The Andhra Agric. J 60(4):881-887, 2013

Yield and Fiber Quality Parameters of *Bt* Cotton (*Gossypium hirsutum* L.) Genotypes Under Water Stress and Non-Stress Conditions

K Jayalalitha, Y Ashoka Rani, S Ratna Kumari and P Prasuna Rani
Department of Plant Physiology, Agricultural College, Bapatla – 522 101, Andhra Pradesh

ABSTRACT

A two-year field study was carried out at the Agricultural College Farm, Bapatla in *kharif* 2009 and *kharif* 2010, with the aim of evaluating 12 *Bt* cotton hybrids for yield and fiber quality parameters under irrigated (non-stress) and rainfed (water stress) conditions.The results revealed that significant differences were observed between irrigated and rainfed treatments and also among *Bt* cotton hybrids for seed cotton yield and all fiber quality parameters. Cotton hybrids under rainfed condition recorded 39.32 and 25.62 per cent reduction in seed cotton yield compared to irrigated condition in both the years respectively. Tulasi 9 BG-II, Tulasi 9 BG-I and Bunny BG-I produced higher seed cotton yield under rainfed (water stress) conditions, while Tulasi 9 BG-II produced higher seed cotton yield under irrigated (non-stress) conditions also than the other hybrids in both the years. Fiber quality parameters were also negatively affected by rainfed (water stress) treatment. 2.5 per cent span length, bundle strength, uniformity ratio, fiber fineness and fiber elongation decreased under water stress (rainfed) compared to non-stress conditions.

Key words : Cotton, Fiber quality parameters, Irrigated condition,Water stress (rainfed), Yield.

Globally cotton is being cultivated on an area of 31.74 m ha in about 80 countries. It is a premier cash crop in India and plays an important role in the economy of the country. It sustains the country's textile industry which is the largest segment of organized industries of the country. India earns foreign exchange from export of cotton yarn, thread, fabrics, apparel and made ups. It has an enormous potential of sustaining employment generation and economic cum trade activity. Nearly one third of the country's export earning is from the textile sector, of which cotton accounts for 65% of the raw material.

Water stress is the most important factor limiting crop productivity and adversely affects fruit production, square and boll shedding, lint yield and fiber quality properties in cotton (El-Zik and Thaxton, 1989). Thus, screening cotton varieties for resistance to drought stress conditions and improving its tolerance to drought conditions will mitigate negative consequences of drought.

In Andhra Pradesh 80 per cent of cotton is being cultivated under rainfed conditions. Apart from irrigated areas, *Bt* cotton hybrids are being extensively grown under rainfed conditions. During the years of low rainfall, performance of *Bt* cotton hybrids was reported poor under rainfed compared to irrigated conditions. Though abundant research was carried out on the effects of moisture stress on non *Bt* cotton hybrids/varieties, information on performance of these BG-I and BG-II hybrids under moisture stress or rainfed is scanty. Hence, generating information on yield and fiber quality parameters of *Bt* cotton genotypes under rainfed (water stress) conditions is a research priority. Keeping this in view, the present investigation was taken up to study the yield and quality parameters of *Bt* cotton genotypes under water stress and non stress conditions.

MATERIAL AND METHODS

The experiment was carried out at Agricultural College Farm, Bapatla during two consecutive years of *kharif* 2009-10 and *kharif* 2010-11 strictly under rainfed conditions in a strip plot design with three replications. The treatments comprised two main plots i.e., no stress (i.e., irrigation was given as per irrigation schedule) and stress (i.e., rainfed condition) and twelve *Bt* cotton genotypes as subplots Viz., Bunny BG-I, Bunny BG-II, Kisan Early BG-I, Kisan Early BG-II, RCH2 BG-I, RCH2 BG-II, Rasi Early BG-I, Rasi Early BG-II, Tulasi 9 BG-I, Tulasi 9 BG-II, JK Durga BG-I and RCH 138 BG-I.

