International Journal of Research in Agronomy 2025; 8(11): 567-572

E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 567-572
Received: 11-09-2025
Accepted: 13-10-2025

PD Khadke
M.Sc. (Agri.) Student, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

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

IAB Mirza
Associate Professor, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

VR Shelke
M.Sc. (Agri.) Student, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

PS Magar
M.Sc. (Agri.) Student, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

JP Patil
M.Sc., (Agri.) Student, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
PD Khadke
M.Sc. (Agri.) Student, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Influence of plant density and Mepiquat chloride spray on yield and economics of *Bt* cotton variety (*Gossypium hirsutum* L.)

PD Khadke, AD Pandagale, IAB Mirza, VR Shelke, PS Magar and JP Patil

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i11h.4231

Abstract
A field experiment was conducted at Cotton Research Station, Nanded - Dhanegaon farm during *Kharif* 2024 season to evaluate the effect of plant density and number of PGR spray on crop growth and yield of *Bt* cotton straight variety. The experiment was laid out in a split plot design comprising twelve treatments 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 60 cm x 30 cm, 60 cm x 20 cm, 60 cm x 15 cm and 60 cm x 10 cm, respectively. Three treatments on number of PGR spray *i.e.*, P_1: one spray of PGR, P_2: two sprays of PGR, P_0: Control (Water spray) were tested in sub plot treatments. Plant growth retardant (PGR) Mepiquat chloride @ 25 g *a.i*, per ha per spray was applied to restrict plant growth. First spray of PGR was given at square formation and second at 15 days after first spray as per treatment schedule.
The results showed that lowest height to node ratio (HNR) was recorded in plant density of 1.11 lakh plants ha^{-1} (spacing 60 cm x 15 cm). The height: node ratio was increase in closer spacing. However, highest density of 1.66 lakh plants ha^{-1} (60 cm x 10 cm) resulted in seed cotton yield (2109 kg ha^{-1}), lint yield (813 kg ha^{-1}), GMR (Rs.144825 per ha), NMR (Rs. 63037 per ha) and B:C ratio (1.77) whereas lower plant density exhibited greater number of picked bolls $plant^{-1}$, yield $plant^{-1}$, boll weight (g).
HNR was reduced due to two sprays of PGR over control. Two sprays of Mepiquat chloride @ 25 g *a.i.* ha^{-1} at square formation and followed by 15 days has increased number of bolls $plant^{-1}$, boll weight, yield $plant^{-1}$, seed cotton yield (2116 kg ha^{-1}), lint yield (802 kg ha^{-1}), net monetary returns (Rs. 63,367/- ha^{-1}) and B:C ratio of *Bt hirsutum* cotton variety over control.

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

Introduction
Cotton (*Gossypium spp*.), often referred to as 'white gold' or the 'king of fibres,' is a vital crop for India's rural economy. In the world cotton scenario, China is the leading producer of cotton in the world. India is the second largest producer with 25.00 million bales which is around 21% of world production followed by Brazil and the USA (Anonymous, 2025) [1]. Maharashtra occupies first position with area 40.84 lakh ha and second in production with 101.40 lakh bales and productivity 422 kg lint per ha during 2024-25. It is observed that productivity has been stagnated since last decade and profitability is reducing due to increasing cost of production. High density planning system of cotton can improve India's productivity (Venugopalan, 2019) [24]. Plant population plays a crucial role in efficiently utilizing available resources. Agronomists have explored various row spacing, plant densities, and spatial arrangements in cotton cultivation for decades to achieve higher productivity. Yields tend to decrease with wider spacing due to reduced plants per unit area, while overly close spacing can lead to reduced yields due to excessive competition among plants. Therefore, optimizing plant population is essential to boost production.
Cotton grown by High Density Planting System (HDPS) can yield 20 - 30% more than conventional cotton (Khetre *et al*. 2018) [6]. It can lead to earlier crop canopy cover and higher yields. It can help make better use of resources like water, light, and fertilizers. (Wang *et al*. 2021) [25]. However, as most of cotton area is covered by *Bt* hybrids, increase in seed cost of

hybrid which are currently used, is the major difficulty in adoption of HDPS cotton. Adoption of *Bt* cotton straight varieties offers a solution to high seed cost of hybrids. *Bt* cotton varieties are comparable with *Bt* cotton hybrids for seed cotton yield. Varieties are more tolerant to pest and diseases than hybrids (Rajkumar *et al.,* 2016) [13]. Farmer can utilise cotton seed produced from their own field during last season for sowing of succeeding year. Fertilizer requirement of varieties is also low as compared to hybrids. The *Bt* cotton varieties which are being released for cultivation are having tolerance against sucking pest. Thus, it reduces seed and fertilizer cost and number of pesticide sprays resulting reduction in cost of production to a great extent. *Bt* cotton varieties now a days are having comparatively compact *i.e.* shorter horizontal as well as vertical growth than hybrids. Hence there is scope to increase plant population per unit area and control its growth using growth retardants which offers scope to increase productivity. The planting density per acre is doubled utilizing straight cotton varieties instead of hybrids in Brazilian model of cotton farming compared to traditional Indian practices. Additionally, varieties mature within 150 - 160 days, which minimizes the need for fertilizers, pesticides, and other inputs - ultimately cutting cultivation costs to nearly two - thirds compared to *Bt* cotton. However, proper density for straight varieties is to be optimized for growing under high density planting system. Simultaneously, controlling growth of plant under HDPS is very much necessary to overcome threats of square shedding and plant competition.

