Biological Forum – An International Journal 13(4): 1129-1133(2021)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of Newly Developed *Bt* Cotton (Cry 1Ac) Genotypes for Seed Cotton Yield under Ultra High Density Planting System in Cotton (*Gossypium hirsutum* L.)

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(Received 03 October 2021, Accepted 24 November, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Cotton being cash crop of rainfed growers have low productivity urging genotype wise change in plant density in particular. *Bt* cotton varieties having 'Cry1Ac' gene will reduce the cost of production of resource poor farmers. Hence, a field experiment was conducted to evaluate newly developed *Bt* cotton (BG I) genotypes of *Gossypium hirsutum* under Ultra High Density Planting System during *kharif* season 2019-20 at Cotton Research Station, Nanded. The experiment was laid out in FRBD design consisting of two factors of plant densities *viz.* 45 × 10 cm^2 (2.22 lakh plants/ha), 45 × 15 cm^2 (1.48 lakh plants/ha) and 45 × 22.5 cm^2 (0.98 lakh plants/ha) in main plots and seven genotypes of *Gossypium hirsutum* cotton in sub plots with three replications. Density 0.98 lakh/ha (spacing 45 × 22.5 cm) out yielded significantly over density 2.22 lakh/ha (spacing 45 × 10 cm) for seed cotton yield. Genotype NH 1901 *Bt* (1458 kg/ha) and NH 1904 *Bt* (1458 kg/ha) were found significant over checks, NH 615 (1286 kg/ha) and Suraj (1076 kg/ha) for seed cotton yield. Genotypes NH 1901 *Bt*, NH 1902 *Bt* and NH 1904 *Bt* performed better under spacing 45 × 22.5 cm (0.98 lakh/ha), genotypes NH 1903 *Bt*, NH 1905 *Bt* and NH 615 performed better under 45 × 15 cm (1.48 lakh/ha) whereas spacing 45 × 10 (2.22 lakh/ha) was found significant for Suraj.

Keywords: Ultra high density planting, seed cotton yield, *Bt* cotton genotype, spacing.

INTRODUCTION

Cotton, the king of fibres, occupies a pre-eminent position as a commercial crop in India. Cotton also known as 'white gold' as it is preferred by farmers as a cash crop. It is grown commercially in the temperate and tropical regions of more than 70 countries. India is perhaps the first country to make use of cotton. Cotton enjoys a pre-eminent status among all cash crops in the country. Specific areas of production include countries such as China, USA, India, Pakistan, Uzbekistan, Turkey, Australia, Greece, Brazil, Egypt *etc.*

Among the various factors responsible for low yield of cotton crop in the country, low plant population, use of low potential varieties and suitable agronomic requirement of genotypes are of primary importance. Various techniques like maintaining suitable plant density, use of optimum dose of fertilizers, growth regulators, etc. are being used to overcome these constraints in cotton production. Moreover, the availability of labour for clean picking is also a serious constraint. At present in India, entire cotton is picked manually which is labour intensive and is becoming expensive day by day. On the contrary, about 30 per cent of world cotton production in Australia, Israel and USA is machine picked.

Under these circumstances, compact cotton genotypes are ideally suited. They offer great scope for reducing not only row width, but also necessitates spacing between the plants in a row. Ultra narrow row (UNR) cotton production is considered as a potential strategy for reducing production costs by shortening the growing season. Compact genotypes provide the scope for increasing plant population per unit area by virtue of their shorter stature. It provides scope for double cropping and mechanical harvesting. These compact types have the added advantage of requiring few pickings only. Therefore, reduces the labour cost as well as seed cost as farmers can use the varietal seeds during next sowing for two to three seasons. Cultivation of *hirsutum* cotton varieties may be an option to high seed cost which further can reduce production cost with low fertilizer requirement as compared to *Bt* cotton hybrids.