Seeds of these cotton genotypes were sown on 17-08-2009 and 23-08-2010. Each genotype was grown in 7 rows of 4.2 m length with a spacing of 105 cm between rows and 60 cm within the rows. Single super phosphate @ 60 Kg P_2O_5 ha^{-1} was applied as basal fertilizer. N and K were applied @ 120 and 60 Kg ha^{-1} in the form of urea and muriate if potash in three equal split doses at 30, 60 and 90 DAS. Prophylactic measures were taken up regularly to prevent the incidence of pests, diseases and weeds.

For rainfed treatments no irrigation was given at any stage of plant growth. For non-stress treatments irrigation was given as per schedule. During *kharif* 2009-10 crop received a total rainfall of 604.7 mm in 23 rainy days. The moisture sensitive growth period *i.e.* squaring to peak flowering suffered with continuous three dry spells (36 days). Similarly boll development to maturity stage exposed to continuous four dry spells (40 days) *i.e.* from 24-11-09 to harvest (4-1-2010). During *kharif* 2010-11, crop received a total rainfall of 986.5 mm in 33 rainy days and the crop experienced comparatively less moisture stress before peak flowering stage (75 DAS). However boll development phase exposed to one dry spell and boll maturity exposed to prolonged six dry spells.

Plots were harvested twice by hand and the obtained seed cotton from each plot was weighed and calculated for seed cotton yield. After the harvest, seed cotton samples were ginned and fiber quality parameters were determined by high volume instrument (HVI spectrum). The data were analysed statistically following Panse and Sukhathme (1978). Statistical significance was tested by 'F' value at 5 % level of probability.

RESULTS AND DISCUSSION

Significant differences were observed between main treatments, genotypes and their interaction with regards to seed cotton yield in both the years (Table 1). The mean seed cotton yield was significantly low under rainfed compared to irrigated condition. This might be due to water stress occurred in rainfed condition. Cotton genotypes under rainfed condition recorded 39.32 and 25.62 per cent reduction in mean seed cotton yield compared to irrigated condition in both the years respectively. According to Karademir *et al.,* (2011), seed cotton yield decreased by 48.04 per cent and fiber yield decreased by 49.41 per cent due to water stress. Water stress is the most important factor limiting crop productivity and adversely affects fruit production, square and boll shedding, lint yield and fiber quality properties in cotton (El-Zik and Thaxton, 1989). Cotton yield is dependent on boll number and their size. Inadequate resource availability such as soil water deficit during early development of reproductive organs greatly limits the growth capacity of individual bolls (Stewart, 1986).

Among the cotton genotypes tested, Tulasi 9 BG-II recorded the highest mean seed cotton yield (3320.21 and 3236.16 kg ha^{-1}) followed by Tulasi 9 BG-I (3113.20 and 3145.08 kg ha^{-1}) and Bunny BG-I (3095.63 and 3018.45 kg ha^{-1}), where as JK Durga BG-I recorded the lowest (1348.50 and 1333.06 kg ha^{-1}) followed by Rasi Early BG-II (1388.86 and 1406.65 kg ha^{-1}) and Rasi Early BG-I (1430.81 and 1441.84 kg ha^{-1}) in both the years respectively.

Among the interactions Tulasi 9 BG-II, Tulasi 9 BG-I and Bunny BG-I produced higher seed cotton yield under rainfed (stress) conditions, while Tulasi 9 BG-II produced the highest seed cotton yield under irrigated condition (non-stress) also. Karademir *et al*., (2011) reported that there was significant difference among cotton genotypes and water stress treatments for seed cotton yield and quality parameters, and stated that the genotypes SER 18 and Stoneville-468 produced higher yield under water stress conditions while Stoneville-468 produced higher yield under well irrigated conditions also.

Significant differences were observed between main treatments and genotypes with regards to all fiber quality parameters but the interaction between main treatments and genotypes was not significant in both the years of study. Cotton genotypes grown under rainfed condition recorded 14.63 and 12.19 per cent reduction (Table 1) in 2.5 per cent span length at maturity in both

Table 1. Effect of water stress on seed cotton yield (kg/ha) and 2.5% span length of *Bt* cotton genotypes.

