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Effect of irrigation methods on growth, yield and economics of hybrid varieties of castor (*Ricinus communis*)

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ABSTRACT

A field experiment was conducted during 2006–08 Sardarkrushinagar to find out suitable method of irrigation and high yielding hybrids of castor (*Ricinus communis* L.). The highest growth parameters, viz plant height at 90 and 120 days after sowing as well as at maturity and yield attributes, like length of spike, capsule/spike, effective spikes/plant, seed yield/primary spike and seed yield/plant were recorded in the treatment receiving 60 mm irrigation in all the furrows at 0.8 IW : CPE ratio, followed by alternate to alternate furrows with 45 mm irrigation. The highest seed and stalk yield with maximum net realization of Rs 58 187/ha was recorded with irrigation in all the furrows, followed by alternate to alternate furrow with 45 mm irrigation with net realization of Rs 56 258/ha but alternate to alternate furrow with 45 mm irrigation recorded the maximum benefit: cost ratio of 3.01. The highest growth parameters and yield attributes as well as seed and stalk yield was recorded in castor hybrid 'GCH 5' with maximum net realization of Rs 53 287/ha with benefit: cost ratio of 2.92 was also obtained in 'GCH 5'.

Key words: Castor, Hybrids, Growth, Irrigation method, Seed yield

Castor (*Ricinus communis* L.) is the most important non edible oilseed crop grown under tropical, sub-tropical and temperate climatic region. Gujarat ranks second in India with respect to area, production and productivity, which were 3.42 lakh ha, 6.65 lakh tonnes and 1944 kg/ha respectively in 2005–06 (DOR 2007). Thus, Gujarat shares about 49% of the total area and 80.8% of the total castor production of the country. Castor is an important oilseed crop with good export potentials. In India, yield of castor has increased from 352 kg/ha (1966–70) to 1 994 kg/ha (1998–99) after release of hybrids 'GAUCH 1', 'GCH 2', 'GCH 4' and 'GCH 5'. These hybrids are well responsive to better management practices. Surface irrigation by adopting border strip methods is the most common practice of irrigation in castor. In this method, sizable quantity of water is lost through evaporation and seepage. It was found that by adopting furrow irrigation method 35 to 50% of water can be saved without any significant reduction in yield of cabbage as compared to surface flooding method (Goudra and Rokhade 2002). Yield loss was recorded in cotton (*Gossyypium hirsutum* L.) (Horst *et al*. 2004) by alternate furrow irrigation as compared to every furrow irrigation but irrigation water use decreased by 30 to 50%. Singh (2002) reported in sugarcane alternate skip furrow method was promising, when the available quantity of water for irrigation is scarce and area to be irrigated is more. Water and hybrid varieties of crop needs to be matched with agro climatic situation. Thus, the present investigation was carried out to find out most efficient irrigation method for high yielding castor hybrid to realize higher net return and benefit : cost ratio.

MATERIALS AND METHODS

A field experiment was carried out during 2006–08 at Sardarkrushinagar on sandy loam soil having *p*H 8.2, EC 0.16 mmhos/cm, bulk density of 1.59 g/cc, moisture content of 10.0% at field capacity and 2.7% at permanent wilting point. The soil was poor in organic carbon (0.25%), available N (143 kg/ha), medium in available P (48 kg/ha) and rich in available K (273 kg/ha). Treatments comprising 5 methods of irrigation in all furrows at 0.8 irrigation water : cumulative pan evaporation ratio at 60 mm depth, alternate furrows with 45 mm of irrigation, alternate to alternate furrows with 45 mm irrigation, alternate furrows with 30 mm irrigation and

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alternate to alternate furrows with 30 mm irrigation were allotted randomly in main plot with 3 hybrids, namely 'GCH 4', 'GCH 5' and 'GCH 6' in subplot with 3 replications. Castor was sown in rows, spaced 120 cm apart on 10 August and 1 August during 2006 and 2007 respectively and fertilized with 120 kg N + 50 kg P_2O_5 + 0 kg K_2O/ha.