High density planting system (HDPS) leads to rapid canopy closing leading to reduced soil water evaporation. Better genotypes which suitable for HDPS is an option to increase productivity in rainfed cotton with shallow to medium soils. Early maturity in shallow to medium soils doesn't support excessive vegetative growth leading to make high density planting system suitable for upland shallow to medium soils. Pandagale *et al.* (2020) reported suitability of non *Bt* genotypes NH 615, Suraj and NH 635 for high density planting system in Marathwada region of Maharashtra state under rainfed condition. However, those are not accepted by farmers for cultivation on large scale for the want of GM cotton genotypes having resistance against bollworms. In view of the above, present research work carried out with the objective to find out the effect of Ultra High Density Planting System (UHDPS) on seed cotton yield and yield contributing traits of *Bt* cotton genotypes (BG I) in upland cotton.

MATERIALS AND METHODS

The field experiment was conducted at Cotton Research Station, Dhanegaon Farm, Nanded (Maharashtra, India) during *kharif* 2019-20. The topography of experimental field was fairly uniform, leveled and with a good drainage. The experiment was laid out in factorial randomized block design with two factors - three plant densities *i.e.* 45 × 10 cm^2 (2.22 lakh /ha); 45 ×15 cm^2 (1.48 lakh /ha) and 45 × 22.5 cm^2 (0.98 lakh /ha) as first factor and seven genotypes of *Bt* cotton (BG I) *viz.*, NH 1901 *Bt*, NH 1902 *Bt*, NH 1903 *Bt*, 1904 *Bt*, NH 1905 *Bt*, NH 615 and Suraj in second factor. Out of the seven genotypes tested, five newly developed BG I genotypes were evaluated along with one *Bt* check (Suraj) and one non *Bt* check (NH 615) under ultra high density planting system. The recommended package of practices were followed during the course of the investigation. The observations on seed cotton yield and yield attributes *viz.*, seed cotton yield per hectare, lint yield per hectare, number of bolls per plant, boll weight (g), test weight (g) along with ginning outturn (%) were recorded. The collected data was statistically analyzed as per Gomez and Gomez (1984) method.

RESULTS AND DISCUISSION

Ancillary characters of *Bt* cotton genotypes under Ultra high density planting system

Plant height is an important morphological character in cotton, which provides seat for nodes and internodes from where monopodial and sympodial branches emerge (Eaton, 1955) and number of sympodia play important role in determining morphological framework relating to productivity. Number of monopodia and sympodia per plant were significantly reduced in narrow plant spacing *i.e.* highest density of 2.22 lakh /ha (45 × 10 cm) over density of 0.98 lakh /ha (45 × 22.5 cm). Ajayakumar *et al.*, (2017); Udikeri and Shashidhara (2017); Pandagale *et al.*, (2020) also observed reduction in number of monopodia / plant in closer row spacing (Table 1). However, plant height was not altered due to spacing.

Table 1: Seed cotton yield, yield attributes and ginning outturn as influenced by Ultra High Density Planting System.

Treatment	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Bolls /$meter^2$	Boll weight (g)	GOT (%)	Test weight (g)	Plant height (cm)	No. of monopodia / plant	No. of sympodia / plant
Factor I (Spacing / density)									
S1 - 45 × 22.5 cm (0.98 lakh /ha)	1393	530	60.70	3.33	37.94	7.66	89.99	0.51	12.39
S2 - 45 × 15 cm (1.48 Lakh /ha)	1331	499	63.44	3.21	37.49	7.79	86.76	0.27	10.74
S3 - 45 × 10 cm (2.22 lakh/ha)	1114	418	66.99	3.20	37.52	7.82	87.14	0.23	10.19
SE±	24.59	9.15	1.94	0.05	0.21	0.09	2.12	0.05	0.35
CD at 5%	68.06	25.32	N.S.	N.S.	N.S.	N.S.	N.S.	0.19	1.22
Factor II (Genotypes)									
V1 (NH 1901 *Bt*)	1458	558	66.75	3.05	38.23	7.34	92.47	0.27	11.85
V2 (NH 1902 *Bt*)	1311	498	62.92	3.00	38.02	7.46	94.85	0.07	11.58
V3 (NH 1903 *Bt*)	1275	476	67.16	2.98	37.32	7.61	88.15	0.10	11.73
V4 (NH 1904 *Bt*)	1458	551	73.47	3.12	37.83	7.52	90.73	0.28	10.80
V5 (NH 1905 *Bt*)	1091	400	56.67	3.43	36.71	7.91	89.33	0.62	10.98
V6 (NH 615) (Non *Bt* check)	1286	498	61.50	3.30	38.68	7.29	79.58	0.43	9.90
V7 (Suraj) (*Bt* check)	1076	396	57.45	3.84	36.78	9.15	80.63	0.60	10.88
SE±	37.57	13.98	2.98	0.07	0.32	0.13	1.89	0.07	0.43
CD at 5%	103.97	38.68	8.24	0.21	0.88	0.37	5.38	0.18	1.21
Interaction S x G									
SE±	65.07	24.21	5.16	0.13	0.54	0.23	5.61	0.15	0.91
CD at 5%	180.08	66.99	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV (%)	10.17	10.04	16.18	8.01	2.92	5.96	13.27	6.63	7.45
GM	1280	482	66.99	3.25	37.65	7.75	87.96	0.34	11.10

