J. Cotton Res. Dev. **31** (2) 213-223 (July, 2017) **ISSN No. 0972-8619**

Effect of irrigation regimes and nutrient management through drip on growth, yield and leaf reddening in *Bt* cotton

R.B.MANE*, A. D. TUMBARE AND C.A. NIMBALKAR

Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri -413 722

**E-mail: rajendrabmane24@gmail.com.*

ABSTRACT: The experiment was conducted to study the effect of irrigation regimes and nutrient management through drip on growth, yield and leaf reddening in *Bt* cotton at Mahatma Phule Krishi Vidyapeeth, Rahuri during 2014 and 2015. The data revealed that maximum and significantly higher seed cotton yield (31.90, 34.58 and 33.24 q/ha) was recorded at 1.0 ETc during both the years and on pooled mean basis. Minimum leaf reddening incidence and intensity during 60 to 120 DAP was observed under scheduling of irrigation at 1.0 ETc coupled with 100 per cent RDF+10 t FYM + $MgSO_4$ (20 kg / ha) + $ZnSO_4$ (25 kg / ha) and foliar spray of $FeSO_4$ (1%) (at flowering and boll development) + Boron (0.5%) (at flowering and boll development)

Key words : *Bt* cotton, irrigation regimes, leaf reddening, nutrient management, seed cotton yield

In India, cotton is grown under diverse agro climatic conditions and contributes nearly 65 per cent of total raw material needs of the textile industry. India rank first in area 12 million ha and the production is 40 million bales in 2014-2015(Anonymous, 2015). Its average productivity in India was 494 kg / ha, which was low as compared to world average of 705 kg/ha. Maharashtra leads the nation in respect of area as it occupies nearly 4.19 Million ha (Anonymous, 2015). The productivity of cotton in Maharashtra is very low mainly due to major rainfed area, low water use efficiency, unbalanced nutrition, lack of use of secondary and minor nutrients, leaf reddening and square and flower drops. The yield losses due to leaf reddening range from 30 to 60 per cent depending on *Bt* cotton hybrid and leaf reddening intensity (Pagare, 2011). Adoption of micro irrigation has proved its superiority because it helps in raising the irrigated area, productivity of crops, water use efficiency and nutrient use efficiency. The balance nutrient at appropriate growth stage of crop increase the crop productivity and also helps in reduction of leaf reddening as well as square and flower drops. In this context, the present investigation was planned and executed during 2014 and 2015 to evaluate response of irrigation regimes and nutrient management through drip in *Bt* cotton.

MATERIALS AND METHODS

The present investigation was conducted at Post Graduate Institute Research Farm, MPKV, Rahuri during 2014 and 2015. The soil of the experimental field was silty clay in texture having low in available nitrogen (175.61 kg / ha), medium in phosphorus (20.66 kg / ha) and high in potassium (448.11 kg / ha) with slightly alkaline in reaction (pH 8.10).The soil was deficit in zinc (0.26 mg / kg) and ferrous (1.07 mg / kg) and high in manganese (15.92 mg / kg) and copper (2.06 mg / kg). The moisture content at field capacity and permanent wilting point was 36.49 and 17.50 per cent, respectively. The present investigation was laid out in split plot design with three replications. The treatment

comprising four irrigation regimes (I_1-0.6 ETc, I_2-0.8 ETc, I_3-1.0 ETc and I_4-Surface irrigation (Control) and two planting techniques (P_1-90 x 90 cm and P_2-150 x 60 cm) as main plot treatments and three levels of fertigation (F_1 - 100% RDF+10t FYM , F_2 -100% RDF+10t FYM +$MgSO_4$ (20 kg / ha) and F_3-100% RDF+10t FYM + $MgSO_4$ (20 kg / ha) + $ZnSO_4$ (25 kg / ha) and foliar spray of 1% Fe SO_4 (at flowering and boll development) + Boron (0.5 %) (at flowering and boll development) as sub plot treatment. The surface irrigation with recommended dose of fertilizer was taken as control treatment. Fertigation was started at 10 days after sowing and scheduled at weekly interval in 12 equal splits upto boll development stage. In treatment F_2 and F_3, MgSO4@ 20 kg / ha and $ZnSO_4$ @ 25 kg/ha was applied at weekly interval in 9 equal splits upto flowering, where as in control treatment, it was applied at sowing as a basal dose. Farmyard manure was applied as a basal dose in all treatments. In drip method, irrigation was applied at every alternate day based on pan evaporation data, and in surface irrigation method irrigation was applied at 75 mm CPE with 7.5 cm of irrigation depth at each irrigation turn. The seed material of *Bt* cotton hybrid Ajeet 155BG II was procured from the local market. Chlorophyll meter (SPAD 502) is a compact, light weight meter which was used to determine the amount of chlorophyll present in plant leaves at 28 to 140 DAP during both the years.

