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Effect of drip and furrow irrigation methods on yield and water use efficiency in cotton

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ABSTRACT

Adoption of drip irrigation method offers opportunity for efficient use of water and higher economic yield of cotton under irrigated conditions in arid and semi-arid regions. A field experiment was carried out at the Soil Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar during 2014 for evaluating the different methods of irrigation for enhancing water use efficiency in cotton. The experiment was consisted of three methods of irrigation (drip, furrow and flood irrigation) and four cultivars of cotton viz., *Bt* (MRC-7017), *Bt* (RCH-134), American (H-1236) and *Desi* (HD-123). The results indicated that drip irrigation significantly increased plant height, number of bolls per plant, boll weight, and number of monopods and sympods per plant. The application of irrigation with drip and furrow methods resulted in increase in seed cotton yield over flood method. The seed cotton yield was recorded highest of 2671 kg/ha of American (H-1236) followed by 2510 kg/ha of *Bt* (MRC-7017), 2287 kg/ha of *Desi* (HD-123) and 2151 kg/ha of *Bt* (RCH-134) in drip irrigation. The water use efficiency (WUE) was found highest in drip irrigation as compared to other methods in all the four cotton cultivars. The highest WUE of 0.58 kg/m^3 was found in American (H-1236), followed by *Bt* (MRC-7017), *Desi* (HD-123) and lowest in *Bt* (RCH-134). The results conclude that drip irrigation has potential to increase the seed cotton yield and water use efficiency in arid and semi-arid region of the state.

Key words : American cotton, *Bt* cotton, drip irrigation, seed cotton yield, water use efficiency

INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important commercial fiber cash crops (White Gold). It plays a prominent role in Indian economy as its production, processing and trade provide employment to large number of people in the country. India is amongst the largest cotton producing countries in the world. The genetically modified *Bt* (*Bacillus thuringiensis*) cotton is getting popularity among the growers of the country. The *Bt* cotton was developed with intention to reduce heavy reliance on pesticides and grown throughout the world with claims of less (<80%) requirement of pesticides than the ordinary cotton. Hence, productivity of cotton could be considerably increased by cultivation of *Bt* hybrids with proper spacing, suitable planting method, water and nutrient management, etc. Therefore, area under *Bt* cotton is increasing rapidly for its acceptability among cotton growers due to higher yield potential, shorter duration and more synchronous boll setting over the conventional varieties of cotton. The cotton is cultivated on 128.19 lakh hectare area in India producing an average yield of 504 kg/ha which is lower than the world average yield of 759 kg/ha. In Haryana, cotton is cultivated on 0.64 million hectare with production of an average yield of 538 kg/ha (Cotton Advisory Board, 2014-15). The *Bt* cotton requires higher input of nutrients and water, and demand for water in agriculture has increased due to intensive agriculture putting a tremendous pressure on the limited water resources. Hence, there is a need to develop techniques for enhancing productivity of irrigation water especially in arid and semi-arid climatic conditions for high water requiring crops.

In India, irrigation mostly depends on traditional systems and irrigation efficiency is about 40-45%. The efficient irrigation systems i. e. drip, furrow, sprinkler irrigation, etc. have potential for increasing water use efficiency of irrigation systems (Zhai *et al.*, 2010). The drip

irrigation has proved its superiority over conventional methods of irrigation (Sezan *et al.,* 2008), especially in row crops due to precise and direct application of water in plant root zone which is quite useful in increasing water use efficiency. Sampathkumar *et al.* (2006) observed highest plant height and dry matter production with drip irrigation. The drip irrigation saved water and increased yield by 23% compared to conventional method of irrigation (Narayanamoorthy, 2010). Application of drip irrigation in sugarcane saved a substantial amount of irrigation water (13.5-56.3%) over the furrow irrigation method. Sugar yield with drip irrigation was observed higher than with surface method (Ahluwalia *et al.*, 1998). Cetin and Bilgel (2002) reported that the drip irrigation increased seed cotton yield by 21 and 30% over furrow and sprinkler irrigation, respectively, whereas Ibragimov *et al.* (2007) reported saving of irrigation water of 18-42% with drip irrigation compared to furrow irrigation in cotton crop, whereas seed lint cotton yield increased by 10-19% relative to that for furrow irrigated cotton. Water use efficiency was found to be increased under drip and furrow irrigation methods (Shirahatti *et al.,* 2007). The impact of drip and furrow irrigation methods on the hybrid cotton yield and increase in yield was recorded from 2.1 to 28.4%. Therefore, the present study was undertaken to : (i) study the effect of drip and furrow irrigation on seed cotton yield and yield attributes, and (ii) evaluate the water use efficiency of different methods of irrigation.