The quantity of irrigation water to be applied was measured with the help of 15 cm Parshall flume. Common irrigation of 60 mm was provided for establishment of the crop at 45 and 50 days after sowing during 2006–07 and 2007–08 respectively. Thereafter, irrigations as per treatments were scheduled according to irrigation water: cumulative pan evaporation ratio (0.8) with 60, 45 and 30 mm irrigation water. Irrigation water was applied when Cumulative pan evaporation value approached to 75 mm after common irrigation. Soil moisture distribution pattern was studied before and after each irrigation. The effective rainfall of 610.2 in 23 rainy days and 359.6 mm in 25 rainy days and pan evaporation of 664.6 and 646.1 mm recorded during crop season of 2006–07 and 2007–08 respectively.

RESULT AND DISCUSSION

Growth attributes

Application of 60 mm irrigation in all the furrows at 0.8 IW : CPE ratio gave the highest plant height at 90, 120 and last picking as well as branches/plant being at par with alternate to alternate furrows with 45 mm irrigation which were significantly superior over rest of the irrigation methods. Higher growth attributes of castor with these treatments might be due to increasing availability soil moisture from both the sides of the row which have resulted better root development and more nutrient absorption consequently accelerated the photosynthesis rate resulting higher plant height. Similar findings were also reported in GAU (2003) in castor. Non significant effect of irrigation methods on number of nodes up to primary spike and days to first spike emergence (Table 1) was recorded. Application of irrigation at 55 days after sowing in 2006–07 and 61 days after sowing in 2007–08 might be responsible for non significant effect.

Among the castor hybrid 'GCH 5' recorded significantly higher plant height at 90 days after sowing (97.5 cm), 120 days after sowing (101.4 cm) and at harvest (107.0 cm), nodes up to primary spike (18.5), maximum days to first spike emergence (58.9 days) over the 'GCH 4' and 'GCH 6'. The difference in growth attributes might be due to genetic make up of plant itself, which is governed by vegetative growth of crop, as it plays vital role in respect to accelerating all the physiological processes in plant. As compare to other hybrids, higher plant height in 'GCH 5' was reported by GAU (2003).

Yield attributes

Irrigation in all furrows with 60 mm irrigation at 0.8 irrigation water: cumulative pan evaporation ratio gave significantly the highest length of primary spike, capsules/

Table 1 Effect of irrigation methods and castor hybrids on growth and yield attributes of castor (mean of two years)

Treatment	Plant height at 90 DAS	Plant height at 120 DAS	Plant height at harvest	Branches/ plant	Nodes upto pri. spike	Days to first spike emergence	Length of spike (cm)	capsules/. pri spike	Effective spikes/ plant	Seed yield/ pri. spike (g)	Seed yield/ plant (g)	100–seed weight (g)
Irrigation method												
All the furrows at 0.8 IW: CPE with 60 mm depth	100.7	105.5	112.0	6.9	18.1	54.6	70.5	77.6	11.8	73.3	274.4	31.39
Alternate furrow with 45 mm depth	90.7	96.9	100.1	6.0	17.7	53.1	63.6	67.8	10.3	63.7	239.4	30.59
Alternate to alternate with 45 mm depth	95.8	99.9	105.0	6.4	18.2	54.7	68.4	73.8	11.2	68.4	260.1	30.63
Alternate furrow with 30 mm depth	81.1	84.0	88.9	4.3	17.6	54.5	53.0	53.7	7.7	47.1	172.1	29.07
Alternate to alternate with 30 mm depth	85.0	90.2	93.6	5.1	18.2	54.0	58.6	58.9	9.0	53.0	199.6	29.88
CD (P =0.05)	6.8	8.2	8.0	0.6	NS	NS	5.4	6.9	1.0	6.2	23.4	0.78
Castor Hybrid												
'GCH 4'	85.6	90.2	94.1	6.1	18.1	49.5	59.9	64.5	9.9	59.0	230.6	30.40
'GCH 5'	97.5	101.4	107.0	6.9	18.5	58.9	67.5	75.9	11.5	69.7	257.0	30.69
'GCH 6'	89.0	94.4	98.6	4.2	17.2	54.1	61.2	58.7	8.5	54.6	199.8	29.85
CD (P =0.05)	4.2	4.7	4.8	0.4	0.5	2.1	2.5	2.8	0.5	2.8	12.6	0.45
Interaction	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	NS