The per cent incidence was recorded by using the following formula

$$\text{Leaf reddening incidence (\%)} = \frac{\text{No. of plants affected by leaf reddening}}{\text{Total No. of plants in the plot}} \times 100$$

The leaf reddening intensity was recorded by 0-9 grade system developed by Gade *et al.,* (2013).

RESULTS AND DISCUSSION

Data presented in Table 1 revealed that among the irrigation regimes, irrigation at 1.0 ETc found superior to registered significantly higher growth attributes *viz.,* plant height (136.83 cm), sympodial branches (19.40), leaves /plant (201.19) and leaf area/plant (793.65 dm^2) than rest of the irrigation regimes and surface irrigation on two years mean basis. The 1.0 ETc irrigation regime create favorable environment at root rhizosphere for increasing the soil moisture and nutrient absorption which leads to increase the cell elongation and multiplications. Optimum supply of moisture and nutrients also results in maximum photosynthetic rate and stomatal conductance which ultimately reflected on healthy and vigorous plant growth. (Dateshwa *et al.,* 2010)

The irrigation at 0.6 ETc registered minimum plant height (109.19 cm), sympodial branches (16.22), leaves/plant at 84 DAP (128.10) and leaf area/plant at 84 DAP (396.38 dm^2). The crop felt at moisture stress condition because inadequate availability of irrigation water at all the crop growth stages. The continuous stress condition at root rhizosphere decreases the enzymatic activities as well as all the physiological process, finally reflected adverse effect on growth attributes of the crop. These results are in confirmity with those reported by Bhalerao *et al.,* (2011) and Wiggins *et al.,* (2014).

Planting of *Bt* cotton at 90 x 90 cm exhibited significantly higher plant height (127.94 cm), sympodial branches / plant (18.83) and leaves / plant (172.59) than 150 x 60 cm planting technique (Table 1).This might be due

Table 1. Growth attributes of *Bt* cotton as influenced by different treatments

Treatments	Plant height (cm)			Sympodial branches/plant			Leaves/plant			Leaf area /plant (dm^2)		
	2014	2015	**Mean**	2014	2015	**Mean**	2014	2015	**Mean**	2014	2015	**Mean**
Irrigation regimes - I												
I_1 0.6 ETc	106.22	112.16	**109.19**	16.26	16.18	**16.22**	120.99	135.22	**128.10**	379.97	412.80	**396.38**
I_2 0.8 ETc	120.17	120.16	**120.16**	19.20	17.46	**18.33**	169.93	182.44	**176.18**	604.30	620.06	**612.18**
I_3 1.0 ETc	136.85	136.81	**136.83**	20.37	18.43	**19.4**	194.90	207.48	**201.19**	805.50	781.80	**793.65**
I_4 Surface irrigation (Control)	117.42	124.59	**121.00**	17.78	16.24	**17.01**	146.69	173.42	**160.05**	560.23	587.84	**574.03**
S.Em (±)	0.72	2.09		0.39	0.09		0.09	2.74		5.38	18.05	
CD (p=0.05)	2.49	7.24		1.21	0.32		0.30	9.49		18.61	62.47	
Planting techniques – P												
P_1 90 x 90 cm	126.56	129.33	**127.94**	19.63	18.03	**18.83**	163.63	181.56	**172.59**	576.47	569.36	**572.91**
P_2 150 x 60 cm	113.77	117.53	**115.65**	17.17	16.63	**16.9**	152.63	167.72	**160.17**	598.53	631.89	**615.21**
S.Em (±)	0.45	1.51		0.29	0.07		0.46	2.38		5.67	17.07	
CD (p=0.05)	1.47	4.91		0.93	0.23		1.48	7.76		18.49	55.66	
Fertigation (Nutrient management) - F												
F_1 RDF(100%)+ 10 t FYM	111.39	116.46	**113.92**	15.48	14.88	**15.18**	152.38	162.14	**157.26**	554.60	503.19	**528.89**
F_2 RDF (100%)+ 10 t FYM + 20 kg $MgSO_4$ / ha	120.08	122.28	**121.18**	18.88	17.28	**18.08**	158.37	173.18	**165.77**	585.50	589.45	**587.47**
F_3 RDF (100%) +10 t FYM + 20 kg $MgSO_4$ + 25 kg $ZnSO_4$ + foliar spray of Fe (1 %) and B (0.5 %)	129.02	131.54	**130.28**	20.85	19.82	**20.34**	163.64	188.61	**176.12**	622.41	709.23	**665.82**
S.Em (±)	0.51	1.85		0.14	0.10		0.15	1.36		8.31	14.01	
CD (p=0.05)	1.46	5.33		0.39	0.29		0.47	3.91		23.93	40.35	