MATERIALS AND METHODS

The field experiment was carried out at Research Farm, Department of Soil Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar during **kharif** season in 2014. The experimental site was located at 29.10^0N, 75.46^0E and an altitude of 215.2 m above mean sea level. The soil of the experimental site was sandy loam (71.5% sand, 9.3% silt and 19.2% clay) and classified as Typic Haplustepts (Soil Survey Staff, 1998). The experiment consisted of three irrigation methods (drip, furrow and flood) in triplicate in 4.2 × 2.7 m sized plots for four cotton varieties [*Desi* (HD-123), American (H-1236), and *Bt* (MRC-7017 and RCH-134)]. A primary harrowing tillage operation was done and pre-sowing heavy irrigation was applied to the whole field. At proper moisture condition of the field, a fine seedbed was prepared by applying two cultivations each followed by planking and cotton was sown on 20 May 2014 manually with spacing of 67.5 x 30 cm in *Desi* and 67.5 x 60 cm in American and *Bt* varieties in all the irrigation treatments. Pre-emergence weedicide pendimethalin at 2.5 l/ha was sprayed before sowing of crop. The recommended dose of fertilizers (RDF) was applied in all the respective cotton varieties viz., *Desi* cotton (50 kg N/ha, 30 kg P_2O_5/ha), American (90 kg N/ha, 30 kg P_2O_5/ha) and *Bt* cotton (150 kg N/ha, 60 kg P_2O_5/ha; 60 kg K_2O/ ha and 25 kg $ZnSO_4$/ha). Full dose of RDF of phosphorus, potassium and $ZnSO_4$ and 25% of nitrogen were applied as basal dose at the time of sowing and remaining amount of nitrogen was given at flowering and square formation. The nitrogen was applied through urea, phosphorus through single super phosphate, and potassium through muriate of potash. First hoeing was done at about 15-20 days after sowing (DAS), second and third hoeings were done at about 50 and 85 DAS to control the weeds. Irrigation was applied as per schedule at IW/CPE of 0.75 in flood and furrow irrigation, whereas in drip, the irrigation was applied at 0.80 of P. E. (PAN evaporation). The drippers were installed at 60 cm spacing in case of *Bt* and American and 30 cm spacing in case of *Desi* cotton. The crop was raised as per Package of Practices of the University. Insecticide spray of rogor and nimbicidine was done for the control of whitefly, other pests, etc., for plant protection as per Package of Practices of the University. The picking of cotton was done on September 23, October 10 and October 25, 2014. Five plants were tagged from each observation plot of all the four cotton cultivars in 2014 for recording plant height, monopods, sympods, number of bolls per plant, boll weight and seed cotton yield per plant. The plant height (cm) of the tagged plants was measured at 120 DAS. At the crop maturity, monopodial and sympodial (fruit bearing branches) branches of the tagged plants were counted and average of monopodial and sympodial branches per plant was calculated. Total number of opened bolls at each picking and total unopened bolls at the time of last picking were counted in each treatment from the tagged plants. Seed cotton was picked from opened bolls of the tagged plants and weighed

for getting average seed cotton weight per boll (g). The seed cotton yield from the tagged plants from three pickings in all the four cotton cultivars in each plot was recorded for calculating seed cotton yield per plant (g). The seed cotton picked for all the pickings (three) including the five tagged plants from each plot was weighed to get total seed cotton yield (kg/ha) of each variety. Water use efficiency (WUE) was calculated as seed cotton yield per unit applied water.

RESULTS AND DISCUSSION

Seed Cotton Yield and Yield Attributes

Plant height : The plant height of *Bt* and American cotton significantly increased with drip and furrow irrigation over the flood irrigation, but plant height of *Desi* cotton in furrow irrigation was found to be statistically at par with flood irrigation (Table 1). Amongst the *Bt* and American cotton cultivars, the American cotton attained highest plant height of 168.4 cm under drip irrigation.

The results also indicated that application of water through drip method increased plant height by 6.8, 4.8, 3.9 and 2.8% compared to the flood method of irrigation in American (H-1236), *Bt* (RCH-134), *Bt* (MRC-7017) and *Desi* (HD-123), respectively, at 120 DAS. The higher plant height under drip and furrow irrigation might be due to favourable soil condition and more water availability to the plants. Similar results on higher plant height of cotton with drip irrigation were observed by Sampathkumar *et al.* (2006).

