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Effect of drip irrigation on productivity and water-use efficiency of hybrid cotton (*Gossypium hirsutum*) in Typic Haplusterts

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ABSTRACT

On-farm trial was carried out during 2001–03 to find out the effect of drip irrigation on cotton (*Gossypium hirsutum* L.) productivity and water-use efficiency in Kalmeshwar Tehsil, Nagpur District. Application of water to hybrid cotton through drip resulted in significantly higher seed cotton yield than the surface methods. The yield advantage due to different irrigation schedules through drip based on ETc was 31% over the broad bed furrow system and 59% over farmer's practice (flood irrigation method), while saving of irrigation water was 44 and 57 % respectively. Among the irrigation schedules through drip, 0.6 evapo transpiration gave significantly higher seed cotton yield than 0.8 and 1.0 evapo transpiration, whereas the later two were at par with each other. Irrigation scheduling in hybrid cotton through drip based on 0.6 evapo transpiration enhanced seed cotton yield by 37% over broad bed furrow and 72% over the farmer's practice. The water-use efficiency with drip-irrigated cotton was 28–58% higher than broad bed furrow and 45–68% higher than the flood method of irrigation.

Key words: Drip irrigated, ETc, Hybrid cotton, Irrigation scheduling, On-farm evaluation, Typic Haplusterts

India is one of the major producers of cotton (*Gossypium hirsutum* L.) in the world with largest acreage (9.59 m.ha) but productivity is only a little above 50% of the world's average productivity of 794 kg lint/ha (AICCIP 2008). In Maharashtra, cotton is being grown mainly on Vertisols and associated soils but productivity is very low (170 kg lint/ha) as compared to India (555 kg lint/ha) and world's average, because about 77% of cotton is cultivated under rainfed conditions.

Cotton under rainfed conditions normally suffers either due to lack of proper distribution of rains or heavy rains and terminal moisture stress. Exposure of the crop to repeated cycles of low and excess moisture stress during the growth period has adverse effect on growth and development. Ever increasing demand for irrigation water coupled with depleting ground water sources call for efficient-use of water. Introduction of micro irrigation systems like drip irrigation can help to bring more area under irrigation and improve the crop yields substantially. Drip irrigation is an option wherever water availability limits conventional irrigation and further it also reduces the risk of yield reduction due to terminal dry spells. Experimental results have widely indicated that drip irrigation would save water and increase yield in different regions (Sivanappan 2004). However, the results vary greatly when tested on farmer's field. Therefore, a study was conducted to find out the effect of drip irrigation on cotton productivity and water-use efficiency in farmer's field.

MATERIALS AND METHODS

The study was carried out in farmer's field at Panubali, Kalmeshwar taluka of Nagpur district under Technology Mission on Cotton (Mini-Mission I). The village, where on-farm irrigation trial was conducted is situated at 21° 20' N Latitude and 78° 51' E longitude on an altitude ranging from 340 m to 360 m above mean sea level.

Agro climatically, the experimental site is located in the eastern Maharashtra plateau experiencing hot, dry, sub-humid eco-region (AESR-10.2). The soil was Typic Haplusterts (a deep black soil with low infiltration and moderate drainage). The soil *p*H is around 8.1 in the plough layers and increases with depth to 8.6 at 150 cm. The soils are medium in organic carbon (0.65%) and phosphorus (30.7 kg P_2O_5/ha) and rich in potash (342 kg K_2O/ha). Rainfall varies from 800 mm to 975 mm and is received mostly from south-west monsoon from second week of June and continues up to October.

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Table 1 Number of squares, number of burst bolls/ plant and mean boll weight as influenced by irrigation treatments

Treatment	Squares/plant at 90 DAS				Burst bolls/plant				Mean boll weight (g)			
	2001–02	2002–03	2003–04	Mean	2001–02	2002–03	2003–04	Mean	2001–02	2002–03	2003–04	Mean
Drip irrigation at 0.6 ETc.	48.8	66.6	63.5	59.6	74.3	62.3	58.7	65.1	3.09	3.57	3.57	3.41
Drip irrigation at 0.8ETc.	44.8	59.5	55.5	53.3	62.0	51.4	53.2	55.5	2.95	3.41	3.37	3.24
Drip irrigation at 1.0 ETc.	51.5	61.2	56.5	56.4	67.4	61.6	57.5	62.2	2.86	3.46	3.42	3.24
BBF*	41.7	40.6	43.2	41.8	64.3	32.4	31.5	42.7	2.84	3.33	3.10	3.09
Farmer's practice (flood irrigation)	36.5	38.2	33.7	36.1	49.4	30.8	29.2	36.5	2.86	3.14	3.00	3.00
CD (*P*=0.05)	NS	12.84	5.17		NS	5.78	2.9		0.16	0.17	0.14	