Table 2. Yield contributing characters of *Bt* cotton as influenced by different treatments

Treatments	Picked bolls/ plant			Seed cotton weight/ bolls (g) at 1st Picking			Seed cotton weight/ plant(g)			Seed cotton yield/ha (q / ha)		
	2014	2015	**Mean**	2014	2015	**Mean**	2014	2015	**Mean**	2014	2015	**Mean**
Irrigation regimes - I												
I_1 0.6 ETc	44.27	43.38	**43.82**	4.44	4.34	**4.39**	190.44	163.18	**176.81**	22.48	23.15	**22.81**
I_2 0.8 ETc	53.65	58.80	**56.22**	4.67	4.96	**4.82**	240.18	260.78	**250.48**	29.79	31.78	**30.78**
I_3 1.0 ETc	60.86	68.50	**64.68**	5.10	5.34	**5.22**	289.62	316.05	**302.83**	31.90	34.58	**33.24**
I_4 Surface irrigation (Control)	50.58	49.63	**50.10**	4.62	4.61	**4.62**	222.85	203.88	**213.37**	24.74	26.12	**25.43**
S.Em (±)	0.50	1.30		0.06	0.03		3.23	5.81		0.83	0.91	**1.07**
CD (p=0.05)	1.74	4.50		0.19	0.09		11.19	20.12		2.89	3.15	**3.29**
Planting techniques – P												
P_1 90 x 90 cm	58.29	64.78	**61.53**	4.62	4.73	**4.68**	258.57	270.97	**264.77**	31.20	34.53	**32.86**
P_2 150 x 60 cm	46.39	45.38	**45.88**	4.80	4.89	**4.85**	212.98	200.97	**206.98**	23.26	23.29	**23.27**
S.Em (±)	0.62	0.44		0.05	0.02		4.00	1.96		0.57	0.62	**0.73**
CD (p=0.05)	2.01	1.44		0.16	0.07		13.06	6.38		1.86	2.01	**2.18**
Fertigation (Nutrient management) - F												
F_1 RDF (100%)+ 10 t FYM	45.31	52.27	**48.79**	4.58	4.76	**4.67**	197.69	220.60	**209.15**	23.18	26.67	**24.93**
F_2 RDF (100%)+ 10 t FYM + 20 kg $MgSO_4$ / ha	52.43	55.09	**53.76**	4.74	4.80	**4.77**	235.81	235.66	**235.74**	27.30	28.49	**27.90**
F_3 RDF (100%) +10 t FYM + 20 kg $MgSO_4$ + 25 kg $ZnSO_4$ + foliar spray of Fe (1 %) and B (0.5 %)	59.28	57.87	**58.58**	4.81	4.88	**4.85**	273.82	251.65	**262.74**	31.20	31.56	**31.34**
S.Em (±)	0.43	0.76		0.04	0.02		2.63	3.23		0.36	0.40	0.47
CD (p=0.05)	1.24	2.19		0.12	0.05		7.57	9.30		1.05	1.15	1.32

to higher plants/unit area efficiently utilized the added nutrients and natural resources (space, water, sunlight) for increasing the growth attributes of crop compared to 150 x 60 cm. In wider spacing *i.e.* 150 x 60 cm there was a competition for moisture and nutrients because of close spacing in inter plant (60 cm) resulted in inadequate availability of growth factors which adversely affect the growth attributes of crop. These results are in confirmity with Pendharkar *et al.,* (2010).

Fertigation of RDF (100 %) +10 t FYM upto 100 days + 20 kg $MgSO_4$/ ha and 25 kg $ZnSO_4$/ ha upto flowering at weekly interval + foliar spray of Fe (1.0 %) and B (0.5%) at flowering and boll development stages registered significantly higher growth attributes *viz.,* plant height (130.28 cm), branches / plant (20.34), leaves / plant (176.12) and leaf area / plant (665.82 dm^2). This might be due to application of fertilizers in 12 equal splits at weekly interval upto boll development stage increase the use efficiency of added nutrients which fulfilled the nutritional requirement of crop, moreover foliar nutrition of iron and boron at appropriate stages which provides balance nutrition. Which improve the physiological activities like photosynthetic rate, CO_2 concentration, stomatal conductance and transpiration rate which helps to accelerate the growth attributes in *Bt* cotton (Table 1).These results in agreement with those reported by Bhalerao *et al.,* (2011).

From Table 2 data revealed that picked bolls/ plant (64.68), seed cotton weight/bolls (5.22g) and seed cotton weight/ plant (302.84 g). These attributes were at higher magnitude under 1.0 ETc irrigation regime through drip. Because soil remained always at field capacity which enhanced all the growth attributes of the crop resulted in maximum absorbed photosynthetically active radiation accompanied with higher rate of photosynthesis reflected in efficient translocation of photosynthates towards reproductive parts helped in increase in yield attributing characters.