Monopods and sympods : The drip and furrow irrigation increased number of monopods and sympods branches per plant of all the four cotton cultivars as compared to flood irrigation (Table 2). The number of monopods was recorded highest in drip irrigation followed by furrow irrigation. However, the results of the present study showed that number of monopods of 5.2, 5.5, 4.5 and 4.8 of *Bt* (MRC-7017), American (H-1236), *Bt* (RCH-134) and *Desi* (HD-123), respectively, in drip irrigation was found significantly higher over flood irrigation. The number of monopods in furrow irrigation was also recorded significantly higher over flood irrigation except in *Desi* (HD-123). The number of sympods in drip and furrow irrigation was found significantly higher than flood irrigation but effect of drip and furrow irrigation on number of sympods was statistically at par in all the cotton varieties except *Desi* (HD-123) where drip irrigation significantly increased the number of sympods (20.6) as compared to furrow irrigation (20.0). The number of monopods and sympods in drip and furrow irrigated plots might be due better water availability for plant growth.

Number of bolls/plant : The application of water through drip method significantly increased the number of open bolls per plant by 24.4, 19.8, 24.8 and 9.6% in *Bt* MRC-7017, American H-1236, *Bt* RCH-134 and *Desi* HD-123, respectively, over flood irrigation (Table 3). The maximum number of bolls per plant was recorded with drip irrigation followed by furrow (37.8) in *Bt* (MRC- 7017). The higher number of bolls per plant in drip irrigation might be due to higher number of sympodial and monopodial branches and better plant growth. Similar effects of drip irrigation on number of bolls per plant were also reported by Ibragimov *et al.* (2007).

Weight of boll : The drip irrigation produced significantly highest boll weight amongst three irrigation treatments in all the four cotton cultivars (Fig. 1). The highest boll weight of 3.56 g was measured in *Bt* (MRC-7017) under drip, followed by furrow equal to

Table 1. Effect of different irrigation methods on plant height of different cotton cultivars at 120 DAS

Irrigation method	Plant height (cm)			
	Bt (MRC-7017)	American (H-1236)	*Bt* (RCH-134)	*Desi* (HD-123)
Flood	152.9	157.6	144.9	172.1
Furrow	156.4	164.6	148.6	174.6
Drip	158.9	168.4	151.9	177.0
C. D. (P=0.05)	2.6	4.0	3.0	2.8

Table 2. Effect of different irrigation methods on monopods/plant and sympods/plant of different cotton cultivars

Irrigation method	*Bt* (MRC-7017)	American (H-1236)	*Bt* (RCH-134)	*Desi* (HD-123)
		Monopods		
Flood	4.5	4.8	3.9	4.2
Furrow	5.0	5.2	4.2	4.4
Drip	5.2	5.5	4.5	4.8
C. D. (P=0.05)	0.2	0.2	0.2	0.2
		Sympods		
Flood	17.9	20.1	14.7	19.3
Furrow	18.9	21.3	15.4	20.0
Drip	19.7	21.9	15.5	20.6
C. D. (P=0.05)	0.9	0.8	0.4	0.5

Table 3. Effect of different irrigation methods on number of bolls per plant and boll weight (g) of different cotton cultivars

Irrigation method	No. of bolls/plant			
	Bt (MRC-7017)	American (H-1236)	*Bt* (RCH-134)	*Desi* (HD-123)
Flood	33.1	34.3	24.9	29.0
Furrow	37.8	36.1	29.5	31.7
Drip	41.2	41.1	31.1	31.8
C. D. (P=0.05)	3.7	2.7	2.7	3.5

3.48 g. The drip irrigation resulted in 20% higher average boll weight of all the three hybrid cotton cultivars than the *Desi* cotton. Shirahatti *et al.* (2007) observed similar trend of increasing of boll weight with drip irrigation compared to flood method of irrigation.

