International Journal of Advanced Biochemistry Research 2025; SP-9(10): 313-318

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(10): 313-318
www.biochemjournal.com
Received: 18-08-2025
Accepted: 21-09-2025

PD Khadke
M.sc Scholar, Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharastra, India

AD Pandagale
Associate Professor, Cotton Research Station Nanded, Maharashtra, India

AR Hendre
M.sc Scholar, Department of Agronomy, College of Agriculture Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharastra India

VR Shelke
M.sc Scholar, Department of Agronomy, College of Agriculture Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharastra India

KV Sapkal
Department of Genetics and Plant Breeding, College of Agriculture Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharastra India

SS Bhale
M.sc Scholar, Department of Agronomy, College of Agriculture Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharastra India

Corresponding Author:
PD Khadke
M.sc Scholar, Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharastra, India

Effect of high density planting and growth retardant spray on growth and yield of *Bt* cotton variety (*Gossypium hirsutum* L.)

PD Khadke, AD Pandagale, AR Hendre, VR Shelke, KV Sapkal and SS Bhale

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i10Sd.5848

Abstract
A field experiment was conducted at Cotton Research Station, Nanded to evaluate the effect of high density planting and number of PGR sprays on crop growth and yield of *Bt* cotton straight variety during *Kharif* 2024 season under rainfed condition. The experiment was laid out in a split plot design comprising twelve treatment combinations and three replications. Four plant densities *i.e.*, D_1: 55,555 plants ha^{-1}, D_2: 83,333 plants ha^{-1}, D_3: 1,11,111 plant ha^{-1}, D_4: 1,66,666 plants ha^{-1} were evaluated in main plot with spacing of 60 cm x 30 cm, 60 cm x 20 cm, 60 cm x 15 cm and 60 cm x 10 cm, respectively. Three treatments of number of PGR spray, P_1: One spray of PGR, P_2: Two sprays of PGR, P_0: Control (water spray) were evaluated in sub plot. Plant growth retardant (PGR) Mepiquat chloride @ 25 g *a.i.* per ha was sprayed to retard plant growth. First spray was done at square formation and second at 15 days after first spray as per treatment schedule.

The results showed that increase in plant density has reduced number of monopodial branches $plant^{-1}$, dry matter accumulation $plant^{-1}$ and AGR whereas, plant height, number of sympodial branches $plant^{-1}$, CGR and leaf area index were increased with increase in plant density. The plant density of 1.66 lakh plants ha^{-1} (spacing 60 cm x 10 cm) resulted in higher seed cotton yield (2109 kg ha^{-1}), whereas lower plant density exhibited greater value of harvest index (27.34).

Application of two sprays of PGR has reduced plant height, dry matter accumulation $plant^{-1}$ significantly over control. Number of monopodia were increased in two sprays of PGR (P_2) over control. Whereas number of sympodia were reduced in number of PGR sprays. Absolute growth rate, Crop growth rate and leaf area index were greater in control. Two sprays of Mepiquat chloride @ 25 g *a.i.* ha^{-1}, first at square formation stage and followed by 15 days has increased number of bolls m^{-2}, seed cotton yield (2116 kg ha^{-1}), and harvest index of *Bt hirsutum* cotton variety over control.

Keywords: HDPS, plant density, spacing, *Bt* cotton variety, PGR spray, Mepiquat chloride

Introduction
Cotton (*Gossypium spp*.), is one the important commercial crop of India. It supports the livelihoods of numerous farming communities. It is also known as 'white gold' due to its role in national economy, earning foreign exchange as well as employment generation. It is a subtropical crop with an indeterminate growth habit. It continues both vegetative and reproductive growth simultaneously. Although vegetative growth supports reproductive development, excessive vegetative growth can have negative effects. Cotton yield are stagnated and crop is observed to uneconomical especially under rainfed condition. This necessitates new technologies which will be helpful for reducing cost of cultivation along with sustainable yield. High density planting of cotton is proved to be an alternative technology for improving yield and profitability along with input use efficiency (Nalayini *et al.*, 2018) [8]. The High Density Planting System (HDPS) is envisioned as an alternative cotton production strategy with the potential to enhance both productivity and profitability. It aims to reducing the risks linked to conventional cotton farming practices in India. There is a positive correlation between plant population and seed cotton yield, and hence selecting the most suitable spacing is crucial. Proper spacing allows plants to optimize growth conditions, which is closely related to both root development and shoot growth.