	Seed cotton yield (kg/ha)						2.5% span length					
	2009-10			2010-11			2009-10			2010-11		
Genotype	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
Bunny BG-I	3770.6	2420.7	3095.6	3343.9	2693.0	3018.5	32.3	28.7	30.5	31.4	28.2	29.8
Bunny BG-II	3448.6	2404.1	2926.3	3211.8	2589.3	2900.5	32.8	28.1	30.4	31.6	28.4	30.0
Kisan Early BG - I	2246.9	1414.0	1830.5	2157.5	1589.8	1873.7	31.6	27.2	29.4	31.0	27.3	29.1
Kisan Early BG – II	2197.6	1359.6	1778.6	2053.5	1600.4	1827.0	30.7	27.1	28.9	30.4	27.7	29.1
RCH 2 BG- I	2195.7	1203.0	1699.3	2067.1	1375.8	1721.5	29.5	25.2	27.4	28.9	25.6	27.2
RCH 2 BG- II	2058.3	1195.8	1627.0	1858.1	1462.2	1660.2	29.4	25.2	27.3	29.3	24.9	27.1
Rasi Early BG-I	1858.0	1003.7	1430.8	1696.0	1187.7	1441.8	29.5	24.5	27.0	28.1	24.1	26.1
Rasi Early BG-II	1832.2	945.6	1388.9	1685.7	1127.6	1406.7	29.8	24.4	27.1	28.8	25.0	26.9
Tulasi 9 BG-I	3696.6	2529.8	3113.2	3499.2	2791.0	3145.1	33.1	28.6	30.8	32.1	28.6	30.4
Tulasi 9 BG-II	3992.4	2648.0	3320.2	3578.0	2894.3	3236.2	33.6	29.6	31.6	32.5	29.6	31.0
JK Durga BG-I	1812.0	885.0	1348.5	1588.5	1077.7	1333.1	29.7	23.7	26.7	28.2	23.0	25.6
RCH 138 BG-I	3213.5	1604.2	2408.9	3093.9	1799.4	2446.6	30.4	25.7	28.1	30.1	25.6	27.9
Mean	2693.5	1634.4	-	2486.1	1849.0	-	31.0	26.5	—	30.2	26.5	—

	2009-10			2010-11			2009-10			2010-11		
	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction
SEm±	31.1	128.7	73.9	33.6	115.4	66.4	0.3	0.4	0.2	0.1	1.3	0.54
CD at 0.05	189.2	377.6	228.8	204.3	338.4	201.8	1.7	1.1	NS	0.7	2.7	NS
CV (%)	8.6	14.6	6.8	9.3	13.0	8.5	5.7	3.1	4.9	2.4	11.0	3.7

Table 2. Effect of water stress on uniformity ratio and bundle strength (g/tex) of *Bt* cotton genotypes