Maximum and higher seed cotton yield was recorded in 1.0 ETc irrigation regime (33.24q/ha) and *at par* with 0.8 ETc irrigation regime. The yield obtained under 1.0 ETc irrigation regime was 45.72 per cent higher over 0.6 ETc irrigation regime and 30.72 per cent over surface irrigation method. Under 1.0 ETc irrigation regime, the soil moisture in root zone of the crop remains always at field capacity throughout crop growth period, which increase the vegetative growth and interception of light which improve the light use efficiency resulted in increases photosynthetic rate and efficient translocation of photosynthates towards reproductive parts and finally leads to enhance the seed cotton yield of *Bt* cotton.

The deficit irrigation regime (0.8 ETc) found second best treatment to obtained higher seed cotton yield as it was recorded almost identical yield (30.78 q/ ha) compared to 1.0 ETc irrigation. This indicate that there was saving of 20 per cent of irrigation water without affecting the economic yield over 1.0 ETc irrigation regime. The surface irrigation method was at third in rank in respect of seed cotton yield (25.43 q/ ha). The deficit irrigation regime (0.6 ETc) registered significantly minimum seed cotton yield (22.81 q / ha) because of continuous moisture stress at root rhizosphere throughout the crop growth period reduces the nutrient availability, different enzymatic activities, photosynthesis rate and translocation of photosynthates due to stress resulted in decrease in seed cotton yield. These results also supported by Sampathkumar *et al.,* (2012).

The yield attributes in *Bt* cotton *viz.,* picked bolls/ plant and seed cotton weight/ plant

Table 3. Periodical chlorophyll content in *Bt* cotton as influenced by different treatments

Treatments	Chlorophyll content (%) (DAP) during 2014						Chlorophyll content (%) (DAP) during 2015					
	28	56	84	112	140	**Mean**	28	56	84	112	140	**Mean**
Irrigation regimes - I												
I_1 0.6 ETc	36.80	43.26	46.59	43.58	43.09	**42.66**	39.88	44.18	47.96	44.96	44.23	**44.24**
I_2 0.8 ETc	37.48	47.88	53.69	49.08	47.43	**47.11**	45.43	49.77	52.55	49.58	48.97	**49.26**
I_3 1.0 ETc	38.58	51.03	54.76	51.23	50.49	**49.22**	47.77	51.86	54.03	52.73	52.25	**51.73**
I_4 Surface irrigation (Control)	37.95	46.30	49.59	46.55	45.83	**45.24**	43.25	47.25	51.12	48.00	47.35	**47.39**
S.Em (±)	0.37	0.96	0.74	0.71	0.68		0.68	0.61	0.63	0.66	0.68	
CD (p=0.05)	NS	3.30	2.55	2.47	2.34		2.37	2.12	2.17	2.27	2.34	
Planting techniques – P												
P_1 90 x 90 cm	38.16	47.89	51.43	48.17	47.41	**46.61**	45.29	48.78	52.79	49.59	48.95	**49.08**
P_2 150 x 60 cm	37.24	46.35	49.88	46.55	46.01	**45.21**	43.87	47.20	51.04	48.05	47.46	**47.52**
S.Em (±)	0.31	0.53	0.55	0.55	0.56		0.53	0.57	0.58	0.53	0.52	
CD (p=0.05)	NS	NS	NS	NS	NS		N.S.	N.S.	N.S.	N.S.	N.S.	
Fertigation (Nutrient management) - F												
F_1 RDF (100%) +10 t FYM	37.26	43.90	47.58	44.14	43.54	**43.28**	41.21	44.81	48.70	45.60	45.00	**45.06**
F_2 RDF (100%) +10 t FYM + 20 kg $MgSO_4$ / ha	37.39	46.85	50.32	47.13	46.40	**45.62**	44.24	47.60	51.61	48.55	47.95	**47.99**
F_3 RDF (100%) +10 t FYM + 20 kg $MgSO_4$ + 25 kg $ZnSO_4$ + foliar spray of Fe (1 %) and B (0.5 %)	38.45	50.60	54.07	50.80	50.20	**48.82**	48.28	51.56	55.45	52.30	51.66	**51.85**
S.Em (±)	0.44	0.55	0.52	0.53	0.51		0.57	0.52	0.54	0.55	0.52	
CD (p=0.05)	NS	1.58	1.50	1.52	1.46		1.64	1.50	1.56	1.58	1.51	

were found maximum with 90 x 90 cm planting technique. This is because at square method of planting obtained even space to each plant which helps to increase the availability of moisture and nutrients as well as interception of maximum solar radiation resulted in increased photosynthetic rate and stomatal activities and that enhanced the translocation of photosynthates towards the reproductive organs. The results are in confirmity with Manjunatha *et al.,* (2010). Data pertaining to seed cotton weight / bolls of *Bt* cotton were found maximum at 150 x 60 cm planting technique (Table 2).

