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Productivity and quality of Bt cotton (*Gossypium hirsutum*) as influenced by planting geometry and nitrogen levels under irrigated and rainfed conditions

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ABSTRACT

A field experiment was carried out during two consecutive *kharif* seasons of 2009 and 2010 at research farm of Department of Agronomy, Marathwada Krishi Vidyapeeth, Parbhani to evaluate the effect of planting geometry and different nitrogen levels on productivity and quality of *Bt*-cotton (*Gossypium hirsutum* L.) under irrigated and rainfed conditions. The results reveals that, Bt cotton sown under irrigated condition (irrigation applied at three critical growth stages of cotton) significantly improved the seed cotton yield (33.71 q/ha) over rainfed condition (15.00 q/ ha). The growth attributes, yield contributing characters and ginning percentage were improved significantly in irrigation as compared to rainfed during both the seasons of experiment. The plant geometry of 120 cm × 45 cm recorded highest seed cotton yield (26.46 q/ha) and stood significantly superior over other planting geometries. It has 8.9 and 13.5% yield increment over 90 cm × 60 cm and 180 cm × 30 cm, respectively. All growth and yield contributing parameters were recorded significantly higher with 120 cm × 45 cm plant geometry as compared to other planting geometries, except plant height (cm), monopodials/plant, leaf area (dm^2) and dry matter accumulation (g/plant). Application of nitrogen @ 150 kg N/ha to Bt cotton increases 25.5% and 8.6% seed cotton yield over 100 kg N/ha and 125 kg N/ha, respectively. Quality parameters did not influence significantly by irrigation, planting geometries and nitrogen levels confirms that fibre properties governs by genetic makeup and least affected by management practices.

Key words: Bt cotton, Ginning percentage, Monopodials, Uniformity ratio and Yield attributes

Cotton plays a pivotal role in Indian's agrarian and industrial economy and also provides a livelihood to more than 60 million peoples by way of support in agriculture, processing and use of cotton in textiles. However, during the last decade, existing cotton cultivars turn down in seed cotton yields. Hence, the farmers have choosen alternate crops, i.e. Bt cotton (*Gossypium hirsutum* L.). Owing to fast growth and better performance of Bt cotton hybrids in terms of high seed cotton yield, it became popular among cotton growing farmers. Apart from improvement in yield, Bt cotton hybrids have also lowered the pest incidence (specially cotton bollworm) and reduced environmental pollution by limited use of insecticides. Other special feature of Bt cotton are shorter crop duration, compact crop canopy, synchronized boll bursting, capable of accommodating a higher plant population per unit area and to withstand high fertility conditions (Venugopal 2004). With the introduction of Bt cotton hybrids, there has been a significant change in the cotton cultivation scenario of India. Now, around 40 per cent area under cotton is occupied by Bt cotton hybrids. Compared to world average cotton lint yield (600 kg/ha) stagnates around 300-330 kg lint/ha in India. The lower cotton lint yield in India is associated with number of reasons, of them, its cultivation mainly under rainfed situation and pest infestation (Hosmath *et al.* 2011), cultivation under rainfed condition (Manjunatha *et al.* 2010) and also mainly due to non adoption of precise location specific production practices specially suitable planting geometry and optimum nitrogen doses. The yield and yield attributing parameters of cotton vary with the plant spacings (Tomar *et al*. 2000 and Butter and Singh 2007). Balanced fertilization is one of the major key factors for enhancing the cotton yields (Sharma *et al*. 2001). Among the different plant nutrients; nitrogen is widely considered one of the major essential nutrients for Bt cotton growth. Higher Bt cotton yields were realized under irrigation than rainfed ecosystem (Pawar and Pawar 2006).

Maximum yield potential of Bt cotton hybrids can only be realised with suitable agronomic practices like plant geometry and balanced nitrogen fertilization both under irrigated and rainfed conditions. Looking towards increase in area of Bt cotton as well as, farmer's individual experiments with different plant geometries, it was felt necessary to conduct present experiment to specifying suitable plant geometry and nitrogen levels. Therefore, the

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present study was undertaken to identify suitable plant geometry and nitrogen levels under both irrigated and rainfed conditions in vertisol of Marathwada region of Maharashtra.