Cotton hybrids currently used by farmers often display varied growth behaviors, with many showing a tendency for vigorous vegetative growth. There is risk of overcrowding of plants under HDPS that warrants adoption of varieties having short stature with shorter length of fruiting branches.

Mepiquat chloride, a plant growth retardant is been found beneficial to control the vegetative growth of cotton with diverting photosynthates to reproductive parts. (Khetre *et al.* 2018, Gobi and Valyapuiri 2013 and Shekar *et al.* 2011) [6, 3]. This line of research supports the development of cost-effective cotton management practices by integrating key components such as the adoption of straight varieties under high density planting system and strategic use of growth retardants can improve yield with comparatively lower production cost. Considering these facts, it was felt essential to prioritize research and development in cotton cultivation practices. Emphasis was given on improving productivity of straight variety of *Bt* cotton through optimized planting density, and number of sprays of PGR (Mepiquat chloride) needed to manage canopy of straight variety.

Material and method

The field trial was carried out at Cotton Research Station, Nanded (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani), under rainfed condition during the *Kharif* seasons 2024 - 25. The field was fairly level and uniform. The soil was medium-black cotton soil belonging to *Vertisol* which was low in nitrogen, medium in phosphorus and having high potassium content. The total rainfall received during *Kharif*, 2024 season at the location was 871 mm (June - December, 2024) as against average rainfall of 901 mm. Nanded is situated at latitude, longitude and altitude of 19.13^0 N, 77.34^0 E and 274.63 m above mean sea level, respectively. The experiment consisted of twelve treatment combinations, comprising of four different plant densities in main plot and three treatments on number of PGR (Mepiquat chloride) sprays in subplot. These treatments were laid out in Split Plot Design with three replications. Four plant densities *i.e.*, D_1: 55,555 plants ha^{-1}, D_2: 83,333 plants ha^{-1}, D_3: 1,11,111 plant ha^{-1}, D_4: 1,66,666 plants ha^{-1} were evaluated with spacing 60 cm x 30 cm, 60 cm x 20 cm, 60 cm x 15 cm and 60 cm x 10 cm, respectively. Three PGR sprays treatments *i.e.*, P_1: One spray of PGR, P_2: Two sprays of PGR, P_0: Control (Water spray) was tested in sub plot. Newly released straight variety of *Bt* cotton, NH 1902 (BG I) was sown by dibbling method on 22^{nd} June 2024. Size of gross plot was 5.4 m x 5.4 m. Data were recorded on plant height, number of monopodial and sympodial branches $plant^{-1}$, dry-matter accumulation were recorded at periodical intervals. Data on seed cotton yield, lint yield and stalk yields (kg ha^{-1}) were collected and subjected for statistical analysis. Growth indices were calculated using standard formulae.

Absolute growth rate of plant height (cm day^{-1} $plant^{-1}$)

The absolute growth rate of plant height refers to the rate at which a growth variable such as plant height (H) increases over time (t). It is represented as the differential of height with respect to time. To calculate this, the formula proposed by Richards (1969) [17] was used, and the results were expressed in units of cm day^{-1} $plant^{-1}$.

$$AGR\ (cm\ day^{-1} plant^{-1}) = \frac{(H_2 - H_1)}{(t_2 - t_1)}$$

Where,

H_2 and H_1 refer to the plant height of plant in cm at t_2 and t_1 time, respectively.