Table 2 Effect of irrigation methods and castor hybrids on yield and quality of castor (mean of two years)

Treatment	Seed yield at first picking (kg/ha)	Seed yield at second picking (kg/ha)	Seed yield (kg/ha)	Stalk yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Shelling percentage
Irrigation method							
All the furrows at 0.8 IW : CPE with 60 mm depth	846	1 393	3 393	3 797	49.31	1 673	66.14
Alternate furrow with 45 mm depth	753	1 232	2 999	3 369	49.24	1 476	65.72
Alternate to alternate with 45 mm depth	794	1 321	3 218	3 640	49.29	1 586	66.26
Alternate furrow with 30 mm depth	535	851	1 985	2 298	49.15	975	64.35
Alternate to alternate with 30 mm depth	604	959	2 270	2 683	49.22	1 117	64.60
CD (P =0.05)	66	107	275	284	NS	136	NS
Castor Hybrid							
'GCH 4'	707	1 183	2 826	3 133	48.94	1 383	65.56
'GCH 5'	754	1 284	3 071	3 570	49.43	1 519	65.72
'GCH 6'	658	987	2 422	2 770	49.36	1 195	64.97
CD (P =0.05)	28	67	137	172	NS	68	NS
Interaction	Sig.	Sig.	Sig.	Sig.	NS	Sig.	NS

primary spike, number of effective spikes/plant, seed yield/primary spike, seed yield/plant and 100-seed weight, but it did not differ significantly with alternate to alternate furrows with 45 mm irrigation (Table 1). Increased yield attributes under all furrows and alternate to alternate furrow methods of irrigation was due to increased availability of soil moisture from both the sides of the row. It might be due to higher available soil moisture increased the cell turgor, which led to effective physiological processes, like cell division and cell elongation, better root development, more nutrients absorption and profuse vegetative growth which resulted higher fertilization and seed setting. There is good evidence to show that the rate of appearance of floral primordial is increased under adequate soil moisture status. All these leads to more seed setting. The results are partially in the line of the results reported by Lisong *et al*. (2005) in castor.

Among the castor hybrid 'GCH 5' recorded significantly the highest length of primary spike (67.5 cm), number of capsules/primary spike (75.9), number of effective spikes/plant (11.5), 100-seed weight (30.69 g) and seed yield/primary spike (69.7 g) seed yield/plant (257.0 g). This higher yield attributes of castor hybrids might be due to their genetical constituent as well as ability to absorb more nutrients and water from the soil.

Seed and stalk yield

Irrigating the crop in all furrows with 60 mm irrigation at 0.8 IW : CPE ratio recorded significantly the highest seed yield at first and second picking and total seed yield as well as stalk yield but it remained at par with alternate to alternate furrow with 45 mm irrigation (Table 2). This might be due to favourable influence of all furrows and alternate to alternate furrows methods of irrigation on growth and yield contributing characters which ultimately reflected in seed yield per picking and total seed yield. However, in alternate to alternate furrow with 45 mm irrigation, considerable quantity of water could be saved (22%) as compared to that under all the furrows method of irrigation. Thus, the increase in seed yield owing to all the furrows and alternate to alternate furrow irrigation might be attributed to overall increase in growth and yield attributes. Lisong *et al*. (2005) reported that all furrow and alternate to alternate furrow irrigation was resulted significantly higher seed yield over that of alternate furrow irrigation. Further, he reported that alternate to alternate furrow irrigation was the most economical method which could save 30–60% of irrigation water over all the furrows method of irrigation in cotton (*Gossipium hirsutam*). Availability of adequate soil moisture resulted in higher absorption of nutrients with developing healthy root system and better production of photosynthates which consequently resulted vigorous vegetative growth and higher stalk yield.

