production and significantly taller plants with longer spikes and no of spikes/plant (Table 1). However, 50 mm CPE and 75 mm CPE were found to be on par (Table 2) in case of castor bean yield. According to Pratap Kumar Reddy *et al*., (2006) irrigation has to be scheduled at 55mm to 80mm CPE for *rabi* castor for realising higher bean yield of castor. Nagabhushanam and Raghavaiah (2005) also concluded that castor has to be irrigated at 0.8 IW/CPE ratio (wet regime). While Sesha Saila Sree and Bhaskar Reddy (2005) recommended irrigation scheduling at 80 mm CPE for summer castor under rice fallows as it gave significantly higher seed yield of castor on red chalka soils in Peninsular India. On the contrary, higher water use efficiency was observed with dry regime (100 mm CPE: 3.53 and 75 mm CPE: 3.50 kg/ha-mm) than wet regime (50 mm CPE: 2.91 kg/ha-mm). It was because of less amount of water was used for irrigation due to longer interval in dry regimes than wet regime (Table 2).

Sowing on October 1 resulted in significantly higher bean yield of castor (2.32 t/ha) (Table 2). This is mainly due to significantly more plant population, longer spikes, more no. of total and effective spikes/plant (Table 1). With delay in sowing from October 1 to October 15, November 1 and November 15, bean yield of castor declined by 21.5, 24.1 and 44.1%, respectively. Castor crop sown at later dates was stunted in growth and had shorter and less no. of spikes/plant. Further early sown crop established well with more plant stand and yield attributes. It also escaped low temperature stress prevailed during November and December months and also high temperature stress during later stages (March and April) thus produced more of pistillate spikes. Nagabhushanam and Raghavaiah (2005) also obtained significantly higher seed yield of castor when sown on October 15 than that of November 1 and November 15 at Hyderabad. Water use efficiency was found to be higher (3.73 kg/ha/mm) in the early (October 1) sown crop as compared to subsequent times of sowing (Table 2).

Oil content and yield

Though oil content of castor beans was not significantly influenced by either irrigation or dates of sowing, but, oil yield was significantly affected (Table 2). Significantly higher oil yield was obtained due to scheduling of irrigation at 50 mm CPE and 75 mm CPE as compared to 100 mm CPE. It was owing to significantly higher bean yield under wet regime than dry regime. October 1 sowing being at par with October 15 sowing significantly out yielded other dates of sowing with regard to oil yield, which might be due to significantly higher bean outturn in early sowing than late sowing.

Nutrient uptake and use efficiency

Irrigation failed to exert significant effect on N, P and K uptake, but showed significant influence on partial factor productivity of N (PFP-N). I1 (50mm CPE) and I2 (75 mm CPE) were at par and both were significantly superior to I3 (100 mm CPE) in case of PFP-N. Nutrient uptake and PFP-N were significantly influenced by sowing date. Early sown crop (October 1) has removed significantly higher amount of phosphorus (23.9 kg/ha) than late sown crop. In case of N and K uptake, crop sown on October 1 removed significantly higher amount than late sown

Table 1. Growth parameters and yield attributes of *rabi* castor as influenced by irrigation scheduling and sowing date (Pooled data of 2007-08, 2008-09 and 2009-10)

Treatment	Plant Population/ ha	Nodes up to primary raceme/plant	Total spike length (cm)	Effective spike length (cm)	Spikes/ plant	Effective spikes/ plant	100 seed wt. (g)
Irrigation level							
50 mm CPE	16386	11.7	48.8	42.6	6.7	6.3	30.3
75 mm CPE	16074	11.4	46.8	41.0	5.9	5.7	30.0
100 mm CPE	16139	11.6	42.4	41.0	5.4	5.2	30.8
SEm±	457.8	0.21	1.8	1.5	0.3	0.3	0.2
CD (P=0.05)	NS	NS	5.4	NS	0.9	0.9	NS
Sowing Date							
October 1	16841	12.1	49.3	42.6	8.2	7.7	30.9
October 15	16391	11.1	49.4	43.4	7.4	7.2	30.2
November 1	15809	11.1	47.2	42.0	5.1	5.0	30.7
November 15	15752	11.1	43.4	38.3	4.4	4.0	29.7
SEm±	251.9	0.2	1.4	1.2	0.4	0.4	0.4
CD (P=0.05)	748.5	0.6	4.0	3.5	1.3	1.1	NS