Absolute growth rate of dry weight (g day^{-1} $plant^{-1}$)

The absolute growth rate of dry weight refers to the rate of increase in a growth variable, namely dry matter accumulation (W), over time (t). It is determined as the differential of 'W' with respect to time 't'. The absolute growth rate of total dry matter was calculated using the formula reported by Richards (1969) [17] and expressed in units of g day^{-1} $plant^{-1}$.

$$AGR\ (g\ day^{-1}\ plant^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W_2 and W_1 refer to the total dry matter of plant in g at t_2 and t_1 time, respectively.

Leaf area index (LAI): It is the ratio of the land area to the leaf area per plant, expressed in the same unit. The formula for calculating the LAI was given by Watson (1952) [22].

$$LAI = \frac{\text{Leaf area plant}^{-1}\ (dm^2)}{\text{Land area plant}^{-1}\ (dm^2)}$$

Crop growth rate (g g^{-1} day^{-1} $plant^{-1}$)

The crop growth rate is widely utilized to compare plant stands and communities of different species across various habitats, as well as to assess the production efficiency of a plant stand (Hunt, 1978) [5]. It is calculated in grams per day per square meter (g day^{-1} m^{-2}) using the following formula.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \text{number of plants } m^{-2}\ (g\ day^{-1}\ m^{-2})$$

Where,

W2 = dry weight of plant at time t_2 (g $plant^{-1}$)

W_1 = dry weight of plant at time t_1 (g $plant^{-1}$)

Results and discussion

I) Plant density

Plant growth characters: Plant height was increased numerically due to increased plant density however was not significant (Table 1). Plant density of 1,66,666 plants ha^{-1} (D_4 - 60 cm x 10 cm) recorded highest plant height at harvest 123.62 cm. Similar findings were reported by Singh *et al.* (2020) [19] and Thakur (2020) [21]. Gouthami *et al.* (2023) [4] reported increased plant height in late season under higher density due to inter plant completion whereas reduction in height under lower density due to suppression of apical dominance. The straight variety of *Bt* cotton under study might have adjusted in all the spacing under study resulting in non-significant differences due plant height in present study.

The number of monopodial branches $plant^{-1}$ was significantly increased with decrease in plant density (Table 1). Plant density of 55,555 plants ha^{-1} (60 cm x 30 cm) (D_1) recorded maximum number of monopodial branches than other density. Significant effect of plant density on number of monopodia $plant^{-1}$ is reported by Thakur (2020) [21]. Wider plant spacing allows achieving a greater number of branches due to more efficiency in the rate of photosynthesis is documented by Singh *et al.* (2020) [19]. This might be due to better aeration, adequate interception of light and suppression of apical dominance which resulted in to increasing branching in lower plant density. Number of sympodial branches plant^{-1} were not influenced statistically at harvest. Highest plant density (1,66,666 plants ha^{-1}) recorded higher numerical values of sympodial branches (22.87).

Dry matter accumulation plant^{-1} was increased with decrease in plant density (Table 1). At lower plant density of 55,555 plants ha^{-1} (spacing 60 cm x 30 cm), dry matter plant^{-1} at 150 DAS (88.12 g) was significantly higher as compared to 1,11,111 plants ha^{-1} (60 cm x 15 cm - 76.11 g) and 1,66,666 plants ha^{-1} (60 cm x 10 cm - 74.87 g). Higher dry matter in lower plant density might be likely due to enhanced canopy development under wider spacing. Kumar *et al.* (2017) [7] and Parihar *et al.* (2018) [10] opined that notable improvement in growth and yield-related traits can be attributed to increased availability of solar radiation in wider spacing, which promotes better synthesis and partitioning of assimilates to individual plants. This in turn facilitates efficient translocation of assimilates from source to sink, ultimately resulting in a significant increase in growth parameters such as plant weight and stem girth. Gauthami *et al.* (2023) [4] also reported higher dry matter per hectare in cotton with high density planting.

Growth indices

Sowing of *Bt* cotton variety NH 1902 at 60 cm x 10 cm (1,66,666 plants ha^{-1}) tended to give higher values of AGR for plant height between 31 - 60 days as compared to 60 cm x 15 cm (1,11,111 plants ha^{-1}), 60 cm x 20 cm (83,333 plants ha^{-1}) and 60 cm x 30 cm (55,555 plants ha^{-1}).