The yield obtained under 90 x 90 cm planting technique was significantly higher (32.86 q / ha) than 150 x 60 cm planting technique (23.27 q / ha). The yield obtained with 90 x 90 cm planting was 41.10 per cent higher than 150 x 60 cm planting technique. This might be because maximum plants/unit of area increase the nutrients use efficiency and higher values of growth and yield contributing characters *viz.,* plant height, sympodial branches, bolls and seed cotton weight / plant resulted in higher seed cotton. These results are in confirmity of the results reported by Devraj *et al.,* (2011).

The data pertaining to yield attributes presented in Table 2 revealed that the nutrient management through fertigation influenced the yield attributes of *Bt* cotton. Fertigation of RDF (100 %) +10 t FYM upto 100 days + 20 kg $MgSO_4$/ ha and 25 kg $ZnSO_4$/ ha upto flowering at weekly interval + foliar spray of Fe (1.0 %) and B (0.5%) at flowering and boll development stages registered significantly higher number of bolls/ plant and this might be because of frequent application of nutrients in 12 equal splits as per the requirement of crop increase the use efficiency of added nutrients thereby increase the physiological activities which translocate more photosynthates towards reproductive organs resulted in increase the yield attributes of *Bt* cotton. The reverse trend was noticed with fertigation of RDF (100%) +10 t FYM alone because of limiting micro nutrients. These results in agreement with those reported by Nalayini *et al.,* (2012) and Yadav *et al.,* (2014).

The enhancement of seed cotton yield (31.20 q / ha, 31.56 q / ha and 31.34 q / ha) was observed in fertigation of RDF (100%) +10 t FYM upto 100 days + 20 kg $MgSO_4$/ ha and 25 kg $ZnSO_4$/ ha upto flowering at weekly interval + foliar spray of Fe (1.0 %) and B (0.5%) at flowering and boll development stages might be due to crop fulfill the nutritional requirement through fertigation of N,P and K at weekly interval in 12 equal splits upto 100 days and fertigation of $MgSO_4$ and $ZnSO_4$ in 9 equal splits at weekly interval upto 70 DAP along with foliar nutrition of iron and boron plant remains physiologically more active resulted in luxurious growth of crop which increases the biomass accumulation. The experimentation site was deficient in iron, zinc and boron because of that seed cotton yield was reduced to the extent of 25.71 per cent in fertigation of RDF (100%) + 10t FYM alone and 12.34 per cent in fertigation of RDF (100%) +10 t FYM +20 kg $MgSO_4$/ ha over fertigation of 100 % RDF+10 t FYM upto 100 days + 20 kg $MgSO_4$/ ha and 25 kg $ZnSO_4$/ ha upto flowering at weekly interval + foliar spray of Fe (1.0 %) and B (0.5%) at flowering and boll development stages, respectively. These results are in confirmity of the results reported by Arivalagan *et al.,* (2014).

Among the irrigation regimes, irrigation at 1.0 ETc recorded significantly higher chlorophyll content (49.22 % and 51.73 %) than 0.6 ETc (42.66 % and 44.24 %) and surface irrigation (45.24 % and 47.39 %) on mean basis during both the years (Table 3). Irrigation at 1.0 ETc regime provides sufficient soil moisture in

Table 4. Periodical leaf reddening incidence in *Bt* cotton as influenced by different treatments

