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Effect of irrigation levels on growth and yield of Bt-cotton in vertisol

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Abstract
A field experiment was conducted at Water Management Research Centre (WMRC) Belvatagi, Navalgund taluk (Dharwad dist.) during *kharif* 2014-15 to study the effect of irrigation levels on growth and yield of Bt-cotton in Vertisol. Irrigation scheduled at 0.8 IW/CPE (I_1) recorded significantly higher kapas yield (17.32 q ha^{-1}) as compared to irrigation scheduled at critical stages (15.21 q ha^{-1}). It can be concluded that irrigation at 0.6 IW/CPE (I_2) found suitable for getting higher yield and net profit which also saves water.

Keywords: Irrigation levels, IW/CPE ratio, Vertisol, *Gossypium hirsutum* L.

1. Introduction
Cotton (*Gossypium hirsutum* L.), the king of fibre crops, has an importance of industrial commodity. Bt-cotton is a genetically modified variety of cotton producing an insecticide. Cotton is an important commercial crop and forms principal raw material for a flourishing textile industry. As much as 70 per cent of raw material need of textile industry is met only from cotton. In India 60 million people are involved in raw cotton production. India takes pride in having largest area (101.5 lakh ha) of cotton and being second largest cotton producing (295 lakh bales) country in the world. However, the productivity (494 kg/ha) is lower than the world average (725 kg/ha). In India, the largest area under cotton crop is in Maharashtra. The area and production of cotton crop in Maharashtra during 2006-07 is 31.07 lakh ha and 3250 thousand bales, but has the lowest productivity of 187 kg/ha (Anon., 2008a). Karnataka, has a relatively smaller area of cotton (4.57 lakh ha) and produces 7.54 lakh bales accounting for productivity of 295 kg/ha during 2007-08. With the popularization of Bt-cotton productivity of cotton in Karnataka is constantly in increasing trend. The future of cotton in Karnataka appears to be very bright because of the prevailing system of liberal recommendation of hybrids, over 600 Bt-cotton hybrids are released for cultivation in India. As a result of this markets are flooded with innumerable hybrids and the farmers are unaware of which hybrid suits their region and situation. The Bt-cotton retains relatively more number of bolls and synchronous boll development and hence it needs higher quantity of nutrients compared to non-Bt hybrids. Moisture is one of the important factors for crop production. Crop production suffers not only from drought but also from non-scientific use of available water and fertilizer doses. Because of faulty method of irrigation, considerable amount of water is being wasted by seepage and deep percolation below the root zone resulting in loss of valuable plant nutrients through leaching (Kumar *et al*., 1991 and Sit *et al*., 2001) [2, 4].

2. Materials and methods
The experiment consisted of three levels of irrigation as main plot and five different integrated nutrient management levels as sub plot. The experiment was laid out in split plot design, three replications with a gross plot size of 6.0 x 5.8 m and net plot size of 5.6 x 5.4m.

2.1 Location of experimental site
The experiment was conducted at Irrigation Water Management Research Centre (IWMRC) Belavatagi, Navalagund taluk of Dharwad district which is situated in the Northern dry zone (Zone-3) of Karnataka.

Crop details
Crop: Bt-cotton (*Gossypium hirsutum* L.)
Variety: Paras Brahma
Season: *Kharif*, 2014-15
Date of sowing: 21st July, 2014
Dates of harvesting: 4 pickings dates
I picking------- 10/02/2015
II picking------ 11/03/2015
III picking----- 10/04/2015
IV picking----- 27/04/2015

2.2 Treatment details
I_1= 0.8 IW/CPE ratio
I_2= 0.6 IW/CPE ratio
I_3= Critical stages

Note: IW=Irrigation water
CPE=Cumulative Pan Evaporation

Table 1: Irrigation scheduled dates

Treatments	Dates of irrigation
I_1= 0.8 IW/CPE	22-09-2014, 23-10-2014, 05-11-2014, 29-11-2014, 21-12-2014, 08-01-2015
I_2= 0.6 IW/CPE	27-09-2014, 02-11-2014, 30-11-2014, 28-12-2014, 18-01-2015
I_3=Critical stages	29-09-2014, 27-11-2014, 02-01-2015

Table 2: Total amount of water used by the crop

Treatments	Common irrigation (mm)	Treatmental irrigation (mm)	Effective rainfall (mm)	Total (mm)
I_1= 0.8 IW/CPE	60 (1)	360 (6)	186.7	606.7
I_2= 0.6 IW/CPE	60 (1)	300 (5)	238.4	598.4
I_3= Critical stages	60 (1)	180 (3)	247.1	487.1

Values in paranthesis indicates number of irrigations.