Lowest absolute growth rate (AGR) of dry matter values was observed during harvesting period (Table 2). Reduction in AGR of dry matter during the terminal period might be due to reduction in plant dry weight after first picking as well drying of green bolls and shedding of leaves due to senescence during the period. More accumulation of photosynthates with increase in leaf area and other plant growth characters might have resulted in higher values of AGR for dry matter in lower plant density of 55,555 plants ha^{-1} (60 cm x 30 cm) in comparison with higher densities at all the stages.

Plant density with spacing 60 cm x 10 cm (1,66,666 plants ha-^{1}) tended to give higher values of crop growth rate (CGR) for plant height between 61 - 90 days as compared to other wider spacing and was decreased thereafter (Table 3). Although AGR for dry weight was lowest in 60 cm x 10 cm spacing, CGR was highest due to increased plant density in unit area. Khetre *et al.* (2018) [6] and Parihar *et al.* (2018) [10] recorded highest values of CGR with closer spacing.

The mean leaf area index (LAI) was increasing up to 61 - 90 DAS stage and gradually decreased thereafter till harvest due to leaf senescence (Table 3). A clear variation in leaf area index was observed due to different plant density and it was noted that sowing of *hirsutum* cotton at 60 cm x 10 cm (1,66,666 plants ha^{-1}) recorded higher LAI over 60 cm x 15 cm (1,11,111 plants ha^{-1}) and 60 x 30 cm (55,555 plants ha^{-1}).

Bolls m^{-2} and seed cotton yield (kg ha^{-1}): The plant density of 1.11 lakh ha^{-1} and 1.66 lakh ha^{-1} recorded significantly greater number of bolls m^{-2} over lower densities (Table 3). Higher plant population per unit area has increased the number of bolls picked per square meter. Increase in seed cotton yield was observed with increased plant densities (Table 4). Higher plant density might have utilized maximum natural resources like solar radiation, moisture, nutrients and space more efficiently resulting in greater yield per unit area in closer spacing. Lower plant population is the major cause for its low seed cotton yield in wider spacing. Increase in seed cotton yield with higher plant population was also reported by Pawar *et al*. (2010) [12], Parihar *et al*. (2018) [10], Pandagale *et al*. (2020) [9] and Gouthami *et al*. (2023) [4].

Harvest index (kg ha^{-1}): The plant density influenced the values of harvest index (Table 4). Harvest index of lowest plant density 55,555 plants ha^{-1} (spacing 60 cm x 30 cm) was higher (27.34 per cent) over density 1,11,111 plants ha^{-1} (spacing 60 cm x 15 cm - 25.28 per cent) and 1,66,666 plants ha^{-1} (spacing 60 cm x 10 cm - 21.51%). These results are supported by the findings of Pendharkar *et al.* (2011). Final reproductive allocation as indicated by harvest index was usually reduced by increased plant density because of comparatively more vegetative growth and comparatively lower lint yield over biomass (Ali *et al.*, 2009) [1]. High plant density has produced the greater biological yield but lowest harvest index.

Ginning turn out (%): The plant density didn't influence the values of ginning out turn (Table 4). Plant density of 55,555 plants ha^{-1} (D_1 - 60 cm x 30 cm) recorded numerically highest ginning out turn (38.36 per cent) as compared to higher densities.

Effect of number of sprays of PGR (Mepiquat chloride)

Plant growth characters: The plant height was significantly reduced with Mepiquat chloride sprays (Table 1). Two sprays of Mepiquat chloride (P_2) had lowest plant height (117.98 cm) over one spray of Mepiquat chloride (P_1 - 123.27 cm) and control *i.e.* water spray (P_0 - 129.63 cm). Mepiquat chloride acts as antigibberelline and reduces internodal length which results in reduced plant height (Raut *et al.* (2019) [15]. Results in present study reducing plant height by Mepiquat chloride sprays are also supported with the findings of Borge and Dalvi (2019) [2].