*Broad bed furrow irrigation method

Earlier the maximum rainfall was received in July but in recent years August recorded highest rainfall. About 90 % rainfall received during June–September. The effective rainfall covers only 77% of the gross annual water demand, even in normal rainfall year.

On-farm trial with 5 treatments was laid out in randomized complete block design with 4 replications from 2001 to 2003. The treatments consist of drip irrigation at 0.6, 0.8 and 1.0 ETc (crop evapo-transpiration) compared with broad bed furrow (BBF) and farmer's practice (flood irrigation method). Irrigation was given at every alternative day in drip treatments as per the treatments requirement by adjusting the duration of water release at constant flow rate 4lt/hr, whereas in BBF and farmer's practice 4, 10 and 8 irrigations were provided in 2001, 2002 and 2003 respectively. 'NHH 44' cotton hybrid was sown in 60 cm × 90 cm × 120 cm (paired row). Recommended dose of N (100 kg/ha) was applied in 3 splits and P and K (50 kg each/ha) applied in 2 splits through urea, single super phosphate and murate of potash. The observations on yield components, yield and fibre quality were recorded and analyzed statistically by using randomized block design. Water-use-efficiency was calculated from yield data and quantity of irrigation water applied in each treatment.

RESULTS AND DISCUSSION

Mean of 3 years data indicated that drip irrigation at 0.6 evapo transpiration (ETc) was superior than 0.8 and 1.0 ETc. Lowest seed cotton yield was recorded in farmer's practice (flood irrigation method) (Table 2). Drip irrigation at 0.6 ETc recorded significantly higher seed cotton yield in all the 3 years (2.24, 2.32 and 2.18 tonnes/ha, respectively) as compared to other treatments but it was at par with 0.8 ETc in 2001–02 and 0.8 and 1.0 ETc in 2002–03. Increase in seed cotton yield in 0.6 ETc was due to significantly higher number of burst bolls/ plant and boll weight (Table 1). Number of squares formed at 90 days after sowing in 2001-02 was less than other 2 years because of dry spell during September but the second flush of square formation after September compensated the total seed cotton yield. During 2001–02 and 2003–04, quantity and distribution of rainfall was normal because of this drip irrigation at 0.6 ETc brought in mild moisture stress to induce synchronized square and boll formation. Whereas 2002–03 was a deficit year hence drip irrigation at 0.6, 0.8 and 1.0 ETc showed similar growth and yield attributes and seed cotton yield was at par with each other. However drip irrigated treatments were superior to surface irrigation methods, viz. broad bed furrow and farmer's practice of flooding. During normal (2001–02) and surplus (2003–04) rainfall years, broad bed furrow method was significantly better than drip irrigation at 1.0 ETc. This shows that broad bed furrow perform better as the furrows act as drainage channel to remove excess water from fields especially in deep Vertisols with impaired drainage. Whereas, in deficit year drip irrigation system was advantageous to

Table 2 Seed cotton yield and water-use efficiency as influenced by irrigation treatments

Treatment	Seed cotton yield (tonnes)				Water-use efficiency				Per cent water saving over							
									BBF				FP**			
	2001–02	2002–03	2003–04	Mean	2001–02	2002–03	2003–04	Mean	2001-02	2002-03	2003-04	Mean	2001-02	2002-03	2003-04	Mean
Drip irrigation at 0.6 ETc	2.24	2.32	2.18	2.25	233.3	123.21	161.48	172.66	64.0	53.0	57.8	58.3	70.0	66.0	69.3	68.4
Drip irrigation at 0.8ETc	2.12	1.90	2.08	2.03	166.9	78.67	109.13	118.23	52.2	40.0	40.5	44.2	60.0	56.0	56.7	57.6
Drip irrigation at 1.0 ETc	1.72	2.23	2.04	2.00	108.8	71.00	83.10	87.63	41.0	22.0	22.5	28.5	50.0	43.0	43.7	45.6
BBF*	1.82	1.13	1.97	1.64	91.0	28.25	61.56	60.27								
Farmer's practice (flood irrigation)	1.32	1.08	1.54	1.31	66.0	19.63	35.00	40.21								
CD (P=0.05)	0.25	0.46	0.06													

