J. Cotton Res. Dev. **35**(2), 226-231 (July, 2021) **ISSN No. 0972-8619**

Effect of different levels of drip irrigation and fertigation on water use efficiency and seed cotton yield of *Bt* cotton

ANNU, KARMAL SINGH*, PRIYANKA DEVI, MEENA SEWHAG AND SHWETA MALIK
CCS Haryana Agricultural University, Hisar-125004
**E-mail:- karmalsingh@gmail.com*

ABSTRACT: A field experiment was conducted at Cotton Research area of CCS Haryana Agricultural University, Hisar, during *kharif* 2019 to study the effect of different levels of drip irrigation and fertigation on water use efficiency and seed cotton yield of *Bt* cotton. The experiment comprising 3 irrigation levels: I_1 (1.0 Etc), I_2 (0.8 Etc), I_3 (0.6 Etc) and four fertigation levels: F_1 (control), F_2 (50 % RDF-recommended dose of fertilizer), F_3 (75 % RDF), F_4 (100 % RDF) was conducted in factorial randomized block design with three replications. The results revealed that maximum seed cotton yield (3854 kg/ha), bolls/plant and sympodial branches/plant were obtained with I_1 (1.0 Etc) level though it was statistically *at par* with I_2 (0.8 Etc) level. The highest WUE was recorded in I_3 (0.6 Etc) level of irrigation which was significantly higher than other two irrigation levels. Similarly, among different fertigation levels, highest seed cotton yield (4404 kg/ha), bolls/plant, sympodial branches/plant and water use efficiency were recorded in F_4 (100 % RDF) level which were statistically *at par* with F_2 (50 % RDF) and F_3 (75 % RDF) levels of fertigation.

Keywords: Cotton, drip irrigation, fertigation, water use efficiency

Cotton (*Gossypium hirsutum* L.), also known as “White Gold” is one of the most important commercial cash crop of semi-arid regions of the world. The top three cotton producing countries are India, China and USA. India has been a traditional home of cotton and cotton textile industries. Cotton is an international crop grown by about 80 countries across the world and on average, cotton is planted in an area of 34.5 m ha in the world. India accounts about 33 per cent global cotton area which is largest in the world. The area, production and productivity of cotton in India is 12.76 million ha, 36.1 million bales and 466 kg ha respectively (Anonymous, 2020).

Though India is having largest area under cotton cultivation globally, but production and productivity of country is low in comparison to other countries like Australia, China, USA etc. The top three cotton producing states are Maharashtra, Gujarat and Andhra Pradesh. The major constraints in cotton production in our country are competition with other more economical crops, cultivation under rainfed condition, non availability of critical inputs, weed infestation, attack of various insect pests and diseases, costly and time consuming harvesting by hand picking etc. Among all practices, management of irrigation water is very important to increase the yield of crop. Fertilizer management is also an important component in cultivation of cotton crop.

Due to increasing cost of irrigation projects and limited supply of good quality water, the best known technique is micro-irrigation that is proven for its efficiency, water and input saving. Cotton in north India is mainly irrigated by flooding method (Singh *et al.*, 2020). But, World over it is proved that cotton respond well under micro irrigation. Cotton irrigated by flood method of irrigation consumes 40-50 per cent more water as compared to microirrigation (Bhaskar *et al.*, 2005). Under micro-irrigation system, more than 90 per cent irrigation efficiency can be achieved with improved yield and quality of the produce. Application of fertilizers through drip irrigation system is known as fertigation.

Fertigation results in saving of 25-30 per cent of recommended dose of fertiliser thus, reduced cost of fertilizers (Kumar and Singh, 2002). The net utilization of irrigation water in drip system is 90 per cent. In view of the same, microirrigation is of supreme importance with brighter future prospects. However, whatever little developments and adoption of drip technology have taken place so far, are mainly concentrated in acute water scarcity areas and in high value crops like perennial and horticultural crops, but not in crop like cotton. As total water availability is also decreasing over the years almost in all cotton growing states in the country, economization of available water and its proper management in cotton is of prime importance and that could be made possible through cultivation of cotton with drip irrigation.