Treatments	Leaf reddening incidence (%) (DAP) during 2014						Leaf reddening incidence (%) (DAP) during 2015						Mean
	60	75	90	105	120	**Mean(A)**	60	75	90	105	120	**Mean(B)**	**(A+B)**
Irrigation regimes - I													
I_1 0.6 ETc	2.78	6.76	15.09	26.85	33.23	**16.94**	2.50	9.81	18.33	28.43	33.98	**18.61**	**17.78**
	(6.39)*	(13.59)	(21.92)	(30.84)	(35.04)		(5.67)*	(16.89)	(24.85)	(32.05)	(35.54)		
I_2 0.8 ETc	1.76	5.28	12.76	18.14	30.83	**13.75**	1.30	7.04	13.80	23.24	28.33	**14.74**	**14.25**
	(4.02)	(11.64)	(20.58)	(25.04)	(33.60)		(3.09)	(13.49)	(21.55)	(28.69)	(32.05)		
I_3 1.0 ETc	1.02	2.78	9.72	15.55	23.61	**10.54**	0.74	4.91	9.72	14.17	19.35	**9.78**	**10.16**
	(2.37)	(6.39)	(17.91)	(22.98)	(28.87)		(1.65)	(10.83)	(17.37)	(21.74)	(25.78)		
I_4 Surface irrigation (Control)	3.80	8.42	18.98	27.49	35.73	**18.88**	2.04	8.80	15.28	24.44	28.15	**15.74**	**17.31**
	(8.34)	(15.64)	(25.37)	(31.38)	(36.61)		(4.74)	(16.03)	(22.54)	(29.30)	(31.75)		
S.Em (±)	1.14	0.79	0.94	0.54	0.53		0.70	0.80	0.58	0.60	0.36		
CD (p=0.05)	3.95	2.72	3.25	1.87	1.82		2.42	2.77	2.02	2.08	1.26		
Planting techniques – P													
P_1 90 x 90 cm	2.31	6.48	15.49	22.91	31.70	**15.78**	1.62	8.33	15.51	22.92	26.16	**14.91**	**15.34**
	(4.66)	(12.00)	(22.38)	(28.19)	(34.12)		(3.26)	(15.20)	(22.69)	(28.14)	(30.39)		
P_2 150 x 60 cm	2.36	5.14	12.78	21.11	30.00	**14.28**	1.67	6.94	13.06	22.22	28.75	**14.53**	**14.40**
	(5.90)	(11.63)	(20.51)	(26.93)	(32.93)		(4.31)	(13.42)	(20.47)	(27.75)	(32.17)		
S.Em (±)	0.76	0.85	0.89	0.43	0.49		0.60	0.56	0.71	0.59	0.61		
CD (p=0.05)	N.S.	N.S.	NS	NS	N.S.		N.S.	N.S.	N.S.	N.S.	NS		
Fertigation (Nutrient management) - F													
F_1 RDF (100%) +10 t FYM	4.72	8.61	18.73	27.63	37.08	**19.35**	3.61	11.11	20.14	28.13	33.96	**19.40**	**19.37**
+ 20 kg $MgSO_4$ / ha	(10.51)	(16.44)	(25.31)	(31.35)	(37.40)		(8.34)	(18.79)	(26.28)	(31.75)	(35.49)		
F_2 RDF (100%)+10 t FYM	2.29	6.18	14.44	22.22	31.10	**15.20**	1.32	7.57	12.43	22.36	26.81	**14.10**	**14.67**
	(5.33)	(12.98)	(21.93)	(27.86)	(33.74)		(3.01)	(14.78)	(20.42)	(27.96)	(31.02)		
F_3 RDF (100%) +10 t FYM	0.00	2.64	9.23	16.18	24.37	**10.50**	0.00	4.24	10.28	17.22	21.60	**10.67**	**10.58**
+ 20 kg $MgSO_4$ + 25 kg $ZnSO_4$	(0.00)	(6.03)	(17.08)	(23.47)	(29.45)		(0.00)	(9.36)	(18.04)	(24.12)	(27.33)		
+ foliar spray of Fe (1 %)													
and B (0.5 %)													
S.Em (±)	1.15	1.36	0.84	0.84	0.55		1.08	1.05	0.45	0.54	0.67		
CD (p=0.05)	3.33	3.92	2.42	2.41	1.57		3.11	3.03	1.28	1.54	1.94		

Table 5. Periodical leaf reddening intensity in *Bt* cotton as influenced by different treatments