Numbers of monopodial as well as sympodial branches plant^{-1} at harvest were not affected due to number of PGR sprays (Table 1). Patel *et al.* (2021) [11] also reported non-significant effect of mepiquat chloride sprays on number of vegetative branches.

Two sprays of Mepiquat chloride has found to reduce dry matter accumulation plant^{-1} significantly over control *i.e.* water spray (Table 1). Rosolem *et al*. (2013) [16] documented that reduction in dry matter accumulation due to Mepiquat chloride sprays could be due to disturbance in source - sink ratio under Mepiquat chloride application.

Growth indices: Application of PGR (Mepiquat chloride) spray resulted in reduction in AGR of plant height of cotton (Table 2). Either one or two foliar sprays of PGR (Mepiquat chloride) have reduced rate of increase in dry weight of plant as compared to control. Reduced elongation of internode distance has resulted to reduction in dry matter in two sprays of PGR. The AGR for dry matter accumulation values were greater in control. The AGR for plant height and dry weight were drastically reduced from 30-60 DAS stage as the foliar spray was done 45 DAS. As the second application of PGR was done at 60 DAS, the AGR value was lower in two sprays of PGR since 60-90 DAS stage.

The dry matter production was reduced in PGR sprays resulting to decrease in CGR values compared to control (Table 3). Control recorded higher crop growth rate from. It was followed by one spray of Mepiquat chloride and two sprays of Mepiquat chloride. Two sprays of PGR resulted to decreased CGR as compared to other treatments. Patel *et al.* (2021) [11] also observed decrease in CGR in two sprays f Mepiquat chloride as compared to control.

Leaf area index (LAI) was greater in control (Table 3). Thus, highest LAI was recorded in control. Increase in light interception and leaf area might be reason for increased leaf area index under control.

Bolls m^{-2} and seed cotton yield: Number of bolls m^{-2} was increased with two sprays of Mepiquat chloride which was significantly superior over control spray (Table 4). But it was found at par with one spray of Mepiquat chloride. Prasad and Prakash (2011) suggested that energy saved in reduced dry matter production $plant^{-1}$ has been diverted to increased reproductive parts leading to increased number of bolls m^{-2}.

Two sprays of Mepiquat chloride (P_2) recorded significantly higher seed cotton yield (2116 kg ha^{-1}) over water spray (1920 kg ha^{-1}). However, one spray (2032 kg ha^{-1}) and two sprays of Mepiquat chloride were found statistically equal. Khetre *et al.* (2018) [6] and Borge and Dalvi (2019) [2] opined that Mepiquat chloride also increased the source: sink ratio and sympodial branches. Spray of Mepiquat chloride favorably influence development and retention of fruiting bodies, thus increased seed cotton yield plant. Increase in seed cotton per hectare due to foliar application of Mepiquat chloride were also reported by Shekhar (2011) [18], Gobi and Valyapuri (2013), Borge and Dalvi (2019) [2], Thakur (2020) [21], Srikala *et al.* (2023) [20].

Harvest index: Two sprays of Mepiquat chloride had highest harvest index (27.46 per cent) over control (22.57 per cent) and was followed by one spray of Mepiquat chloride (25.34 per cent). Thus, increase in harvest index was noted with one and two sprays of Mepiquat chloride (Table 4).

GOT: Ginning out turn was not statistically altered due to sprays of Mepiquat chloride (Table 4). Two sprays of Mepiquat chloride had highest ginning out turn (38.20 per cent) over control (37.65 per cent) and one spray of Mepiquat chloride (38.01 per cent). Ginning percentage is governed by genetic makeup of the variety and hence was not differed by plant density. These finding are similar to Kumar *et al.* (2017) [7].