Seed cotton yield : The drip irrigation resulted in significant increase in seed cotton yield of all the four cotton cultivars (Table 4). The seed cotton yield was recorded highest of 2671 kg/ha of American (H-1236) followed by 2510 kg/ha of *Bt* (MRC-7017), 2287 kg/ha of *Desi* (HD-123) and 2151 kg/ha of *Bt* (RCH-134) in drip irrigation. The seed cotton yield of *Bt* cotton was found lower than American cotton due to severe attack of white fly despite of spray in the region during 2014. The average seed cotton yield of all the cotton cultivars was 16.7 and 10.6% higher in drip and furrow irrigation,

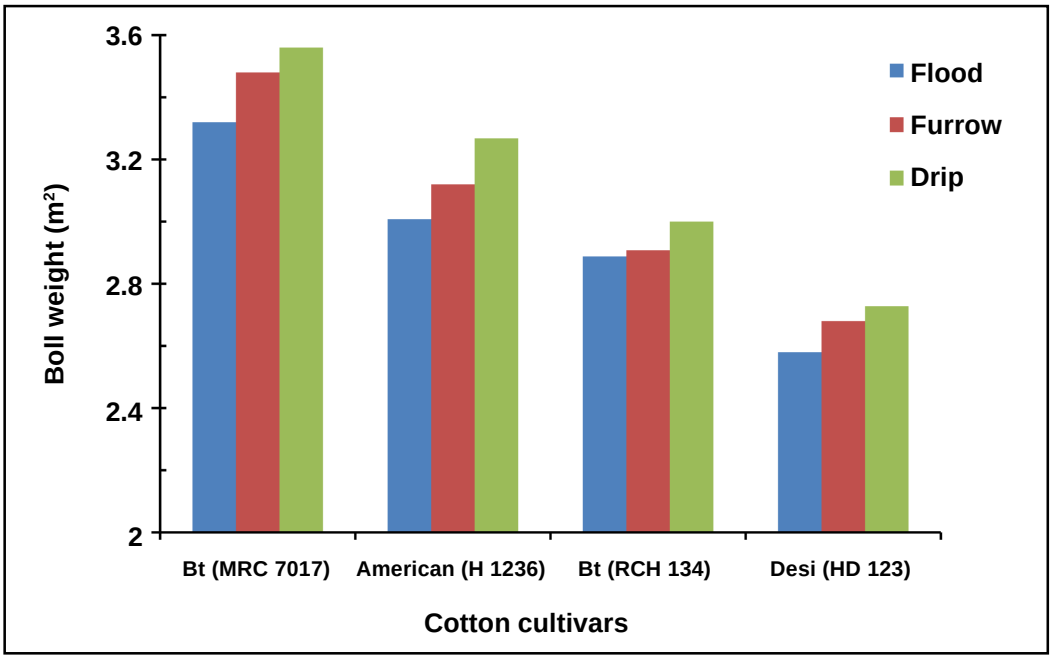

Fig. 1. Effect of different irrigation methods on boll weight (g) of different cotton cultivars.

Table 4. Effect of different irrigation methods on seed cotton yield (kg/ha) of different cotton cultivars

Irrigation method	Seed cotton yield (kg/ha)			
	Bt (MRC-7017)	American (H-1236)	*Bt* (RCH-134)	*Desi* (HD-123)
Flood	2180	2337	1836	1883
Furrow	2426	2526	2024	2137
Drip	2510	2671	2151	2287
C. D. (P=0.05)	205	265	147	122

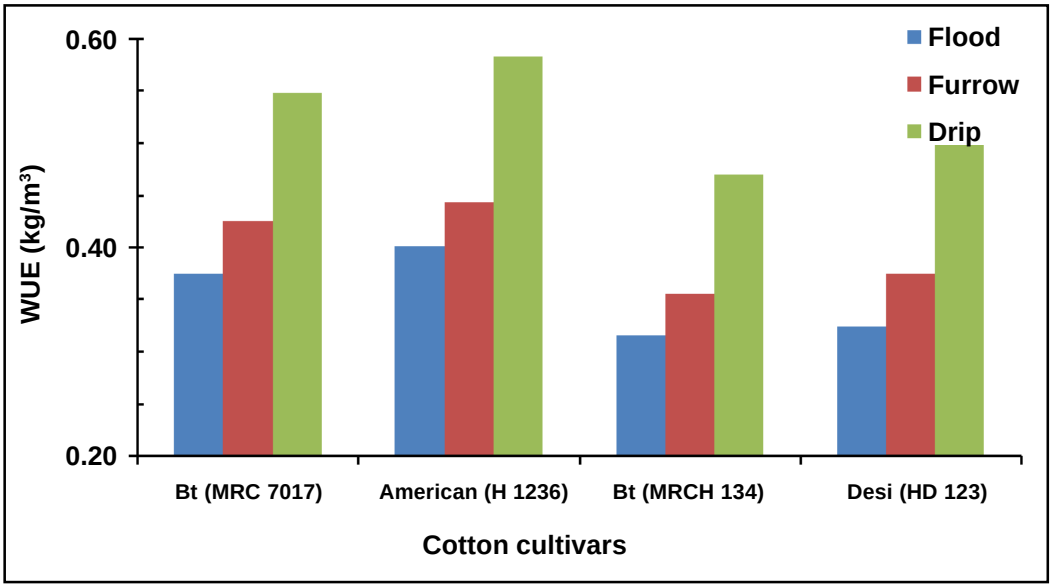

Fig. 2. Effect of irrigation methods on WUE of different cotton cultivars.