The present investigation was carried out during *kharif* of 2019 at cotton research farm of CCS Haryana Agricultural University. *Bt* cotton genotype RCH 776 was sown by dibbling method, by putting 2 seeds/hill at a depth of 3-5 cm to maintain optimum plant population. All intercultural operations of experimental crop were followed according to the package of practices of cotton crop recommended by the CCS Haryana Agricultural University.

TREATMENTS

Irrigation levels

I_1 = 1.0 Etc

I_2 = 0.8 Etc

I_3 = 0.6 Etc

Fertigation levels

F_1 = Control

F_2 = (50 %) RDF

F_3 = (75 %) RDF

F_4 = (100 %) RDF

Note: (RDF = 175:60:60:25 N, P, K and ZnSO4 kg/ha)

Genotype: RCH 776

Plot size: 4.0 x 9.0 m

Treatments: 12

Replications: 3

Total plots: 36

Design: Factorial Randomized Block Design

Season/ year: *kharif* 2019

In Haryana, recommended dose of fertilizers for *Bt* cotton is 175 kg N, 60 kg P_2O_5, 60 kg K_2O and 25 kg $ZnSO_4$ /ha. Fertilisers were applied through drip fertigation as per treatment (15 equal splits through fertigation between 30 to 120 DAS at six days interval). Gap filling was done five days after germination of cotton crop to obtain optimum plant stand in each plot. Thinning had been done to keep one plant/hill. Five plants from each plot were selected randomly and tagged for the recording of different observations till maturity of the crop.

Total bolls/plant were counted from 5 tagged plants in each plot by adding the mean number of good and poor opened bolls harvested per plant. Ten completely opened bolls from tagged plants in each plot were picked randomly and weighed and averaged to give boll weigh (g)/plant. Monopodial branches in each plot were counted at maturity stage from the five tagged plants and mean was determined and expressed/plant basis. The sympodial branches also known as the reproductive branches were counted at maturity stage from the five tagged plants in each plot and expressed as average sympodial branches/plant. After ginning, weight of 100 cotton seeds taken randomly from each plot was expressed in grams. Total seed cotton harvested from two pickings per plot was recorded and expressed as seed cotton yield in kg/ha. In case of different drip irrigation treatments, the irrigation scheduling was done on the basis of climatological approach. Irrigation was scheduled at every three days interval in all drip irrigated treatments during crop period and volume of water was calculated as per pan evaporation (E_0).

The volume of irrigation water applied was computed by using following formula (Allen *et al.*, 1998) as given below,

Water Requirement (WR) = EPan x Kp x Kc

Where, EPan = Pan evaporation (mm/3

days), Kp = Pan factor (0.70) and Kc = Crop coefficient

Kc for cotton: Kc = 0.45 (0-25 DAS), 0.75 (26-70 DAS), 1.15 (71-120 DAS) and 0.70 (121-upto harvest). Emitter discharge = 2.2 ltr./h. Drip irrigation efficiency = 90 per cent. Water requirement for the entire season of crop was computed by adding measured quantities of irrigation water applied to the experimental crop.

Water use efficiency (%)

The water use efficiency (WUE) was measured by calculating the ratio of the economic crop yield obtained to the amount of water required for crop growth. It was computed by the formula given below:

WUE = Y / WR

Where, WUE = Water use efficiency (kg/ha/mm)

Y = Yield, kg/ha

WR = Seasonal water requirements, mm

Effect of irrigation levels

Monopodial branches are the vegetative branches which appear from the lower nodes of the plant. Different irrigation levels had no significant effect on monopodial branches/plant. Similar findings were reported by Gladston (2017). The number of monopodial branches in cotton depends on the availability of resources and moisture. Higher is the dose of fertilizers, the where number of monopodial branches were more. Similarly, optimum moisture condition in root zone of crop resulted in more monopodial branches/plant as stated by Pettigrew (2004). Different irrigation levels significantly influenced the sympodial branches/plant. I_1 (1.0 Etc) level of irrigation recorded maximum sympodial branches/plant which were statistically *at par* with I_2 (0.8 Etc) level but significantly higher than I_3 (0.6 Etc) level of irrigation. The number of sympodial branches in cotton again depends on the availability of resources and moisture. Velmurugan *et al.*, (2014) also observed higher sympodial branches under drip irrigation with 100 per cent potential evapotranspiration and (100 % RDF) (150:75:75). Similar results were also reported by Sampathkumar (2006).