Conclusion

On the basis of field investigation, it can concluded that, the plant height and number of branches were not influenced due to plant densities however dry matter accumulation $plant^{-1}$ was reduced in higher plant densities. Plant density 1,11,111 plants ha^{-1} i.e. spacing 60 cm × 15 cm was found optimum to increase seed cotton yield of straight *Bt* variety *of hirsutum* cotton. Foliar application of Mepiquat chloride has reduced plant height and dry matter accumulation. Two sprays of Mepiquat chloride @ 25 g *a.i.* ha^{-1} at square formation and followed by 15 days has increased seed cotton yield and harvest index of *Bt* variety of *hirsutum* cotton.

Table 1: Mean plant growth characters as influenced by plant densities and number of Mepiquat chloride spray

Treatments	Plant height (cm)	No. of Monopodia $plant^{-1}$	No. of sympodia $plant^{-1}$	Dry matter $plant^{-1}$ (g) at 150 DAS
A. Plant density (D)				
D_1 : 55,555plants ha^{-1} (60 ×30 cm)	123.40	0.53	22.58	88.12
D_2 : 83,333 plants ha^{-1} (60 × 20 cm)	122.80	0.18	20.62	82.33
D_3 : 1,11,111 plants ha^{-1} (60 ×15 cm)	122.93	0.12	20.00	76.11
D_4 : 1,66,666 plants ha^{-1} (60 × 10 cm)	125.38	0.11	22.87	74.87
SE ±	2.54	0.01	0.75	1.69
CD at 5%	N.S.	0.04	N.S.	5.86
CV (%)	6.17	13.52	10.47	6.32
B. No. of PGR spray (P)				
P_1 : One spray of PGR	123.27	0.23	21.78	82.00
P_2 : Two sprays of PGR	117.98	0.26	20.04	76.08
P_0 : Control (water spray)	129.63	0.22	22.73	83.00
SE ±	1.98	0.03	0.75	1.89
CD at 5%	5.78	0.04	N.S.	5.67
CV (%)	5.40	39.62	12.13	8.15
Interaction D x P				
SE ±	3.85	0.05	1.51	3.78
CD at 5%	N.S.	N.S.	N.S.	N.S.
GM	123.62	0.23	21.51	80.36

Table 2: AGR for plant height and dry matter accumulation influenced by different treatments

Treatments	AGR for plant height (cm day^{-1} plant^{-1})					AGR for dry weight (g day^{-1} plant^{-1})				
	0 -30 DAS	31-60 DAS	61 90 DAS	91-120 DAS	121 - 150 DAS	0 -30 DAS	31-60 DAS	61 -90 DAS	91 120 DAS	121 - 150 DAS
A. Plant density (D)										
D_1 : 55,555plants ha^{-1} (60 cm ×30 cm)	0.721	1.108	1.502	0.519	0.496	0.689	0.311	1.411	0.555	0.393
D_2 : 83,333 plants ha^{-1} (60 cm × 20 cm)	0.703	1.094	1.495	0.497	0.471	0.685	0.293	1.081	0.470	0.300
D_3 : 1,11111 plants ha^{-1} (60 cm ×15 cm)	0.721	1.101	1.490	0.512	0.463	0.674	0.281	0.915	0.417	0.280
D_4 : 1,66666 plants ha^{-1} (60 cm × 10 cm)	0.730	1.133	1.523	0.544	0.517	0.595	0.226	0.878	0.367	0.250
B. No. of PGR spray (P)										
P_1 : One spray of PGR	0.724	1.121	1.508	0.521	0.479	0.665	0.275	1.128	0.451	0.314
P_2 : Two sprays of PGR	0.723	1.047	1.477	0.508	0.458	0.650	0.247	0.969	0.446	0.283
P_0 : Control (water spray)	0.709	1.158	1.522	0.526	0.522	0.668	0.311	1.150	0.459	0.320
GM	0.718	1.108	1.500	0.518	0.490	0.661	0.277	1.082	0.452	0.305