All the newly developed Bt cotton (BG I) genotypes (V1 to V5) were significantly taller than checks (NH 615 and Suraj). Among the genotypes under trial, BG I genotypes under evaluation were taller than checks. Highest plant height was recorded by the genotype NH 1902 *Bt* (94.85 cm) followed by NH 1901 *Bt* (92.47 cm) and NH 1904 *Bt* (90.73 cm). Highest number of sympodia per plant were recorded by NH 1901 *Bt* (11.85) followed by 1903 *Bt* (11.73) and NH 1902 *Bt* (11.58). Lower number of monopodia and higher sympodia per plant were found in genotypes NH 1901 *Bt*, NH 1902 *Bt* and NH 1903 *Bt* significantly over checks.

Table 2: Interaction effect of Spacing × Genotypes.

Treatment	Genotypes						
Spacing / density	V1 (NH 1901 *Bt*)	V2 (NH 1902 *Bt*)	V3 (NH 1903 *Bt*)	V4 (NH 1904 *Bt*)	V5 (NH 1905 *Bt*)	V6 (NH 615)	V7 (Suraj)
S1 -45 × 22.5 cm (0.98 lakh /ha)	**1753**	**1520**	1407	**1534**	1104	1360	1077
S2 -45 × 15 cm (1.48 Lakh /ha)	1510	1391	**1411**	1424	**1171**	**1378**	1035
S3 -45 × 10 cm (2.22 lakh/ha)	1112	1022	1009	1416	1000	1120	**1117**
SE±	65.07						
CD at 5%	180.08						

Effect of ultra high density planting system on seed cotton yield and yield attributes

Plant density (spacing): Highest boll weight was recorded under lower plant density of 0.98 lakh /ha (45 × 22.5 cm - 3.33 g) as compared to other plant densities (Table 2). The variation in boll weight in plant density was due to better aeration and adequate interception of light and lesser competition for nutrients in wider spacing, which resulted in synthesis of higher photosynthates and thereby helped to produce higher boll weight. Udikeri and Shashidhara (2017) also reported more boll weight and light transmission in wider spacing whereas, more light absorption in closer spacing. Number of bolls per square meter was highest in plant density of 2.22 lakh /ha (45 × 10 cm) however, were not statistically influenced due to densities. Spacing 45 × 22.5 cm (0.98 lakh/ha) out yielded significantly over spacing 45 × 10 cm (2.2 lakh/ha) for seed cotton yield and lint yield. Under wider geometry, greater availability of photosynthates to individual plant resulted in increased seed cotton yield as compared to closer plant geometry. This might be due to overall improvement in growth attributes and its positive effect on number of bolls / plant under wider plant geometry. The above result is in conformity with the findings of Solanke *et al*., (2001); Raut *et al*., (2005); Srinivasan (2006); Sisodia and Khamparia (2007); Giri *et al*., (2008); Reddy and Gopinath (2008); Bhalerao and Gaikwad (2010); Reddy and Kumar (2010); Pradeep Kumar *et al*., (2017). Increase in seed cotton yield in wider plant spacing of 22.5 cm might be due to more boll weight as compared closer spacing (Nehra *et al*., 2004). The boll weight is major yield components in *G. hirsutum* cotton under rainfed condition (Singh *et al*., 1983).