respectively, over the flood irrigation. The effect of drip irrigation on seed cotton yield was found to be statistically at par with furrow irrigation in all the cotton cultivars except *Desi* cotton. The increase in seed cotton yield under drip irrigation was reported 23.7, 45 and 53% over all furrows, alternate furrow and check basin method, respectively, by Veeraputhiran *et al.* (2002).

Water use efficiency : The water use efficiency (WUE) for all the four cotton cultivars was found highest in drip irrigation (Fig. 2). The WUE was observed lowest when irrigation was applied with flood method. Amongst the different cotton cultivars, the highest WUE of 0.58 kg (seed cotton yield)/m^3 was found in American (H-1236), followed by 0.55 kg/m^3 in *Bt* (MRC-7017), *Desi* (HD-123) and *Bt* (RCH-134). Ramamurthy *et al.* (2009) reported 28-58% higher water use efficiency with drip-irrigated cotton than broad bed furrow and 45-68% higher than the flood method of irrigation. The WUE was higher under drip and furrow irrigation methods as observed by Shirahatti *et al.* (2007) who studied the impact of drip and furrow irrigation methods on the hybrid cotton yield and concluded that all the treatments showed increase in yield than control.

REFERENCES

Ahluwalia, M. S., Singh, K. J., Singh, B. and Sharma, K. P. (1998). Influence of drip irrigation on water use and yield of sugarcane. *Int. Water and Irrig. Rev.* **18** : 12-17.

Cetin, O. and Bilgel, L. (2002). Effects of different irrigation methods on shedding and yield of cotton. *Agric. Water Manage.* **54** : 1-15.

Cotton Advisory Board (2014-15). http://www.cotcrop.gov.in.

Ibragimov, N., Evet, S. R., Esanbekov, Y., Kamilov, B., Mirzaev, L. and Lamers, J. P. A. (2007). Water use efficiency of irrigated cotton in Uzbekistan under drip and furrow irrigation. *Agric. Water Manage.* **90** : 112-20.

Narayanamoorthy, A. (2010). Can drip method of irrigation be used to achieve the macro

objectives of conservation agriculture? *Indian J. Agric. Econ.* **65** : 428-38.

Ramamurthy, V., Patil, N. G., Venugopalan, M. V. and Challa, O. (2009). Effect of drip irrigation on productivity and water use efficiency of hybrid cotton (*Gossypium hirsutum*) in Typic Haplusterts. *Indian J. agric. Sci.* **79** : 118-21.

Sampathkumar, T., Krishnasamy, S., Ramesh, S., Prabukumar, G. and Gobi, R. (2006). Growth, nutrient uptake and seed cotton yield of summer cotton as influenced by drip, surface irrigation methods and mulching practices. *Res. J. Agric. and Biol. Sci.* **2** : 420-22.

Sezan, S. M., Yazar, A., Akyildiz, A., Dasgan H. Y. and Gencel, B. (2008). Yield and quality response of drip irrigated green beans under full and deficit irrigation. *Sci. Hort.* **117** : 95-102.

Shirahatti, M. S., Itnal, C. J. and Mallikarjunapp, D. S. (2007). Impact of differential methods of irrigation on yield levels of cotton in red soils. *Karnataka J. Agric. Sci.* **20** : 96-98.

Soil Survey Staff (1998). *Key to Soil Taxonomy, 8th edn.* USDA and Natural Resource Conservation Service.

Veeraputhiran, R., Kandasamy, O. S. and Sundarsingh, S. D. (2002). Effect of drip irrigation and fertigation on growth and yield of hybrid cotton. *J. Agric. Resour. Manage.* **1** : 88-97.

Zhai, Y. M., Shao, X. H., Xing, W. G., Wang, Y., Hung, T. T. and Xu, H. L. (2010). Effect of drip irrigation regime on tomato fruit yield and water use efficiency. *J. Food Agric. Environ.* **8** : 709-13.