2.3 Irrigations
Irrigations were given based on the IW/CPE ratio as per treatment. Each time 60 mm depth of water was used for irrigation. Ridges and furrows were made and water was let in through furrows at every irrigation. Amount of Irrigation water applied under 0.6, 0.8 IW/CPE ratio and critical stages during the entire cropping season is given in Table 2. Hence irrigation water used under different IW/CPE ratios was calculated based on the number of irrigations given during entire cropping season taking a common depth of 60 mm of irrigation water at each irrigation.

3. Result
3.1 Growth parameters
The data on plant height, number of monopodial and sympodial branches recorded at crop growth stages and dry matter production recorded at harvest are presented in Tables 3 and 4 respectively.

3.1.1 Plant height (cm)
At 30 DAS
The results indicated that irrigation level, higher plant height (75.99 cm) was recorded in treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior over the treatment irrigation at critical stages (I_3) and on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2).

At 60 DAS
Higher plant height (111.29 cm) was recorded in the treatment irrigation at 0.8 IW/CPE ratio which is significantly superior to treatment irrigation at critical stages (I_3) and on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2) at 60 DAS.

At 90 DAS
Among irrigation level, higher plant height (136.39 cm) was recorded in treatment irrigation at 0.8 IW/CPE ratio (I_1). It is significantly superior to the treatment irrigation at critical stages (I_3) and was on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2) 90 DAS.

At 120 DAS
Among irrigation level, higher plant height (151.89 cm) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1). It is significantly superior to the treatment irrigation at critical stages (I_3) and was on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2).

At 150 DAS
Among irrigation levels, higher plant height (162.39 cm) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1). It is significantly superior to the treatment irrigation at critical stages (I_3) and it was on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2).

At harvest
Among irrigation levels, higher plant height (172.99 cm) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1). It is significantly superior to the treatment irrigation at critical stages (I_3) and it was on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2).

Table 3: Effect of irrigation and INM levels on plant height (cm) of Bt-cotton at different Days After Sowing (DAS)

Treatments		30	60	90	120	150	At harvest
Main - Irrigation levels							
I_1	0.8 IW/CPE ratio	75.99	111.29	136.39	151.89	162.39	172.99
I_2	0.6 IW/CPE ratio	74.83	109.93	135.23	150.73	161.37	171.83
I_3	Critical stages	64.49	99.59	124.82	141.47	150.89	161.35
SEm+		0.40	0.33	0.41	0.40	0.39	0.42
CD (0.05)		1.58	1.29	1.60	1.56	1.53	1.66

3.1.2 Number of monopodial branches

Non significant difference was observed in number of monopodial branches with respect to irrigation and INM levels. However, higher number of monopodial branches (1.58) was recorded in treatment irrigation at 0.6 IW/CPE ratio (I_2) and lower number of monopodial branches (1.48) was recorded in treatment irrigation at 0.8 IW/CPE ratio (I_1).

3.1.3 Number of sympodial branches

Among irrigation levels, higher number of sympodial branches (34.07) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior over the treatment irrigation at critical stages (I_3) and it was on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2).

Table 4: Effect of irrigation levels on number of monopodial and sympodial branches of Bt-cotton

Treatments	Monopodial branches/plant	Sympodial branches/plant
Main-Irrigation levels		
I_1 0.8 IW/CPE ratio	1.48	34.87
I_2 0.6 IW/CPE ratio	1.58	33.87
I_3 Critical stages	1.53	31.27
S.Em±	0.02	0.45
CD (0.05)	NS	1.79
CV (%)	5.30	5.28

3.1.4 Dry matter production

Among irrigation levels, higher dry matter production (50.41 q/ha) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior than the treatment (44.65 q/ha) irrigation at critical stages (I_3) and it was on par with the treatment (48.56 q/ha) irrigation at 0.6 IW/CPE ratio (I_2).