Treatments	Leaf reddening intensity (%) 2014 (DAP)						Leaf reddening intensity (%) 2015 (DAP)						Mean
	60	75	90	105	120	**Mean(A)**	60	75	90	105	120	**Mean(B)**	**(A+B)**
Irrigation regimes - I													
I_1 0.6 ETc	0.15	0.86	3.64	9.78	14.54	**5.79**	0.12	0.98	3.08	7.11	14.13	**5.08**	**5.44**
	(1.27)*	(4.38)	(10.21)	(17.44)	(21.82)		(1.06)*	(4.96)	(9.61)	(15.17)	(21.57)		
I_2 0.8 ETc	0.12	0.73	3.03	7.58	13.18	**4.93**	0.10	0.64	2.44	6.16	10.07	**3.88**	**4.41**
	(1.06)	(4.07)	(9.37)	(15.45)	(20.96)		(0.85)	(3.75)	(8.45)	(13.90)	(17.98)		
I_3 1.0 ETc	0.07	0.42	1.76	5.18	9.92	**3.47**	0.05	0.32	1.86	4.47	8.46	**3.03**	**3.25**
	(0.63)	(2.33)	(6.78)	(12.37)	(17.80)		(0.42)	(2.75)	(7.27)	(11.82)	(16.39)		
I_4 Surface irrigation	0.24	1.39	4.11	10.56	16.82	**6.62**	0.15	1.12	4.16	8.24	17.04	**6.14**	**6.38**
(Control)	(1.99)	(5.93)	(11.16)	(18.56)	(24.00)		(1.27)	(5.31)	(11.35)	(16.30)	(23.85)		
S.Em (±)	0.22	0.50	0.65	0.54	0.64		0.14	0.37	0.54	0.58	0.57		
CD (p=0.05)	0.77	1.73	2.24	1.88	2.22		0.47	1.29	1.85	2.02	1.97		
Planting techniques – P													
P_1 90 x 90 cm	0.12	0.67	2.69	7.65	12.17	**4.66**	0.09	0.66	2.66	5.82	11.77	**4.20**	**4.43**
	(1.06)	(3.59)	(8.57)	(15.12)	(19.95)		(0.74)	(3.96)	(8.75)	(13.45)	(19.28)		
P_2 150 x 60 cm	0.17	1.03	3.58	8.90	15.06	**5.75**	0.12	0.87	3.10	7.17	13.08	**4.87**	**5.31**
	(1.42)	(4.76)	(10.20)	(16.78)	(22.34)		(1.06)	(4.42)	(9.59)	(15.15)	(20.62)		
S.Em (±)	0.18	0.51	0.51	0.54	0.79		0.18	0.27	0.45	0.53	0.79		
CD (p=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	N.S.	N.S.		
Fertigation (Nutrient management) - F													
F_1 RDF (100%) +10 t FYM	0.29	1.43	4.75	12.03	17.42	**7.18**	0.22	1.19	3.94	8.21	17.25	**6.16**	**6.67**
	(2.44)	(6.27)	(12.20)	(19.89)	(24.30)		(1.90)	(5.68)	(11.16)	(16.26)	(24.14)		
F_2 RDF (100%) +	0.15	0.83	3.39	8.47	13.59	**5.29**	0.09	0.83	2.90	6.60	12.78	**4.64**	**4.96**
10 t FYM + 20 kg	(1.27)	(4.36)	(10.04)	(16.45)	(21.29)		(0.79)	(4.51)	(9.20)	(14.54)	(20.46)		
$MgSO_4$ / ha													
F_3 RDF (100%) +10 t	0.00	0.29	1.27	4.33	9.85	**3.15**	0.00	0.28	1.82	4.68	7.24	**2.80**	**2.98**
FYM + 20 kg $MgSO_4$ +	(0.00)	(1.90)	(5.90)	(11.52)	(17.85)		0.00	(2.38)	(7.14)	(12.09)	(15.25)		
25 kg $ZnSO_4$ + foliar													
spray of Fe (1 %)													
and B (0.5 %)													
S.Em (±)	0.33	0.53	0.58	0.72	0.85		0.30	0.42	0.48	0.50	0.60		
CD (p=0.05)	0.95	1.52	1.68	2.09	2.44		0.85	1.21	1.39	1.45	1.74		

the vicinity of root zone which increases solubility and mobility of nutrients and help to absorb more major and minor nutrients which enhance the chlorophyll synthesis in leaf tissues. Whereas, under deficit irrigation (0.6 ETc) because of inadequate soil moisture, nutrient uptake and translocation reduces the physiological activities like synthesis of chlorophyll in leaf tissues.

Planting of *Bt* cotton at 90 x 90 cm recorded maximum chlorophyll content at all growth stages during both the years of experimentation. These results are in agreement with those reported by Pendharkar *et al.,* (2010) and Jat *et al.,* (2014).

Fertigation of RDF(100%)+10 t FYM upto 100 days + 20 kg $MgSO_4$/ ha and 25 kg $ZnSO_4$/ ha upto flowering at weekly interval + foliar spray of Fe (1.0 %) and B (0.5%) at flowering and boll development stages registered significantly maximum chlorophyll content (48.82 and 51.85%) than rest of fertigation treatments during both the years of experimentation.

The leaf reddening incidence and leaf reddening intensity presented in Table 4 and 5 indicated that significantly minimum leaf reddening incidence (10.16 %) and leaf reddening intensity (3.25 %) on pooled mean basis with 1.0 ETc irrigation regime through drip because of sufficient and continuous supply of moisture throughout the growth period resulted in luxurious growth of leaves which intercept the maximum solar radiation resulted in increase chlorophyll synthesis and reducing anthocyanins pigment formation. Whereas, significantly maximum leaf reddening incidence (17.78 %) and leaf reddening intensity (5.44 %) was observed under deficit irrigation regime (0.6 ETc). These results are in line with Praharaj and Sankaranarayanan (2010) and Naidu and Mahalakshmi (2011).

