

Effect of Drip Irrigation on Water-use Efficiency and Productivity of Castor

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Received: June 2011

Abstract: The field experiment was conducted to see effects of drip irrigation system on water-use efficiency and productivity of castor grown on light textured soils of Western Rajasthan. The treatments comprising of four levels of irrigation viz., 0.8V, 1.0V and 1.2V (volume/plant/day worked out on ET basis) and check basin system were compared in RBD with six replications. Results revealed that application of irrigation water at 1.0 unit volume through in-line drippers gave maximum seed yield of 4085 kg ha⁻¹ which was significantly higher over 0.8V and check basin system by 682 and 497 kg ha⁻¹, respectively. Irrigation at 1.0 unit volume increased net return and water-use efficiency by Rs. 5,197 ha⁻¹ and 5 kg mm⁻¹ ha⁻¹, respectively, compared to check basin system with 31.2% saving of water.

Key words: Drip irrigation, castor, seed yield, water-use efficiency, economics.

The soil and agro-climatic conditions prevailing in western Rajasthan are well suited to castor. The area and productivity of castor from 2002-03 to 2011-12 has increased in Rajasthan from 26.1 thousand to 2.91 lac ha and 793 kg ha⁻¹ to 1408 kg ha⁻¹, respectively (Anonymous, 2012). Under prevailing agro-climatic conditions, castor requires at least 8-10 irrigations to produce satisfactory yield. Due to high rate of percolation in light soils, irrigation through traditional system is difficult. The main and subsidiary irrigation channels in castor fields are covered with a thin layer of lime+sand mixture by the farmers to avoid deep percolation of water as it is the important and crucial input of the production system. Water table in the most parts of State is declining at an alarming rate of 15-20 feet every year. Research work on drip irrigation in Gujarat revealed that drip system can save water up to 30-50% over check basin method without affecting crop yield (Patel *et al.*, 2004). Information with regard to its efficacy against surface method and its appropriate scheduling for castor is lacking. This trial was therefore, carried out to investigate efficacy of drip irrigation in terms of water saving vis-à-vis surface method and to work out its schedule in castor.

Materials and Methods

The experiment was conducted at Agricultural Research Station, Mandore (Jodhpur), during 2007-08 and 2008-09. The E-mail: isingh_1963@yahoo.com

soil of the site was loamy sand in texture with low in available nitrogen (156 kg ha⁻¹), medium in available phosphorus (36 kg ha⁻¹) and available potash (280 kg ha⁻¹). The bulk density of soil was 1.3 Mg m⁻³. The field capacity and permanent wilting point was 9.0 and 2.8%, respectively. The treatments had four irrigation levels viz., 0.8V, 1.0V, 1.2V (volume of water requirement/plant/day worked out on ET basis) and surface method of irrigation (9 and 10 irrigations with 50 mm of water in each irrigation through check basin system in 2007-08 and 2008-09, respectively) were compared in RBD with six replications. The mean total quantity of water applied to the crop in 0.8V, 1.0V, 1.2V and check basin system was 260, 325, 390 and 475 mm, respectively. In drip irrigation method, volume of water worked out on three days cumulative ET basis was applied through in-line drippers placed over every row of castor at 120 cm spacing with plant-to-plant/hydrogel distance of 60 cm. Drippers were operated at 1.2 bar pressure for required period as per treatment to deliver water at flow rate of 4 LPH. Volume of water (V) was calculated by the following formula:

$$V = ET.Kc.Sp.Se.Wp,$$

where, V = Volume of water required (litre/day/plant), ET = Evapo-transpiration measured by Automatic Weather Station (mm/day), Kc = Crop coefficient (0.8), Sp = Plant to plant spacing, Se = Row to row spacing and Wp = Wetted area.

Table 1. Growth, yield attributes, seed yield, WUE and economics of castor as affected by drip irrigation system (Pooled data of 2007- 08 and 2008-09)

Treatment	Plant stand ('000 ha ⁻¹)	Plant height (cm)	Nodes up to primary raceme	100-seed wt. (g)	Primary raceme length (cm)	Spikes plant ⁻¹	Seed yield (kg ha ⁻¹)	Net returns (Rs. ha ⁻¹)	WUE (kg ha ⁻¹ mm ⁻¹)	Water saving (%)	Total water applied (mm)
T ₁ - 0.8 V	13.7	58.1	13.7	26.2	45.2	13.2	3403	45203	13.1	45.3	260
T ₂ - 1.0 V	13.7	61.7	14.4	27.8	46.8	17.4	4085	59535	12.6	31.2	325
T ₃ - 1.2 V	13.6	65.2	17.0	27.4	45.8	16.4	3785	53235	9.7	17.9	390
T ₄ - Check basin	13.6	63.3	13.9	27.4	46.1	15.1	3588	54338	7.6	--	475
S Em ±	0.1	1.9	0.7	0.4	1.5	0.8	80.8	875	0.40	--	--
CD(P=0.05)	NS	6.1	2.3	1.2	NS	2.5	252.6	2976	1.20	--	--