The maximum number of bolls/plant were recorded in I_1 (1.0 Etc) level of irrigation which were statistically *at par* with I_2 (0.8 Etc) but significantly higher than I_3 (0.6 Etc) level of irrigation. This significant increase in the bolls/plant in I_1 (1.0 Etc) and I_2 (0.8 Etc) levels of irrigation was resulted with increasing rate of applied irrigation water. Similarly the highest bolls was observed in fully irrigated cotton relative to deficit irrigated plots in line with Hussein *et al.*, (2011). These findings are also in conformity with Yadav *et al.*, (2014). Whereas, highest boll weight was observed in I_1 (1.0 Etc) level of irrigation and lowest boll weight was observed in I_3 (0.6 Etc) level of irrigation Similar results have been reported by Singh *et al.*, (2018). Different irrigation levels had no significant effect on seed index in line with findings of Shekar *et al.*, (2016).

Cotton yield is a function of many yield attributing parameters such as bolls/plant, boll weight, and sympodial branches etc. The results revealed that different drip irrigation levels had a significant effect on seed cotton yield. The highest seed cotton yield (3854 kg/ha) was obtained in I_1 (1.0 Etc) level of irrigation which was *at par* with I_2 (0.8 Etc) level and significantly higher than I_3 (0.6 Etc) level due to higher yield components such as sympodial branches/plant and bolls/plant. Thus, application of 80 per cent water required by crop through drip was found optimum for *Bt* cotton. The adequate water application through the drip in I_1 (1.0 Etc) and I_2 (0.8 Etc) levels of irrigation has also helped in keeping the moist condition in the root zone of crop and ultimately resulted in higher seed cotton yield. Similar finding were also reported by Aladakatti *et al.*, (2012).

The results further indicated that the highest and the lowest total water use was recorded in I_1 (1.0 Etc) and I_3 (0.6 Etc) levels of irrigation respectively. Singh and Bhati (2018) also reported that the consumptive use and irrigation water applied were the highest in crop irrigated at 1.0 Etc compared to 0.6 and 0.8 Etc levels of drip irrigation. These results indicated that any increase in the irrigation levels in drip irrigation system decreased the WUE of *Bt* cotton. Significantly higher WUE was recorded in I_3 (0.6 Etc) level of irrigation than all other irrigation levels. The lowest value of WUE was recorded in I_1 (1.0 Etc) level of irrigation. Increasing the level of water application by drip irrigation system decreased the WUE which was mainly due to limited quantity of water applied under lower levels of drip irrigation. Similar results were also reported by Singh and Bhati (2018).

Effect of fertigation levels

Different fertigation levels had no significant effect on monopodial branches/plant. Similar findings were reported by Gladston (2017). However, different fertigation levels had significant effect on monopodial branches/plant. F_4 (100 % RDF) level of fertigation recorded maximum sympodial branches/plant which were statistically *at par* with F_2 (50 % RDF) and F_3 (75 % RDF) levels of fertigation, but significantly higher than F_1 (control). Higher the rate of fertilizer application, more were the sympodial branches. Velmurugan *et al.*, (2014) also observed higher sympodial branches under drip irrigation with (100 % RDF) (150:75:75 of N:P:K).Similar results were also reported by Sampathkumar (2006).

Different fertigation levels had exerted significant effect on bolls/plant. Highest bolls/plant were recorded in F^4 (100 % RDF) level which were significantly better than F_1 (control), but statistically *at par* with F_2 (50 % RDF) and F_3 (75 % RDF) levels. Jat *et al.*, (2012) reported 9.2 per cent increase in bolls/plantwith (100 % RDF) (175.0: 60: 60 N, P and K kg/ha) over the lower level of RDF. Our results revealed that boll weight was not significantly influenced by different fertigation levels. Availability of adequate amount of fertilizers at boll development stage in F_4 (100 % RDF) level of fertigation increased boll weight. Fertigation of 150 kg N/ha to *Bt* cotton increased boll weight by 16.6 per cent over 80 kg N/ha (Singh *et al.*, 2010). Seed index was influenced significantly due to various fertigation levels. F_4 (100 % RDF) level of fertigation recorded significantly higher seed index which remained *at par* with F_3 (75% RDF) level but significantly higher as compared to F_2 (50 % RDF) and F_1 (control) levels. Similar results were also reported by Shekar *et al.*, (2016).