Table 3: CGR and LAI influenced by different treatments

Treatments	CGR (g day^{-1} m^{-2})					LAI				
	0 -30 DAS	31-60 DAS	61 90 DAS	91-120 DAS	121 -150 DAS	0 -30 DAS	31-60 DAS	61 -90 DAS	91 120 DAS	121 - 150 DAS
A. Plant density (D)										
D_1 : 55,555plants ha^{-1} (60 cm ×30 cm)	3.789	1.711	7.761	3.051	2.159	0.605	3.426	8.131	7.920	5.053
D_2 : 83,333 plants ha^{-1} (60 cm × 20 cm)	5.687	2.429	8.976	3.901	2.297	0.780	4.664	11.589	11.273	6.825
D_3 : 1,11111 plants ha^{-1} (60 cm ×15 cm)	7.489	3.127	10.164	4.629	3.111	0.950	5.620	14.595	14.173	8.243
D_4 : 1,66666 plants ha^{-1} (60 cm × 10 cm)	9.907	4.648	15.364	6.109	4.165	1.278	7.648	20.392	19.759	11.327
B. No. of PGR spray (P)										
P_1 : One spray of PGR	6.861	3.033	11.105	4.417	3.169	0.902	5.430	13.593	13.197	7.786
P_2 : Two sprays of PGR	6.495	2.848	9.077	4.386	2.575	0.905	5.011	12.569	12.173	6.947
P_0 : Control (water spray)	6.797	3.056	11.517	4.465	3.200	0.903	5.576	14.868	14.473	8.853
GM	6.718	2.979	10.566	4.422	2.953	0.903	5.339	13.677	13.280	7.862

Table 4: Bolls m^{-2}, seed cotton yield (kg ha^{-1}), harvest index (%) and ginning turn out (%) as influenced by different treatments

Treatments	No. of bolls m^{-2}	Seed cotton yield (kg ha^{-1})	Harvest index (%)	Ginning turn out (%)
A. Plant density (D)				
D_1 : 55,555plants ha^{-1} (60 ×30 cm)	82.89	1896	27.34	38.89
D_2 : 83,333 plants ha^{-1} (60 × 20 cm)	89.22	2031	26.31	38.36
D_3 : 1,11,111 plants ha^{-1} (60 ×15 cm)	114.56	2056	25.28	37.64
D_4 : 1,66,666 plants ha^{-1} (60 × 10 cm)	128.44	2109	21.57	36.93
SE ±	3.43	40.97	0.56	0.24
CD at 5%	11.88	141.8	1.92	N.S.
CV (%)	9.92	6.08	6.64	1.93
B. No. of PGR spray (P)				
P_1 : One spray of PGR	104.17	2033	25.34	38.01
P_2 : Two sprays of PGR	112.25	2116	27.46	38.20
P_0 : Control (water spray)	94.92	1921	22.57	37.65
SE ±	3.84	49.92	0.77	0.25
CD at 5%	11.51	149.67	2.31	N.S.
CV (%)	12.82	8.55	10.62	2.29
Interaction D x P				
SE ±	7.68	99.84	1.54	0.50
CD at 5%	N.S.	N.S.	N.S.	N.S.
GM	**103.77**	**2023**	**25.12**	**37.95**