	Uniformity ration						Bundle strength (g/tex)					
	2009-10			2010-11			2009-10			2010-11		
Genotype	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
Bunny BG-I	53.4	48.0	50.7	51.7	45.9	48.8	24.5	22.1	23.3	26.2	23.1	24.7
Bunny BG-II	52.7	47.5	50.1	51.2	45.4	48.3	24.3	21.7	23.0	26.1	22.7	24.4
Kisan Early BG - I	52.0	44.9	48.5	49.9	42.9	46.4	23.2	21.3	22.3	25.6	22.6	24.1
Kisan Early BG – II	51.4	44.9	48.1	49.3	43.1	46.2	22.8	20.8	21.8	25.0	22.5	23.8
RCH 2 BG- I	50.3	43.9	47.1	48.8	41.9	45.3	22.6	21.0	21.8	24.5	21.2	22.9
RCH 2 BG- II	49.6	42.9	46.3	47.5	41.0	44.2	22.7	20.8	21.7	24.7	21.2	23.0
Rasi Early BG-I	49.2	42.6	45.9	47.3	40.7	44.0	22.4	19.4	20.9	23.8	20.4	22.1
Rasi Early BG-II	48.3	42.1	45.2	46.2	40.3	43.2	22.0	18.8	20.4	23.4	19.8	21.6
Tulasi 9 BG-I	54.0	48.3	51.2	52.0	46.9	49.5	25.3	22.3	23.8	26.4	22.5	24.5
Tulasi 9 BG-II	54.7	49.1	51.9	52.8	47.1	50.0	26.0	23.0	24.5	27.2	24.0	25.6
JK Durga BG-I	46.8	41.8	44.3	44.9	40.9	42.9	21.5	17.9	19.7	23.0	18.9	20.9
RCH 138 BG-I	48.9	43.9	46.4	46.8	41.9	44.4	23.0	19.8	21.4	24.7	20.9	22.8
Mean	50.9	45.0	—	49.0	43.2	—	23.4	20.8	—-	25.1	21.7	—

	2009-10			2010-11			2009-10			2010-11		
	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction
SEm±	0.6	0.8	0.4	0.5	0.5	0.3	0.2	1.1	0.5	0.4	1.0	0.4
CD at 0.05	3.8	2.5	NS	3.1	1.4	NS	1.5	NS	NS	2.7	NS	NS
CV (%)	7.8	4.3	3.7	6.6	2.6	2.4	6.6	12.7	4.0	11.5	10.8	3.7

Table 3. Effect of water stress on fibre fineness (10^{-6} g.inch^{-1}) and elongation per cent of *Bt* cotton genotypes

Genotype	Fibre fineness (10^{-6} g.inch^{-1})						Elongation per cent					
	2009-10			2010-11			2009-10			2010-11		
	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
Bunny BG-I	4.5	4.1	4.3	4.2	3.7	3.9	6.0	5.7	5.8	5.8	5.5	5.7
Bunny BG-II	4.4	4.0	4.2	4.2	3.6	3.9	6.0	5.6	5.8	5.8	5.5	5.7
Kisan Early BG - I	4.3	3.9	4.1	4.1	3.5	3.8	5.8	5.4	5.6	5.5	5.2	5.4
Kisan Early BG – II	4.2	4.0	4.1	4.1	3.5	3.8	5.8	5.4	5.6	5.6	5.1	5.4
RCH 2 BG- I	4.0	3.4	3.7	4.0	3.0	3.5	5.7	5.0	5.4	5.4	5.0	5.2
RCH 2 BG- II	4.0	3.3	3.6	4.0	2.9	3.4	5.7	5.2	5.4	5.4	5.1	5.2
Rasi Early BG-I	3.9	3.1	3.5	3.9	2.8	3.3	5.5	4.9	5.2	5.5	4.6	5.0
Rasi Early BG-II	4.0	3.1	3.5	3.9	2.8	3.4	5.4	5.0	5.2	5.3	4.8	5.1
Tulasi 9 BG-I	4.7	4.1	4.4	4.3	3.7	4.0	6.2	5.7	6.0	6.0	5.4	5.7
Tulasi 9 BG-II	4.9	4.1	4.5	4.6	3.8	4.2	6.2	5.5	5.8	5.9	5.5	5.7
JK Durga BG-I	3.8	2.9	3.4	3.7	2.6	3.1	5.4	5.0	5.2	5.4	5.0	5.2
RCH 138 BG-I	4.3	3.9	4.1	4.2	3.5	3.9	5.8	5.5	5.7	5.5	5.2	5.3
Mean	4.2	3.7	—	4.1	3.3	—	5.8	5.3	—	5.6	5.2	—

	2009-10			2010-11			2009-10			2010-11		
	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction	Main plots	Genotypes	Interaction
SEm±	0.01	0.1	0.1	0.04	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
CD at 0.05	0.09	0.4	0.2	0.26	0.3	NS	0.4	0.4	NS	0.4	0.4	NS
CV (%)	2.17	7.9	4.1	7.05	7.8	5.4	6.3	6.5	3.6	6.6	6.6	4.5

the years respectively. Similar response in 2.5 per cent span length was observed in Bt cotton hybrids subjected to soil moisture deficit by Pettigrew (2004). Plants stressed at peak flowering will have fibre length more affected than those stressed later will have limited fibre thickening (Mc Donald, 2003).