Among different fertigation levels, highest seed cotton yield was obtained in F_4 (100 % RDF) level which was significantly better than F_1 (control), but statistically *at par* with F_2 (50 % RDF) and F_3 (75 % RDF) levels due to higher yield components such as bolls/plant.

Table 1. Effect of different irrigation and fertigation levels on yield attributes and seed cotton yield of *Bt* cotton

Treatments	Monopodial branches/plant	Sympodial branches/plant	Bolls/ plant	Boll wt. (g)	Seed index (g)	Seed cotton yield (kg/ha)
Irrigation levels						
I_1 - 1.0 Etc	1.4	24	48	4.02	9.83	3854
I_2 - 0.8 Etc	1.5	22	45	3.99	9.44	3816
I_3 - 0.6 Etc	1.5	20	43	3.98	9.48	3327
SE (m) ±	0.15	0.87	1.17	0.06	0.09	154
CD (p = 0.05)	NS	2.56	3.47	NS	NS	453
Fertigation levels						
F_1 - Control	1.5	15	28	3.84	8.08	2022
F_2 - (50 %) RDF	1.4	23	50	3.99	9.63	3984
F3 - (75 %) RDF	1.4	24	51	4.07	9.88	4251
F_4 - (100 %) RDF	1.5	25	53	4.09	10.0	4404
SE (m) ±	0.17	1	1.36	0.07	0.1	177
CD (p = 0.05)	NS	2.97	4	NS	0.3	524

Table 2. Effect of different irrigation and fertigation levels on total water use and water use efficiency (WUE) of *Bt* cotton

Treatments	Total water use (mm)	WUE (kg/ha/mm)
Irrigation levels		
I_1 - 1.0 Etc	448	8.60
I_2 - 0.8 Etc	358	10.65
I_3 - 0.6 Etc	269	12.36
SE (m) ±		0.52
CD (p = 0.05)		1.54
Fertigation levels		
F_1 - Control	358	5.64
F_2 - (50 %) RDF	358	11.12
F_3 - (75 %) RDF	358	11.87
F_4 - (100 %) RDF	358	12.30
SE (m) ±		0.6
CD (p = 0.05)		1.78

Thus, (50 % RDF) through drip fertigation was found optimum for *Bt* cotton. The adequate availability of fertilizers throughout the crop growth and development period in F_4 (100 % RDF) level of drip fertigation helped for more uptakes of nutrients which eventually reflected in higher seed cotton yield (4404 kg/ha). These results are in accordance with the Chauhan *et al.*, (2014).

Different fertigation levels had distinct bearing on WUE Higher WUE was associated with higher level of drip fertigation F_4 (100 % RDF) due to higher yield in F_4 (100 % RDF) level which was significantly higher than F_1 (control) but, statistically *at par* with F_2 (50 % RDF) and F_3 (75 % RDF) levels. Similar results have been reported by Harish *et al.*, (2017). Bhalerao *et al.*, (2011) also reported that increased WUE was obtained with drip irrigation at 0.8 Etc with (125 % RDF). Similar results were also reported by Bhatoo *et al.*, (2009).

REFERENCES

Aladakatti, Y. R., Hallikeri, S. S., Nandagavi, R. A., Shivamurthy, D. and Malik, R. 2012. Precision irrigation and fertigation to enhance the productivity and economic returns of *Bt* cotton in Vertisols. *Proceedings of Agro-Informatics and Precision Agriculture*, 115-16.

Anonymous, 2020 Accessed from agricoop.nic.in. Department of Agriculture Cooperation and Farmer Welfare

Bhalerao, P. D., Gaikwad, G. S. and Imade, S. R. 2011. Productivity and nutrient uptake of *Bt* cotton (*Gossypium hirsutum*) as influenced by precision in application of irrigation and fertilizer. *Ind. J. Agron.*, **56** : 150-53.