Broad bed furrow irrigation method
** Farmer's practice (flood irrigation)

Table 3 Fibre quality parameters as influenced by irrigation treatments

Treatment	2.5 % SL (mm)				Fineness (micronaire)				Uniformity ratio (%)				Bundle strength (g/t)			
	2001–02	2002–03	2003–04	Mean	2001–02	2002–03	2003–04	Mean	2001–02	2002–03	2003–04	Mean	2001-02	2002-03	2003-04	Mean
Drip irrigation at 0.6 ETc	25.3	26.0	26.3	25.9	3.8	3.6	3.7	3.7	48.4	51.0	50.0	49.8	19.2	18.9	19.1	19.1
Drip irrigation at 0.8ETc	25.6	26.1	26.4	26.0	3.7	3.6	3.6	3.6	46.0	50.0	49.0	48.3	18.5	19.0	19.2	18.9
Drip irrigation at 1.0 ETc	25.1	25.8	25.9	25.6	4.2	3.7	3.8	3.9	48.0	52.0	50.0	50.0	19.9	18.5	19.2	19.2
BBF (broad bed furrow irrigation)	25.1	26.4	26.2	25.9	3.7	3.4	3.5	3.5	49.0	52.0	49.0	50.0	19.3	19.8	19.1	19.4
Farmer's practice (flooding)	25.6	26.0	26.0	25.9	3.9	4.0	3.5	3.8	48.0	52.0	49.0	49.7	19.2	18.7	19.2	19.0

improve cotton productivity. Patil *et al*. (2004) also indicated that drip irrigation is more beneficial in improving cotton productivity.

Among drip treatments, irrigation at 0.6 ETc recorded 12.5% higher yield over 1.0 ETc and 11% over 0.8 ETc. The saving of water at 0.6 ETc was 51 % over 1.0 ETc and 24% over 0.8 ETc. Similarly, drip irrigation treatments recorded 31% higher seed cotton yield over broad bed furrow and 59% over farmer's practice. The saving of irrigation water was 44 and 57 % over broad bed furrow and farmer's practice respectively. These results corroborate with the results obtained by Sivanappan (2004).

Drip irrigation at 0.6 ETc recorded higher water-use efficiency (233.3, 123.21 and 161.48 kg/ha-cm in 2001–02, 2002–03 and 2003–04 respectively) than at 0.8 and 1.0 ETc. Among the surface irrigation treatments, BBF method was found superior to farmer's practice (Table 2). The per cent increase in water-use efficiency due to drip irrigation at 0.6 ETc was 97% over 1.0 ETc and 35% over 0.8 ETc. BBF method recorded 50% higher water-use efficiency over farmer's practice. This finding corroborates with the results of Mussaddak and Somi (2001). The per cent water saving due to drip irrigation was more in 2001–02 than 2003–04 and 2002–03 as former was a normal and surplus years compared to later one. Similarly, quantity of water applied was lower in 2001–02 and 2003–04 than 2002–03.

Fibre quality parameters, like staple length, fineness of fibre, bundle strength and uniformity ratio didn't show consistent treatment effect over years (Table 3). However fibre length was more in 0.8; fineness was more when crop irrigated through drip at 1.0 ETc alternate days. Uniformity ratio and bundle strength were more in broad bed furrow. Johnson *et al*. (2002) also reported that micronaire, length, uniformity ratio and strength are more strongly correlated with favourable soil moisture.

In deep black soils (Typic Haplusterts), drip irrigation at 0.6 ETc alternate days significantly improved the seed cotton yield and saves water compared to 0.8 and 1.0 ETc and surface irrigation methods. Drip irrigation was more beneficial in scanty rainy years and broad bed furrow improved the yield of cotton substantially in normal and surplus rainfall years.

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