MATERIALS AND METHODS

The experiment was conducted at experimental farm of Department of Agronomy, Marathwada Krishi Vidyapeeth, Parbhani during two consecutive *kharif* seasons of 2009 and 2010. The soils of the experimental field belongs to order vertisol having low available nitrogen (158 kg/ha), medium in available phosphorus (14.20 kg/ha), rich in available potash (445.60 kg/ha) and slightly alkaline in reaction (pH 8.3). The experiment was laid out in split plot design with three replications. The net plot size was 7.20 m × 3.60 m. There were eighteen treatment combinations comprising two irrigation treatments, viz. irrigation and rainfed in main plots, three crop geometries, viz. 90 cm × 60 cm, 120 cm × 45 cm and 180 cm × 30 cm in sub plots and three nitrogen levels, viz. 100 kg N/ha, 125 kg N/ha and 150 kg N/ha in sub-sub plots. The total rainfall received during 2009-10 and 2010-11 was 651.2 and 1235.1 mm distributed over 37 and 58 rainy days, respectively as against the normal precipitation of 885 mm in 57 rainy days. Seed of cotton hybrid, Bunny Bt (NCS-145 Bt) was sown by dibbling as per treatments on 6 and 15 June of 2009 and 2010 under rainfed condition and on 9 and 7 July 2009 and 2010 irrigated condition, respectively. The nitrogenous fertilizer was applied as per treatments. Half dose of nitrogen and full dose of phosphorus and potash were applied as basal application at the time of sowing. Top dressing of remaining half dose of nitrogen was given 30 and 60 DAS through urea under irrigated condition and for rainfed cotton half dose of nitrogen was given after 30 days after sowing through urea by ring method. Irrigation was applied at three critical growth stages, viz. square formation, flowering and boll development stage for irrigated cotton. For control of insect pest and disease recommended plant protection measures were taken up during both the years. Cotton was harvested in three pickings up to last week of January. The yield contributing characters were counted at each picking from five observational plants and calculated per plant. Seed cotton yield/net plot was weighed and converted into q/ha. For fibre quality studies, 100 g lint from first picking of net plot was collect and analyzed from Central Institute for Research on Cotton Technology (CIRCOT), Mumbai. The experimental data obtained on various selected variables were analyzed by the standard method of statistical analysis (Panse and Sukhatme 1967). For pooled analysis, the homogeneity of error variance was tested by applying Bartlett's and Chi-square test.

RESULTS AND DISCUSSION

Growth attributes

The maximum values of growth attributing characters like plant height (131.98 cm), number of monopodial branches (2.54/plant) and sympodial branches (33.27/plant), number of functional leaves (138.37/plant), leaf area (99.57 dm^2) and dry matter production (324.26 g/plant) were recorded under irrigated cotton as compared to rainfed cotton (Table 1) due to seasonal advantage and availability of sufficient moisture at important critical growth stages. This may be ascribed to availability of more moisture to the crop resulted in greater cell elongation and turgidity through more uptakes of nutrients and their assimilation in irrigated cotton. These observations are in close conformity with the findings of Singh and Nehra (2001). Among the different plant geometries, 120 cm × 45 cm plant geometry produced significantly higher sympodial branches (27.33/plant) and

Table 1 Growth attributing characters as influenced by irrigation, plant geometries and nitrogen levels (Pooled of two years)

Treatment	Plant height (cm)	Monopodias/ plant	Sympodias/ plant	Leaves /plant	Leaf area (dm^2)	Dry matter (g/plant)
Irrigation levels						
I_1 – Irrigation	131.98	2.54	33.27	138.37	99.57	324.26
I_2 – Rainfed	97.73	2.36	19.77	107.45	57.57	135.64
SEm ±	0.57	0.03	0.33	0.46	0.81	1.01
CD (P=0.05)	3.46	0.18	1.99	2.79	4.93	6.14
Planting geometries (cm)						
S_1 – 90 × 60	111.56	2.46	26.27	122.60	78.71	229.29
S_2 – 120 × 45	115.73	2.37	27.33	125.11	80.61	235.28
S_3 – 180 × 30	117.27	2.51	25.96	121.01	76.40	225.27
SEm ±	0.59	0.02	0.26	0.65	0.91	1.97
CD (P=0.05)	1.92	0.08	0.83	2.13	2.96	6.42
Nitrogen levels (kg/ha)						
N_1 – 100	112.24	2.39	25.86	120.01	76.65	222.55
N_2 – 125	114.98	2.45	26.53	122.92	78.30	228.99
N_3 – 150	117.33	2.52	27.18	125.79	80.77	238.30
SEm ±	0.88	0.02	0.28	1.09	0.90	2.54
CD (P=0.05)	2.57	0.06	0.81	3.17	2.62	7.40