The gross plot size was 12.0 m x 9.6 m. Crop was sown in the 2nd fortnight of July every season. Seeds of castor hybrid 'RHC-1' @ 8 kg ha⁻¹ were placed 5 cm deep at every hydrogol located at 60 cm spacing through dibbling. Half the nitrogen (40 kg ha⁻¹ through urea and DAP), full phosphorus (50 kg ha⁻¹ through DAP) and sulphur (20 kg ha⁻¹ through gypsum) were applied as basal dose while opening furrows at 120 cm spacing. Remaining half dose of nitrogen (40 kg ha⁻¹) was applied through urea via fertilizer tank in two equal splits at 35 and 90 DAS. The total rainfall received during the season was 163 mm in 2007-08 and 240 mm in 2008-09. Spikes were harvested in 5 pickings at monthly interval starting from 90 DAS. The net return was calculated on the basis of prevailing sale price and cost of cultivation after deducting 70% cost of drip system as subsidy given by State Government for purchasing drip system.

Results and Discussion

The application of irrigation water at 1.0V gave maximum mean seed yield of 4085 kg ha⁻¹, which was significantly higher over seed yield obtained with 0.8V and check basin system by 682 and 497 kg ha⁻¹, respectively. Increase in water applied from 1.0V to 1.2V significantly decreased the seed yield of castor by 300 kg ha⁻¹. The spikes plant⁻¹ and 100-seed weight at 1.0V were increased by 4.2 plant⁻¹ and 1.6 g, respectively, compared to 0.8V. Increase in volume of water from 1.0V to 1.2V did not influence these parameters.

Higher yield at 1.0V is ascribed to continuous availability of required soil moisture at root level besides pulverized soil condition that prevailed throughout the crop pendency resulting in significant increase in spikes plant⁻¹ and 100-

seed weight. Patel *et al.* (2010) from Anand (Gujarat) reported that timely and frequent irrigations at 0.8 PE provided constant wet root zone, increased the nutrient availability, enhanced the growth, yield attributes and ultimately improving seed yield. Reduction in yield at higher irrigation level (1.2V) might be due to higher vegetative growth as indicated by significant increase in plant height and number of nodes up to primary raceme, which are less desirable characters for obtaining good seed yield in castor. These results are in close conformity with the findings of Patel *et al.* (1997) and Firake *et al.* (1998).

The results further revealed that 18-45% water saving was achieved under different levels of water applied and was highest with 0.8V (45.3%) followed by 1.0V (31.2%). The water-use efficiency (WUE) was also highest at 0.8V of water (13.1 kg ha⁻¹ mm⁻¹), which did not decline significantly with increasing volume of water from 0.8V to 1.0V. Increase in the volume of water from 1.0V to 1.2V tended to lower the WUE significantly by 29.9%. The lowest WUE (7.6 kg ha⁻¹ mm⁻¹) was observed in check basin system. Higher WUE at 0.8V and 1.0V levels was due to better utilization of water at lower fractions, whereas at higher levels of water application, the rate of water losses through evapotranspiration and percolation were high and relative increase in yield was not proportionate to the increasing rate of water application. Similar results were reported by Patel *et al.* (2004).

Raising castor through drip irrigation at 1.0V of water gave maximum net returns of Rs. 59,535 ha⁻¹ which was significantly higher over check basin system by Rs. 5197 ha⁻¹. The net returns was significantly reduced by Rs.

14,332 and Rs. 6,300 ha⁻¹ when volume of water application was either reduced from 1.0V to 0.8V or increased from 1.0V to 1.2V, respectively. On the basis of mean timing of operation of drippers it can be concluded that drippers at 1.0V should be operated for half an hour after every third day with the emission rate of 4 L h⁻¹ in the month of August. For the months of September and October, drip system should be operated for one and half hour after every third day. However, during November to January, drip system should be operated for one hour only after every third day. With increase in the rate of evaporation, the drip operating hours in the month of February and March should be raised to one and half hour to two hours after every third day for obtaining satisfactory plant growth and seed yield.

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