Referances

1. Ali A, Tahir M, Ayub M, Ali I, Wasaya A, Khalid F. Studies on the effect of plant spacing on the yield of recently approved varieties of cotton. Pakistan Journal of Life and Social Sciences. 2009;7(1):25-30. Available from: https://www.pjlss.edu.pk/pdf_files/2009_1/25-30.pdf
2. Borge P, Dalvi D. Effect of plant growth regulators on yield and yield contributing characters of Bt cotton (*Gossypium hirsutum* L.) hybrid. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):132-134.
3. Gobi R, Vaiyapuri V. Effect of growth regulators on growth, yield and economics of irrigated cotton (*Gossypium hirsutum* L.). Plant Archives. 2013;13(1):101-103.
4. Gouthami R, Nagabhushanam U, Ramanjaneyulu AV, Madhavi B, Kamalakar J, Yakadri M. Influence of plant geometry and cultivars on growth, yield attributes and yield of HDPS cotton under rainfed shallow soils. International Journal of Environment and Climate Change. 2023;13(10):245-250.
5. Hunt R. Plant growth analysis. London: Edward Arnold Publishers; 1978.
6. Khetre OS, Shinde VS, Asewar BV, Mirza IAB. Response of growth and yield of Bt cotton to planting densities as influenced by growth regulators. International Journal of Chemical Studies. 2018;6(4):485-488.
7. Kumar P, Karle AS, Singh D, Verma L. Effect of high density planting system (HDPS) and varieties on yield, economics and quality of desi cotton. International Journal of Current Microbiology and Applied Sciences. 2017;6(3):233-238.
8. Nalayini P, Manickam S. Agronomic manipulation of high strength cotton genotype, CCH 4474 for yield maximization under irrigated agro ecosystem of Coimbatore. 2018;32:256-259.
9. Pandagale AD, Baig KS, Rathod SS, Namade TB. Plant density and genotype evaluation for high density planting system of cotton under rainfed condition. International Journal of Current Microbiology and Applied Sciences. 2020;9(9):1291-1298.
10. Parihar LB, Rathod TH, Paslawar AN, Kahate NS. Effect of high-density planting system (HDPS) and genotypes on growth parameters and yield contributing traits in upland cotton. International Journal of Current Microbiology and Applied Sciences. 2018;7(12):2291-2297.
11. Patel BR, Chaudhari PP, Chaudhari MM, Patel KS. Effect of mepiquat chloride on growth parameters and yield of Bt cotton under high-density planting system. Indian Journal. 2021;66(1):67-73. doi: 10.59797/ija.v66i1.2838
12. Pawar SU, Gite AN, Bhosle GP, Suryawanshi SB. Effect of fertilizer level and plant densities on yield, gross and net monetary returns of Bt cotton hybrid. J Cotton Res Dev. 2010;24(2):182-185.
13. Pendharkar AB, Solanke SS, Lambade BM, Dalvi ND, Navale SS. Response of Bt cotton hybrids to different plant spacing under rainfed condition. J Agric Res Tech. 2011;36(1):54-57.
14. Prasad M, Prakash R. Influence of mepiquat chloride on growth, yield and quality of cotton. Pesticide Research Journal. 2011;12(2):261-262.
15. Raut SD, Buttar GS, Gopalakrishnan N, Kardile SP. Effect of foliar application of mepiquat chloride on growth attributes of cotton (*Gossypium hirsutum* L.) under pot culture. Journal of Cotton Research and Development. 2019;33(1):136-139.
16. Rosolem CA, Oosterhuis DM, de Souza FS. Cotton response to mepiquat chloride and temperature. Scientia Agricola. 2011;70(2):82-87.
17. Richards FJ. The quantitative analysis of growth. In: Steward FC, editor. Plant physiology: A treatise. Vol. 5A. London: Academic Press; 1969. p. 3-76.
18. Shekhar K, Venkataramana M, Devi S. Effect of mepiquat chloride spray on Bt cotton yield with different spacing. Madras Agricultural Journal. 2011;100(4-6):429-431.
19. Singh P, George PJ, Ramtweke PW, Paul A. Performance of Bollgard I with different plant spacing and in the presence of refuge crops. Journal of Pharmacognosy and Phytochemistry. 2020;9(2):78-81.
20. Srikala K, Prabhakar Reddy T, Pavan Chandra Reddy K, GM MS. Effect of nitrogen levels and mepiquat chloride on yield and economics of HDPS cotton. International Journal of Environment and Climate Change. 2023;13(11). Available from: https://www.ijeccjournal.com
21. Thakur M. Square formation, boll retention, yield and quality parameters of Bt and non Bt cotton in relation to plant density and NPK levels. International Journal of Chemical Studies. 2020;8(1):2741-2753.
22. Watson DJ. The physiological basis of variation in yield. Advances in Agronomy. 1952;4:101-145. doi: 10.1016/S0065-2113(08)60307-7