Bhaskar, K. S., Rao, M. R. K., Mendhe, P. N. and Suryavanshi, M. R. 2005. *Micro Irrigation Management in Cotton.* Central Institute for Cotton Research, Nagpur, *Tech. Bull.* : 31

Bhatoo, M. S., Devraj, K. S., Nirania, and Jain, P. P. 2009. Effect of different levels of irrigation and fertiliser through drip on productivity of cotton. *Proceedings of National symposium on Bt cotton held at CICR, Nagpur*, on 17–19 Nov, 53–54.

Chauhan, R. P. S., Yadav B. and Singh, R. B. 2014. Studies on drip irrigation, fertigation and spacing in *Bt* cotton. *The J. Rural Agril. Res.* **14** : 27-29.

Gladston, K. M. 2017. Response of *Bt* cotton to different drip irrigation regimes and fertigation levels. *M.Sc. (Agri) Thesis* Professor Jayashankar Telangana State Agricultural University, Hyderabad.

Guillaume, P. G. and Sun Y. 2012. Measuring the contribution of *Bt* cotton adoption to India s cotton yields leap. International Food Policy Research Institute (IFPRI). *Discussion paper on sustainable solutions for ending hunger and poverty*, 1170.

Harish, J., Pawar, D. D., Kale, K. D., Dingre, S. K. and Hasure, R. R. 2017. Growth, yield and water use of *Bt* cotton under drip fertigation using different phosphorus sources. *BIOINFOLET-A Quarterly J. Life Sci.* **14** : 299-302

Hussein, F., Janat, M. and Yakoub, A. 2011. Assessment of yield and water use efficiency of dripirrigated cotton (*Gossypium hirsutum* L.) as affected by deficit irrigation. *Turkish J. Agricl. Forestry*, **35**: 611- 21.

Jat, R. D., Nanwal, R. K. and Kumar, P. 2012. Growth, productivity and profitability of *Bt* cotton (*Gossypium hirsutum* L.) influenced by spacing and nutrient levels. *J. Envir. Ecol.* **30** : 97-101.

Kumar, A. and Singh, A. K. 2002. Improving nutrient and water use efficiency through fertigation. *J. Water Manag.* **10**: 42-48

Pettigrew, W. T. 2004. Moisture deficit effects on cotton lint yield, yield components, and boll distribution. *Agr. J.* **96**: 377-83.

Sampathkumar, T., Krishnasamy, S., Ramesh, K. and Shanmugasundaram, K. 2006. Effect of drip and surface irrigation methods with rice straw mulch on productivity and water use efficiency of summer cotton. *Crop Res.* **32** : 141-44.

Shekar, J. C., Kumar, K. A. and Chary, G. R. 2016. Yield and yield attributes of *Bt* cotton as influenced by different drip fertigation schedules. *J. Res. PJTSAU*, **44** : 58-61.

Singh, K., Singh, H.P., Mishra, S.K. 2020. Irrigation module and sowing dates affect seed cotton yield, quality productivity indices and economics of cotton in north-western India. *Comm. Soil Sci. Pl. Ann.* **51**: 1-13.

Singh, K., Brar, A. S. and Singh, H. P. 2018. Drip fertigation improves water and nitrogen use efficiency of *Bt* cotton. *J. Soil Water Conser.*, **73**: 549-57.

Singh, M. and Bhati, S. 2018. Nutrient use in cotton grown under drip irrigation system in northwestern India. *J. Crop Weed.* **14**: 122-29.

Singh, Y., Rao, S. S. and Regar, P. R. 2010. Deficit irrigation and nitrogen effects on seed cotton yield, water productivity and yield response factor in shallow soils of semi arid environment. *Agri. Water Manag.* **97**: 965-70.

Velmurugan, V., Ganesraja, V., Gurusamy, A. and Mahendran, P. P. 2014. Effect of drip fertigation on growth, yield attributes and yield of cotton. *Madras Agri. J.* **101**: 131- 33.

Yadav, B. S., Chauhan, R. P. S., Bhatia, K. N. and Yadav, N. K. 2014. Studies on drip fertigation on growth, yield and pest incidence of American cotton (*Gossypium hirsutum* L) and *desi* cotton (*Gossypium arboreum* L) on sandy loam soil. *J. Cotton Res. Dev.* **28** : 234-37.

Received for publication : May 23, 2021
Accepted for publication : June 19, 2021