The data revealed that fertigation of RDF (100%) +10 t FYM upto 100 days + 20 kg $MgSO_4$/ ha and 25 kg $ZnSO_4$/ ha upto flowering at weekly interval + foliar spray of Fe (1.0 %) and B (0.5%) at flowering and boll development stages registered significantly minimum leaf reddening incidence (10.58 %) and leaf reddening intensity (2.98 %) on pooled mean basis than rest of the fertigation treatments. The appearance of red leaf is associated with the adverse weather condition and deficiency of nitrogen and magnesium at flowering stage, continuous application of major nutrients at weekly interval upto 100 days in 12 equal splits along with application of micronutrients ($MgSO_4$ and $ZnSO_4$) at weekly interval in 9 equal splits upto 70 DAP and foliar nutrition of iron and boron fulfill the nutritional requirement which enhance the chlorophyll synthesis, accelerate photosynthesis and reduction in anthocynins pigmentation in leaves resulted in minimum leaf reddening (Table 4 and 5).These results are in accordance with those reported by Shivamurthy and Biradar (2014) and Santosh. *et al.,* (2014).

REFERENCES

Anonymous, 2015. *"Annual Report"* All India Co-ordinated Cotton Improvement Project Project Co-ordinated CICR, Coimbatore: pp A1-A4

Arivalagan, T., Janaki, P., Vadivel, A. and Raja Rajan, A. 2014. Role of Zinc and Boron nutrition on yield and quality of winter irrigated hybrid Cotton. *Trends Bio. Sci.* **7 :** 3072-78.

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

Dateshwa, Rajak, Manunatha, M.V., Rajkumar, G.R. and Ravishankar, G. 2010. Response of cotton to drip and surface irrigation in saline vertisiols. *J. Agril. Engg.* **47** : 15-17.

Devraj, Bhattoo, M.S., Duhan, B.S. and Jain, P.P. 2011. Effect of crop geometry and fertilizer levels on seed cotton yield nutrient uptake of *Bt* cotton under irrigated conditions *J. Cotton Res. Dev.* **25 :** 176-80.

Gade, R.M., Tanwar, R.K.P., Jeyakumar and V.Kanwar. 2013. Leaf reddening and its management in cotton. *Tech. Bull.* **30** : 16.

Jat, R. D., Nanwal, R.K. and Pawan Kumar 2014. Productivity,quality and available nutrient of *Bt* cotton under different spacing and nutrient levels. *J. Cotton Res. Dev.* **28** : 70-73.

Manjunatha, M. J., Halepyati, A. S., Koppalkar, B. G. and Pujari, B. T. 2010. Yield and yield components, uptake of nutrients, quality parameters and economics of *Bt* cotton (*Gossypium hirsutum* L.) genotypes as influenced by different plant densities. Karnataka *J. Agric. Sci.,* **23** : 423-25

Naidu,T. C. M. and Mahalakshmi, B. K. 2011.Reddening of *Bt* cotton under water logged conditions. *J. Cotton Res. Dev.***25** : 71-73.

Nalayini, P., Paul Raj, S. and Sankarranarayanan, K. 2012. Drip fertigation of major, secondary and micronutrients for enhancing the productivity of extra long staple *Bt* cotton. *J. Cotton Res. Dev.* **26** : 186-89.

Pagare, G. A.2011. Effect of leaf reddening on yield and yield attributes of cotton. *Bioinfolet* **8 :** 27-28.

Pendharkar, A.B., Solunke, S.S., Lambade, B.M., Nawale, S.S. and Dalvi, N.D. 2010. Response of *Bt* cotton hybrids to different plant spacing under rainfed condition. *J. Cotton Res. Dev.* **24** : 216-18.

Praharaj, C. S. and Sankaranarayanan, K.2010. Red leaf symptoms in cotton its causes and management options. *Indian Farming.*12-14

Sampathkumar, T., Pandian, B. J., Ranghaswamy, M. V. and Manicka Sundaram, P. 2012. Yield and water relations of cotton- maize cropping sequence under deficit irrigation using drip system. *Irrig. Drain.* **61** : 208–19.

Santosh,U.N., Rao, Satyanarayana., Dutturganvi, S. Halepyati, A. S.,Koppakar, B.G., Bheemanna, M. and Desai,B.K.2014. Effect of leaf reddening management practices on sucking pests populations and yield of *Bt.* cotton under irrigation. *BIOINFOLET* **11** : 105-08.

Shivamurthy, D. and Biradar,D.P.2014. Nutrient management approach for mitigating leaf reddening in *Bt* cotton. *Karnataka J. Agric. Sci.* **27 :** 260-66

Wiggins, Matthew S., Leib, Brian G., Mueller., Thomas C., and Christopher L. Main. 2014. Cotton growth, yield, and fiber quality response to irrigation and water deficit in Soil of Varying Depth to a Sand Layer. *J. Cotton Sci.* **18** : 145–52.

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 : December 16, 2016
Accepted for publication : April 11, 2017