Table 5: Effect of irrigation levels on number of bolls per plant and boll weight (g) per boll of Bt-cotton

Treatments	Number of bolls/plant	Boll weight /boll(g)
Main-Irrigation levels		
I_1 0.8 IW/CPE ratio	36.16	4.36
I_2 0.6 IW/CPE ratio	35.00	4.33
I_3 Critical stages	31.72	4.25
S.Em±	0.23	0.02
CD(0.05)	0.92	0.07
CV(%)	1.84	1.52

3.1.5 Water use efficiency (kg/ha.mm)

The results indicated that in irrigation level, higher water use efficiency (3.12 kg/ha.mm) was recorded in the treatment irrigation at critical stages (I_3). I_3 is significantly superior over the treatment (2.85 kg/ha.mm) irrigation at 0.8 IW/CPE ratio (I_1) and the treatment (2.76 kg/ha.mm) irrigation at 0.6 IW/CPE ratio (I_2).

3.2 Yield parameters

The data on number of bolls/plant, boll weight/boll, kapas yield and seed yield recorded are presented in Tables 5 and 6, respectively.

3.2.1 Number of bolls/plant

Among irrigation levels, higher number of bolls (17.05) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior over the treatment irrigation at critical stages (I_3) and it was on par with the treatment irrigation at 0.6 IW/CPE ratio (I_2).

Table 6: Effect of irrigation levels on kapas yield (q/ha), seed yield (q/ha), total dry matter (q/ha) and water use efficiency (kg/ha.mm) of Bt-cotton

Treatments	Kapas (lint+seed) yield (q/ha)	Seed yield (q/ha)	Total dry matter (q/ha)	Water use efficiency (kg/ha.mm)
Main-Irrigation levels				
I_1 0.8 IW/CPE ratio	17.32	12.17	50.41	2.85
I_2 0.6 IW/CPE ratio	16.54	11.48	48.56	2.76
I_3 Critical stages	15.21	10.06	44.65	3.12
S.Em±	0.19	0.16	0.92	0.04
CD (0.05)	0.76	0.64	3.61	0.15
CV(%)	4.58	5.65	7.45	-

3.2.2 Boll weight per boll (g)

Among irrigation level, higher boll weight (4.36 g) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior to the treatment (4.25 g) irrigation at critical stages (I_3) and it was on par with the treatment (I_2) irrigation at 0.6 IW/CPE ratio (4.33 g).

3.2.3 Kapas yield (q/ha)

Among irrigation levels, higher kapas yield (17.32 q/ha) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior to the treatment (15.21 q/ha) irrigation at critical stages (I_3) and it was on par with the treatment (16.54 q/ha) irrigation at 0.6 IW/CPE ratio (I_2).

3.2.4 Seed cotton yield (q/ha)

Among irrigation levels, higher seed yield (12.17 q/ha) was recorded in the treatment irrigation at 0.8 IW/CPE ratio (I_1) which is significantly superior to the treatment (10.06 q/ha) irrigation at critical stages (I_3) and on par with the treatment (11.48 q/ha) irrigation at 0.6 IW/CPE ratio (I_2).

4. Discussion

Among irrigation levels, the treatment irrigation at 0.8 IW/CPE ratio (I_1) recorded higher number of sympodials, number of bolls, kapas yield and seed yield. This might be due to higher frequency of irrigation, increased nutrient level and moisture absorption as well as photosynthesis, which also helped in the translocation of photosynthates to the growing bolls, besides producing and retaining more number of bolls per plant at later stages of crop cycle. Similar results were obtained by Srinivas Reddy (1995) [5]. Irrigation at 0.8 IW/CPE ratio (I_1F_3) recorded higher number of bolls, kapas yield and seed yield. This might be due to higher availability of moisture with integrated application of nutrients. The results are in line with Adarsha *et al*. (2004) [1] who opinioned that, seed cotton yield and yield components were higher with higher doses of RDF and moisture regimes. Increased seed cotton yield was attributed to increased number of bolls per plant, good opened bolls per plant and boll weight in 0.8 IW/CPE irrigation level. Among irrigation levels, the treatment irrigation at 0.8 IW/CPE ratio (I_1) recorded higher plant height. This might be due to higher availability of moisture helps in better growth which inturn increased the yield. The results are in line with Patil *et al*. (2004) [3] who reported that nutrients and moisture levels differed significantly including their interactions with respect to growth components and also due to higher frequency of irrigation and better availability of nutrients.

5. Conclusion

To save the water, giving irrigation at 0.6 IW/CPE ratio congenial which is on par with giving irrigation at 0.8 IW/CPE (I_1F_3) ratio with respect to growth, yield parameters and Economics of Bt-cotton. It is concluded that giving irrigation at 0.6 IW/CPE ratio was found to be optimum moisture regime for Bt-cotton which also saves water.

6. References

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