Table 2. Bean yield, oil yield, water use efficiency, nutrient uptake of *rabi* castor as influenced by irrigation scheduling and sowing date (Pooled mean of 2007-08, 2008-09 and 2009-10)

Treatment	Bean yield (t/ha)	Stubble yield (t/ha)	HI	Oil content (%)	Oil yield (t/ ha)	Water requirement (mm)	WUE (kg/ha/mm)	Shell yield (t /ha)	Gross returns (×10³₹/ha)	Cost of cultivation (×10³₹/ha)	Net returns (×10³₹/ha)	B:C ratio
Irrigation level												
50 mm CPE	2.00	4.40	0.31	50.0	1.01	700	2.91	1.04	53.32	22.50	30.82	2.37
75 mm CPE	1.91	4.28	0.30	50.2	0.96	546	3.50	1.03	50.92	21.30	29.62	2.39
100 mm CPE	1.75	3.99	0.31	49.8	0.87	495	3.53	1.02	46.65	20.80	25.86	2.24
SEm±	0.04	0.07	0.006	0.3	0.04			0.01				
CD (P=0.05)	0.12	0.26	NS	NS	0.12			NS				
Sowing Date												
October 1	2.32	4.29	0.35	49.7	1.16	621	3.73	1.21	61.85.	23.20	38.65	2.67
October 15	1.91	4.28	0.31	50.2	0.96	635	3.00	1.06	50.92	22.60	28.32	2.25
November 1	1.87	4.27	0.30	50.0	0.94	508	3.68	0.99	49.85	22.00	27.85	2.27
November 15	1.61	4.06	0.28	50.0	0.81	558	2.89	0.86	42.92	21.40	21.52	2.01
SEm±	0.06	0.14	0.012	0.2	0.03			0.04				
CD (P=0.05)	0.16	NS	0.034	NS	0.08			0.11				

*Price of castor bean: (Average of three years) ₹26,667/ton

crop (November 15) but at par with that of October 15 and November 1. Partial factor productivity of N which is an indicator of kg bean yield obtained per kg N applied, was also significantly higher in case of early sown crop (29.3 kg/kg N) as compared to other dates of sowing (Table 3). The reason for better performance of October 1 sown crop is due to more dry matter production and significantly bean yield. Patel *et al*., (2010) from Anand concluded that irrigation at 0.6 to 0.8% PE was better with respect to higher castor bean yield, dry matter production and N uptake by seed and stalk.

Table 3. Nutrient uptake by *rabi* castor as influenced by date of sowing and irrigation scheduling (Pooled mean of three years)

Treatment	N uptake (kg/ ha)	P uptake (kg/ ha)	K uptake (kg/ ha)	Partial factor productivity of N (kg beans/kg N applied)
Irrigation level				
50 mm CPE	97.1	20.4	64.8	25.0
75 mm CPE	96.8	19.4	71.0	24.0
100 mm CPE	91.3	20.6	80.2	21.8
SEm±	5.2	0.87	6.3	0.8
CD (P=0.05)	NS	NS	NS	2.4
Sowing Date				
October 1	103.1	23.9	79.6	29.3
October 15	95.5	20.5	75.2	24.1
November 1	93.7	18.6	72.1	22.4
November 15	87.9	17.6	61.0	19.8
SEm±	4.73	0.91	3.7	1.0
CD (P=0.05)	14.1	2.7	11.1	2.8

Economics

Among irrigation levels, scheduling of irrigation at 50 mm CPE was found to be superior in terms of net returns (₹30.82 × 10^3/ha) but b:c ratio was higher in case of 75 mm CPE (2.39). Sowing on 1st Oct resulted in accruing more monetary net returns (₹38.65 × 10^3/ha) and B:C ratio ratio (2.67) (Table 2).

The study suggest that *rabi* castor can be grown profitably by sowing on October 1 and scheduling irrigation at 50 to 75 mm CPE for realizing higher bean yield, water use efficiency and remunerative returns on alfisols of Peninsular India.

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