Among the castor hybrids, the castor hybrid 'GCH 5' resulted significantly higher seed yield at first and second picking, total seed yield and stalk yield over castor hybrids 'GCH 4' and 'GCH 6'. High yield potentiality of hybrid 'GCH 5' might have also been responsible for higher seed yield of castor. The results are in agreement with the findings of Chauhan and Yakadri (2004).

Results pertaining to interaction effect between irrigation methods and castor hybrids on seed yield at first and second picking, total seed yield and stalk yield (Table 3) revealed that the hybrid 'GCH 5' grown under normal moisture situation in all furrows with 60 mm irrigation at 0.8 irrigation water : cumulative pan evaporation ratio exhibited significantly higher seed yield in first and second picking and total seed yield but it was at par with hybrid 'GCH 4'. Thus under normal water situation both 'GCH 5' and 'GCH 4' are suitable hybrids. This might be due to better utilization

Table 3 Interaction effect between irrigation methods and hybrids on yield attributes of hybrid castor (mean of two years)

Irrigation method	Length of primary spike (cm)			Capsules/primary spike			Effective spikes/ plant			Seed yield/primary spike (g)			Seed yield/ plant (g)		
	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'
All the furrows at 0.8 IW: CPE with 60 mm depth	70.8	74.6	66.3	79.9	85.2	67.7	12.2	13.2	10.1	74.7	80.0	65.1	295.5	300.5	227.1
Alternate furrow with 45 mm depth	64.0	66.0	60.9	70.5	75.2	57.8	10.9	11.4	8.6	65.3	71.1	54.8	255.9	258.3	204.2
Alternate to alternate with 45 mm depth	69.1	71.3	64.7	76.4	82.1	62.9	11.8	12.5	9.3	71.3	75.4	58.5	271.8	287.5	220.8
Alternate furrow with 30 mm depth	41.9	61.5	55.7	42.4	66.9	51.8	6.0	9.9	7.2	36.8	58.5	46.2	134.3	209.5	172.5
Alternate to alternate with 30 mm depth	52.1	64.0	58.3	53.1	70.2	53.4	8.8	10.7	7.5	47.1	63.3	48.4	195.2	229.1	174.7
CD (P =0.05)															
Irri. methods×hybrids		5.6			6.2			1.1			6.2			28.2	

Table 4 Interaction effect between irrigation methods and hybrids on seed, stalk and oil yield (mean of two years)

Irrigation method	Seed yield at first picking (kg/ha)			Seed yield at second picking (kg/ha)			Seed yield (kg/ha)			Stalk yield (kg/ha)			Oil yield (kg/ha)		
	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'	'GCH 4'	'GCH 5'	'GCH 6'
All furrows at 0.8 IW: CPE with 60 mm depth	877	885	776	1 483	1 599	1 098	3 569	3 780	2 829	4 039	4 182	3 171	1 748	1 870	1 400
Alternate furrow with 45 mm depth	780	782	696	1 324	1 370	1 001	3 198	3 283	2 516	3 578	3 602	2 927	1 567	1 624	1 238
Alternate to alternate with 45 mm depth	821	833	729	1 408	1 490	1 064	3 393	3 567	2 693	3 795	4 034	3 090	1 662	1 768	1 329
Alternate furrow with 30 mm depth	438	637	531	714	963	875	1 629	2 318	2 007	1 826	2 791	2 277	793	1 142	991
Alternate to alternate with 30 mm depth	621	632	559	985	998	894	2 340	2 407	2 064	2 426	3 241	2 283	1 146	1 189	1 018
CD (*P* =0.05)															
Irri. methods×hybrids		63			150			306			383			153	

Table 5 Economics of different treatments as influenced by different irrigation methods and castor hybrids (Mean of two years)