Among the cotton genotypes, Tulasi 9 BG-II recorded maximum 2.5 per cent span length (31.59 and 31.02 mm) followed by Tulasi 9 BG-I (30.81 and 30.35 mm) and Bunny BG-I (30.52 and 29.80 mm), where as JK Durga BG-I recorded minimum 2.5 per cent span length (26.66 and 25.59 mm) followed by Rasi Early BG-I (27.00 and 26.09 mm) and Rasi Early BG-II (27.09 and 26.85 mm) in both the years respectively.

The mean uniformity ratio of cotton genotypes (11.62 and 11.99 percent) was lower under rainfed compared to irrigated conditions in both the years respectively (Table 2). Among the cotton genotypes, the uniformity ratio was significantly high in Tulasi 9 BG-II (51.90 and 49.97) and it was on a par with Tulasi 9 BG-I (51.17 and 49.45) and Bunny BG-I (50.70 and 48.83), where as low uniformity ratio was recorded by JK Durga BG-I (44.32 and 42.90) followed by Rasi Early BG-II(45.22 and 43.23) and Rasi Early BG-I(45.90 and 43.97) in both the years respectively.

Cotton genotypes grown under rainfed conditions recorded 11.17 and 13.60 per cent reduction in bundle strength compared to irrigated condition in both the years respectively. Karademir *et al*., (2011) reported that fiber strength, fiber length, fiber fineness and fiber elongation were significantly decreased under water stress compared to irrigation treatment in cotton.

There was no significant difference in bundle strength of cotton genotypes. Among the genotypes, Tulasi 9 BG-II recorded numerically higher bundle strength followed by Tulasi 9 BG-I and Bunny BG-I, where as JK Durga BG-I, Rasi Early BG-II and Rasi Early BG-I recorded lower values of bundle strength.

In cotton , moisture makes or breaks fiber quality. Water stress below -22 or -23 bars, particularly in late-bloom stages, will reduce late-developing bolls and fiber strength in mid canopy bolls. Cotton fiber length and strength and even seed weight are governed by moisture. Fiber length is most affected at 16 to 20 days after flowering. Fiber strength is most affected 25 to 30 days into boll development through three to four days prior to boll opening (Mc Williams, 2001).

The mean micronaire values of cotton genotypes were significantly low (13.991 and 19.80 percent respectively) under rainfed conditions compared to irrigated condition in both the years (Table 3). Karademir *et al*., (2011) reported that fiber strength, fiber fineness, fiber elongation and fiber length in cotton decreased under water stress compared to irrigation treatment. The increase in micronaire was observed by Pettigrew (2004) in *Bt* cotton genotypes under irrigation treatments. Severe or prolonged moisture stress reduced the micronaire in cotton (Ramey, 1986).

Among the cotton genotypes, Tulasi 9 BG-II recorded the highest micronaire values (4.49 and 4.18) and it was on a par with other cotton hybrids viz., Tulasi 9 BG-I (4. 38 and 4.03) and Bunny BG-I (4.28 and 3.94), where as JK Durga BG-I recorded the lowest micronaire values (3. 37 and 3.14) followed by Rasi Early BG-I (3.52 and 3.33) and Rasi Early BG-II (3.52 and 3.35) in both the years respectively.