The ultra narrow row spacing might have allowed more interception of light which has translated in yield. Optimum plant density has parabolic relationship with yield which was a function of the genotype, soil type, climate and management (Venugopalan *et al*., 2013). Increase in yield in HDPS was also reported by Nalayini and Manickam (2018).

Genotypes: Highest boll weight was recorded by the genotype Suraj (3.84 g) followed by NH 1905 *Bt* (3.43 g). The genotype NH 1904 *Bt* recorded significantly highest number of bolls per square meter (73.47).

Among the genotypes evaluated, NH 1901 *Bt* (1458 kg/ha) and NH 1904 *Bt* (1458 kg/ha) were found significant for seed cotton yield over checks, NH 615 (1286 kg/ha) and Suraj (1076 kg/ha). Test weight of the genotypes ranged between 7.34 g to 7.91 g. Similar results were reported by Hallemani and Hellikeri (2002); Srinivasulu *et al*., (2007).

Interaction: Interaction effect of plant density (spacing) × genotypes was found significant for seed cotton yield (kg/ha). Genotypes NH 1901 *Bt*, NH 1902 *Bt* and NH 1904 *Bt* performed better under spacing 45 × 22.5 cm; genotypes NH 1903 *Bt*, NH 1905 *Bt* and NH 615 performed better under 45 × 15 cm whereas spacing 45 × 10 was found significant for Suraj. Taller plants associated with more sympodial branches in NH 1901 *Bt*, NH 1902 *Bt* and NH 1904 *Bt* genotypes might have responded to wider plant spacing (density 0.98 lakh/ha) whereas, low plant height associated with less number of sympodial branches in NH 1903 *Bt*, NH 1905 *Bt* and Suraj might have overcome competition effect under high density planting system. Pandagale *et al.* (2020) also reported lower number of sympodia in genotype Suraj and dwarf plants in NH 615 under rainfed condition.

Fibre quality parameters of *Bt* cotton genotypes under Ultra high density planting system

Fibre quality parameters of the genotypes in different plant densities were also studied and presented in Fig. 1 and 2. As quality parameters are genetic characters, plant density didn't influence the fibre quality parameters and ginning outturn statistically. Pandagale *et al.*, (2020) also reported non-significant differences due to plant density under HDPS. Among the BG I genotypes evaluated, NH 1905 *Bt* recorded longer UHML (26.7 mm) and bundle strength (24.8 g/tex). However, none of the BG I genotypes surpassed UHML over non-*Bt* check - Suraj. The fibre fineness of all the genotypes was in desirable range of textile industry. The NH 1905 *Bt* had highest elongation values.

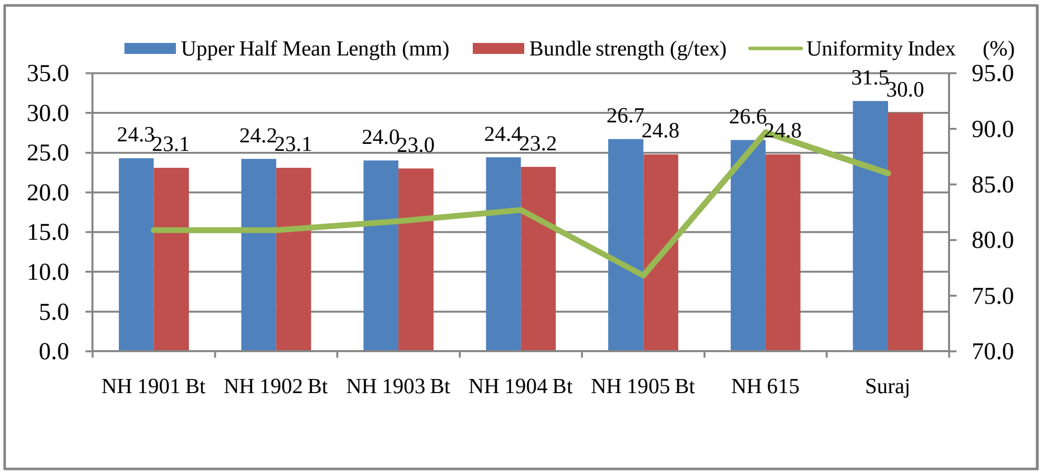

Fig. 1. Upper half mean length (mm), bundle strength (g /tex) and uniformity index (%) as influenced by genotypes.