Treatment	Gross realization (Rs/ha)			Cost of production (Rs/ha)	Net realization (Rs/ha)	Benefit: Cost ratio
	Seed	Stalk	Total			
Irrigation method						
All furrows at 0.8 IW : CPE with 60 mm depth	78 039	949	78 988	20 801	58 187	2.80
Alternate furrow with 45 mm depth	68 977	842	69 819	18 666	51 153	2.74
Alternate to alternate with 45 mm depth	74 014	910	74 924	18 666	56 258	3.01
Alternate furrow with 30 mm depth	45 655	575	46 230	16 531	29 699	1.80
Alternate to alternate with 30 mm depth	52 233	671	52 904	16 531	36 373	2.20
Castor hybrid						
'GCH 4'	64 998	783	65 781	18 239	47 542	2.61
'GCH 5'	70 633	893	71 526	18 239	53 287	2.92
'GCH 6'	55 706	693	56 399	18 239	38 160	2.09

Sale price of castor seed @ 23 Rs/kg; Sale price of castor stalk @ 0.25 Rs/kg

of moisture with adequate water supply under these treatments. Castor hybrids 'GCH 5' and 'GCH 4' performed better and its showed superiority by recording higher yield attributes, viz length of primary spike, number of capsules/ primary spike, number of effective spikes/plant, seed yield/ primary spike and seed yield/plant (Table 1).

Under limited water availability situation alternate to alternate furrows irrigation with 45 mm depth only 'GCH 5' secured higher seed yield in first and second picking as well as total seed yield compared with the hybrids 'GCH 4' and 'GCH 6'. Higher seed yield at first and second picking as well as seed yield stalk yields might be due to that certain hybrid of castor have better ability to adjust osmotically under water stress condition as a drought tolerance mechanism, which permits the lower water potentials for stomata closure and cell elongation with changing the cell wall elasticity. They have ability to maintain transpiration rate under low leaf diffusive resistance, which enhances higher gaseous exchange and accelerates photosynthesis.

Quality parameters

Oil content in seed of castor hybrids was not significantly influenced with methods of irrigation. On the other hand, oil yield increased appreciably with different methods of irrigation. The hybrid irrigating with all the furrows at 0.8 irrigation water : cumulative pan evaporation ratio with 60 mm depth recorded significantly higher oil yield over other methods, but its oil yield was at par with alternate to alternate furrows with 45 mm of irrigation (Table 2). The remarkable increase in seed yield of castor under these treatments is directly responsible for higher oil yield.

Oil content of seed and shelling percentage did not differ significantly due to different hybrids, but oil yield was significantly influenced by different hybrids (Table 2). Significant variation in seed yield might have contributed higher oil yield in 'GCH 5'.

Economics

The highest net realization of Rs 58 187/ha was recorded with application of 60 mm depth of irrigation in all the furrows at 0.8 irrigation water : Cumulative pan evaporation ratio followed by alternate to alternate furrow with 45 mm irrigation with net realization of Rs 56 258/ha, but this method of irrigation recorded maximum benefit: cost of 3.01, followed by all the furrows at 0.8 irrigation water: Cumulative pan evaporation ratio with 60 mm irrigation (2.80). These findings are in accordance with findings of Singh (2002) in sugarcane.

Castor hybrid 'GCH 5' (Table 4) recorded the maximum net realization of Rs 53 287/ha and benefit: cost ratio of 2.92, followed by castor hybrid 'GCH 4' (Rs 47 542/ha). This might be due to differential yield performance of castor hybrids.

It may me concluded that castor hybrid 'GCH 5' irrigated with all the furrows method of irrigation at 0.8 irrigation water: cumulative pan evaporation ratio with 60 mm depth was found optimum by recording higher values of growth and yield attributes, producing the maximum seed yield and recording the maximum net realization of castor in loamy sand soil of North Gujarat agro-climatic conditions of Gujarat. However, profitable production of castor could be achieved by irrigating the hybrid GCH 5 with alternate to alternate furrow irrigation with 45 mm depth of irrigation.

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