Table 2 Yield attributes and seed cotton yield as influenced by irrigation, plant geometries and nitrogen levels (Pooled of two years)

Treatment	Seed cotton yield (g/plant)	No. of picked bolls/plant	Boll weight (g)	Seed cotton yield (q/ha)
Irrigation levels				
I_1 – Irrigation	183.85	55.91	3.57	33.71
I_2 – Rainfed	84.73	25.69	3.52	15.00
SEm ±	1.38	0.95	0.01	0.50
CD (P=0.05)	8.38	5.80	0.05	1.12
Planting geometries (cm)				
S_1 – 90 × 60	131.85	40.28	3.55	24.29
S_2 – 120 × 45	142.89	43.52	3.57	26.46
S_3 – 180 × 30	128.12	38.60	3.51	22.32
SEm ±	1.77	0.89	0.01	0.61
CD (P=0.05)	5.77	2.89	0.03	1.37
Nitrogen levels (kg/ha)				
N_1 – 100	125.37	38.03	3.52	21.43
N_2 – 125	133.85	40.76	3.54	24.75
N_3 – 150	143.64	43.62	3.57	26.89
SEm ±	2.96	0.92	0.01	0.66
CD (P=0.05)	8.64	2.69	0.04	1.38

number of functional leaves (125.11/plant) as compared to 90 cm × 60 cm and 180 cm × 30 cm plant geometries. With regards to leaf area and dry matter production plant geometry of 120 cm × 45 cm remained statistically at par with other plant geometries. However, higher plant height and number of monopodial branches/plant were with the plant geometry of 180 cm × 30 cm (Table 1). This might be due to competition for solar radiation in closer crop geometries.

Application of 150 kg N/ha recorded significantly higher values of all growth contributing characters as compared to lower levels of nitrogen, i.e. 100 and 125 kg N/ha during both the years. However, application of 150 and 125 kg N/ha were found equally effective in enhancing the plant height, number of sympodials/plant, number of functional leaves and leaf area/plant.

Yield attributes and yield

Numbers of picked bolls/plant (55.91), seed cotton yield/ plant (183.85 g), boll weight (3.57 g) and seed cotton yield (33.71 q/ha) were significantly higher under irrigated cotton as compared to rainfed cotton (Table 2). The variation in yield contributing characters of cotton might be due to better fruiting efficiency, efficient source-sink relationship, balanced vegetative growth, sufficient soil moisture availability, more number of picked bolls/plant and bigger boll size which ultimately reflected in higher seed cotton yield/plant and finally seed cotton yield under irrigated cotton.

The higher yield advantage in irrigated cotton over rainfed cotton was also observed by Shinde *et al*. (2009). With regards to planting geometries, the numbers of picked bolls/plant, seed cotton yield/ plant, boll weight and seed cotton yield (26.46 q/ha) were significantly higher in 120 cm × 45 cm planting geometry as compared to 90 cm × 60 cm (24.29 q/ha) and 180 cm × 30 cm (22.32 q/ha) plant geometries. This might be due to the better aeration, adequate interception of light and lesser competition for available nutrients and moisture, which might have resulted in synthesis of higher photosynthates and in turn helped to produce higher seed cotton yield under wider intra row spacing. These results are in conformity with the work done by Singh *et al.* (2007) and Bhalerao and Gaikwad (2010). Application of 150 kg N/ha was found significantly effective in enhancing the number of picked bolls, seed cotton yield/ plant, boll weight and seed cotton yield (26.89 q/ha) and establishing its superiority over application of 125 (24.75 q/ha) and 100 (21.43 q/ha) kg N/ha. The substantial increase in seed cotton yield due to application of 150 kg N/ha over lower levels of nitrogen was associated with the improvement in various growth attributes, viz. number of sympodial branches, leaf area, dry matter accumulation/ plant and its subsequent translocation towards sink which finally improved yield attributes, i.e. number of picked bolls/plant and seed cotton yield. Seed cotton yield was increased linearly with increasing levels of nitrogen from 100 to 150 kg/ha. Such advantage in seed cotton yield due to application of nitrogen was also observed by Srinivasulu *et al*. (2006) and Narayana *et al*. (2007).