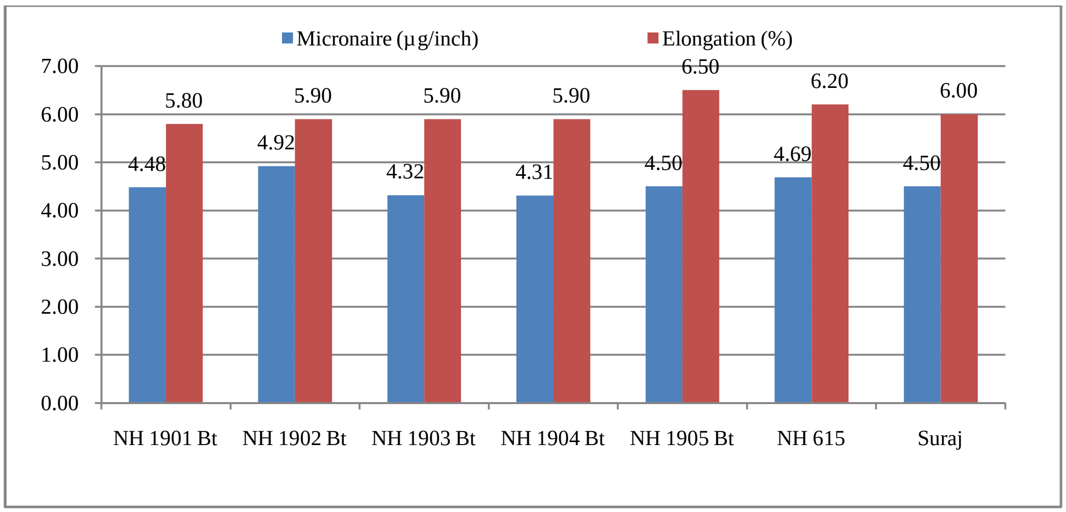

Fig. 2. Micronaire (µg/inch) and Elongation (%) as influenced by genotypes.

Ginning outturn ranged from 36.71 % (NH 1905 *Bt*) to 38.23 % (NH 1901 *Bt*). The genotype NH 1901 *Bt* recorded highest ginning outturn (38.23 %) followed by NH 1902 *Bt* (38.02 %). The upper half mean length (UHML) was ranged from 24.00 mm (NH 1902 *Bt*) to 26.7 mm (1905 *Bt*) amongst the genotypes under investigation. Micronaire values were ranged from 4.31 µg/inch (NH 1904 *Bt*) to 4.92 µg/inch (NH 1902 *Bt*). Highest bundle strength was recorded by the genotype NH 1905 *Bt* (24.8 g/tex) followed by NH 1904 *Bt* (23.2 g/tex). None of the genotype was found superior to check variety, Suraj for upper half mean length and bundle strength. Elongation percentage ranged from 5.8 % (NH 1901 *Bt*) to 6.5 % (NH 1905 *Bt*). All the genotypes under investigation exhibited good elongation percentage as well as uniformity index.

CONCLUSION

Bt cotton genotypes NH 1901 *Bt* and NH 1904 *Bt* were found superior for seed cotton yield and lint yield over *Bt* other genotypes and checks. The spacing 45 × 22.5 cm (0.98 lakh plants/ha) was suitable for *Bt* cotton genotype (BG I) NH 1901 *Bt*, NH 1902 *Bt* and NH 1904 *Bt*; spacing 45 × 15 cm (1.48 lakh plants / ha) was suitable for genotypes NH 1903 *Bt*, NH 1905 *Bt* and NH 615 whereas 45 × 10 (2.22 lakh plants / ha) was found significant for Suraj.

Conflict of Interest. None.

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How to cite this article: Baig, K. S.; Gaikwad, A. R.; Chinchane, V. N.; Pandagale, A. D. and Surewad, S. V. (2021). Evaluation of Newly Developed *Bt* Cotton (Cry 1Ac) Genotypes for Seed Cotton Yield Under Ultra High Density Planting System in Cotton (*Gossypium hirsutum* L.). *Biological Forum – An International Journal*, *13*(4): 1129-1133.