The mean fiber elongation of cotton genotypes (Table 3) decreased under rainfed condition compared to irrigated condition (8.13 and 7.51 per cent in both the years respectively). reduction in fiber elongation in both the years respectively. Similar decrease in fiber elongation was observed in *Bt* cotton genotypes under water stress conditions by Pettigrew, 2004. Severe soil moisture stress during the period of fiber elongation reduced the fiber length (Hearn, 1994). Kater Hake (1990) reported that water stress and potassium deficiency decreased fiber length because the water pressure or expansive force in the elongating fiber is decreased.

Among the cotton genotypes, Tulasi 9 BG-I recorded the highest fiber elongation per cent (5.95 and 5.72 per cent) followed by Tulasi 9 BG-II (5.82 and 5.70 per cent) and Bunny BG-I (5.82 and 5.68 per cent), where as Rasi Early BG-I recorded the lowest elongation per cent (5. 17 and 5.03 per cent) followed by Rasi Early BG- II (5.20 and 5.05 per cent) and JK Durga BG-I (5.20 and 5.22 per cent) in both the years respectively at harvesting stage. Karademir *et al*., (2011) reported that fiber elongation, fiber length, fiber strength and fiber fineness in cotton decreased under water stress. The increase in fiber elongation with irrigation was observed in *Bt* cotton genotypes by Pettigrew (2004). In the present study, apart from seed cotton yield Tulasi 9 BG-II, Tulasi 9 BG-I and Bunny BG-I also maintained high fiber quality parameters under moisture stress conditions**.**

Conclusion:

From the above results, it can be concluded that the water stress (rainfed treatment) significantly affected cotton yield and fiber quality parameters. Seed cotton yield decreased by 39.32 and 25.62 % in 2009-10 and 2010-11 respectively under rainfed condition. Among the *Bt* cotton genotypes, Tulasi 9 BG-II recorded higher seed cotton yield followed by Tulasi 9 BG-I and Bunny BG-I, where as JK Durga

BG-I recorded lower seed cotton yield followed by Rasi Early BG-I and Rasi Early BG-II under rainfed (stress) condition. Water stress had negative consequences on fiber quality parameters viz., fiber length, fiber uniformity, fiber strength, fiber fineness and fiber elongation decreased.

LITERATURE CITED

El-Zik K M and Thaxton P M 1989 Genetic improvement for resistance to pests and stresses in cotton. In integrated pest management systems and cotton production. *John Willey and Sons*, New York, USA.

Hearn A B 1994 The principles of cotton-water relations and their application in management. In: Challenging the Future. *Proceedings of the World Cotton Conference*. I., Constable, G.A and Forrester, N.W. Brisbane, Australia, February 14-17th, Pp. 66-92.

Karademir C Karademir E Ekinci R and Berekatoglu K 2011 Yield and fiber quality properties of cotton (*Gossypium hirsutum* L.) under water stress and non-stress conditions. *African Journal of Biotechnology*, 10(59): 12575-12583.

Kater Hake 1990 Cotton physiology today. *Newsletter of the Cotton Physiology Education Program-National Cotton Council*, 2: Number 2.

Mc Donald Craig 2003 Germinating ideas. *The Australian Cotton Grower*, 67-69. (www.cottongrower.com.au).

Mc Williams D 2001 Drought strategies for cotton. *Co operative Extension Service Circular* 582. U.S. Department of Agriculture (USDA), Co operative State Research, Education and Extension Service.

Panse M and Sukhatme K 1978 Statistical methods for agricultural workers. *Indian Council of Agricultural Research Publication*, Pp 58-67.

Pettigrew W T 2004b Moisture deficit effects on cotton lint yield , yield components and boll distribution. *Agronomy Journal*, 96 : 377-383.

Ramey H H Jr 1986 Stress influences on fibre development. In Cotton Physiology, J.R. Mauney and J.Mc.D.Stewart (eds.). *The Cotton Foundation*, Memphis, TN. 315-59.

Stewart J M 1986 Integrated events in the flower and fruit, In J.R. Mauney and J.M. Stewart, eds. *Cotton Physiology*. Vol. (1). *The Cotton Foundation*, Memphis, Tenn

(Received on 23.06.2012 and revised on 17.12.2012)