Quality parameters

The fibre properties, viz. span length (mm), bundle strength (g/t), fibre fineness (µg/inch) and uniformity ratio (per cent) were not influenced significantly due to irrigation, plant geometries and nitrogen levels. This was due to the fact that quality parameters are primarily governed by genetic makeup of cotton cultivar. However, ginning percentage differed significantly due to irrigated and rainfed conditions. Significantly higher ginning percentage (35.19%) was recorded under irrigated condition as compared to rainfed condition (Table 3).

Interaction effect

The perusal of data presented in Table 4 indicates that treatment combination of irrigated condition with the planting geometry of 120 cm × 45 cm had produced significantly higher seed cotton yield over rest of the treatment combinations in pooled analysis results. The above results clearly indicated that planting geometry of 120 cm × 45 cm under irrigated condition resulting in balance plant growth with sufficient moisture availability in irrigation treatment

Treatment combination of irrigation with application of 150 kg N/ha recorded significantly highest seed cotton yield over rest of the treatment combinations in pooled data. This might be due to sufficient availability of moisture and nutrients during early growth stages of crop resulting into maximum numbers of leaves, leaf area, dry matter and number of bolls/plant which converted into maximum seed cotton yield.

On the basis of above results it may be concluded that the application of irrigation at three critical growth stages

Table 3 Quality parameters of cotton as influenced by irrigation, plant geometries and nitrogen levels (Pooled of two years)

Treatment	Ginning (%)	2.5% SL (mm)	Bundle strength (g/t)	Fibre fineness (µg/inch)	Uniformity ratio (%)
Irrigation levels					
I_1 – Irrigation	35.19	30.15	22.28	4.07	49.74
I_2 – Rainfed	34.68	29.09	21.28	3.96	49.21
SEm ±	0.07	0.34	0.33	0.03	0.17
CD (P=0.05)	0.41	NS	NS	NS	NS
Planting geometries (cm)					
S_1 – 90 × 60	34.86	29.38	21.38	3.97	49.47
S_2 – 120 × 45	34.92	29.75	22.17	4.02	49.48
S_3 – 180 × 30	35.03	29.73	21.79	4.05	49.48
SEm ±	0.15	0.32	0.28	0.04	0.09
CD (P=0.05)	NS	NS	NS	NS	NS
Nitrogen levels (kg/ha)					
N_1 – 100	34.77	29.24	22.15	3.98	49.37
N_2 – 125	34.86	29.78	21.65	4.01	49.53
N_3 – 150	35.18	29.85	21.55	4.05	49.52
SEm ±	0.16	0.30	0.32	0.04	0.08
CD (P=0.05)	NS	NS	NS	NS	NS

Table 4 Mean seed cotton yield (q/ha) as influenced by I × S and I × N interactions in pooled analysis

Irrigation	Planting geometries			Nitrogen levels		
	S_1	S_2	S_3	N_1	N_2	N_3
I_1	32.73	36.93	31.47	29.04	35.10	37.00
I_2	15.84	15.98	13.18	13.82	14.41	16.78
SEm ±		0.87			0.94	
CD (P=0.05)		1.94			1.96	

I_1, Irrigated; I_2, Rainfed; S_1, S_2 & S_3, Planting Geometries; N_1 N_2 N_3, Nitrogen levels

(square formation, flowering and boll development stage) in Bt cotton sown at 120 cm × 45 cm plant geometry and fertilized with nitrogen @ 150 kg/ha is most suitable for obtaining the maximum seed cotton yield under Marathwada region of Maharashtra.

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