Excessive vegetative growth in cotton is conventionally controlled by topping or nipping manually, have been found to be costly, time consuming and labour demanding for adoption on large scale. Growth retardants have been used in recent years, both for controlling excessive plant growth and termination of late growth. When applied at the appropriate growth stage and in the right concentration, growth retardants can effectively redistribute dry matter within the plant, leading to increased yields of economic significance. Two sprays of growth retardant, Mepiquat Chloride are found beneficial to control growth and enhance yield under HDPS (Venugopalan, 2019) [24]. However, as straight varieties are having short stature and also have shorter branches, hence the number of Mepiquat chloride sprays can be reduced. Hence an experiment was conducted with objective to evaluate the effect of plant density and number of PGR spray on crop growth and yield of *Bt* cotton straight variety under HDPS.

Materials and Methods

The field trial was carried out at Cotton Research Station, Nanded (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India) under rainfed condition during the *Kharif* season of 2024-2025. The soil was a medium-black cotton soil belonging to *Vertisol* which was low nitrogen, medium in phosphorus and high potassium content. The total rainfall received during the season at Cotton Research Station, Nanded 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 362 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 Mepiquat chloride sprays in subplot. These twelve treatment combinations (4 × 3) 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 in main plot 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 treatments on number of PGR sprays *i.e*., P_1: One spray of PGR, P_2: Two sprays of PGR, P_0: Control (Water spray) were tested in sub plot treatments. Newly released straight variety of *Bt* cotton NH 1902 (BG I) was sown by dibbling method on 22nd June 2024. Data on plant height and number of nodes was recorded and height to node ratio was calculated. Yield contributing characters, seed cotton yield, lint yield (kg/ha) and economics were collected and subjected for statistical analysis.

Results and Discussion

I) Plant density

HNR: The height to node ratio (HNR) was influenced due to plant densities (Fig. 1). Plant density of 1,66,666 plants ha^{-1} (D_4 - 60 cm x 10 cm) recorded maximum height to node ratio over plant density of 1,11,111 plants ha^{-1} (60 cm x 15 cm) and followed by 55,555 plants ha^{-1} (D_1 - 60 cm x 30 cm) and 83,333 plants ha^{-1} (D_2 - 60 cm x 20 cm). Increase in plant height due to interplant competition in closer spacing with greater plant density without much increase in number of nodes has resulted in increased HNR. It is desirable to have lower HNR under HDPS. These results are in conformity with Siebert and Steward (2006) [15].

Leaf area (dm^2): Leaf area is one of the important factors for photosynthesis potential and harvesting of solar radiation (Table 1). The plant density of (D_1) 55,555 plants ha^{-1} (60 cm x 30 cm) produced significantly higher leaf area than 1,11,111 plants ha^{-1} (60 cm x 15 cm) and 1,66,666 plants ha^{-1} (60 cm x 10 cm) at all the crop growth stages. This was might to be due to reduction in number of functional leaves with comparatively smaller leaf size in higher density. The significant improvement in leaf area plant^{-1} observed in lower plant density (D_1) which might be due to a greater number of functional leaves per plant and increase in size of leaves as influenced by wider spacing *i.e* lower density. Kumar *et al*. (2017) [8] recorded highest leaf area under lower planting density due to increase in number of functional leaves per unit area. This finding similar with Parihar *et al.* (2018) [10].

Yield contributing characters

Plant density of 55,555 plants ha^{-1} (60 cm x 30 cm) recorded significantly a greater number of picked bolls plant^{-1} (14.65). Reduced densities typically produce a greater number of bolls on the first and second position as well as secondary branches arising from monopodial branches which may be due to less interplant competition between cotton plants (Table 1). A lower plant density of 55,555 plants ha^{-1} (D_1 - 60 cm x 30 cm) produced significantly greater boll weight over the higher plant density of 1,66,666 plants ha^{-1} (D_4 - 60 cm x 10 cm). Plant density of 83,333 plants ha^{-1} (D_2 - 60 cm x 20 cm) at par with (D_1) for boll weight. Reduced availability of photosynthates due to reduced leaf area, more competition for interception of solar radiation and nutrition under higher density had resulted to smaller boll size in closer spacing with higher plant density. Singh *et al*. (2020) [17] also published reduction in boll weight with increase in density. Similarly, reduction in yield attributing characters plant^{-1} *viz.*, yield per plant, number of bolls per plant and boll weight due to higher plant density were also observed by Parihar *et al.* (2018) [10] and Pandagale *et al.* (2020) [9].

Seed cotton yield (kg ha^{-1}): Greater plant population in 60 cm x 10 cm and 60 cm x 15 cm has compensated the lower yield plant^{-1} (Table 1). Thus, increase in seed cotton yield in closer spacing was evident due to higher plant population per unit area. Higher plant density utilized all 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. These results are conformity with Pawar *et al.* (2010) [12].

Lint yield (kg ha^{-1}): Higher plant density of (D_4) 1,66,666 plants ha^{-1} (60 cm x 10 cm) recorded significantly higher lint yield (813 kg ha^{-1}) than lower plant density of 55,555 plants ha^{-1} (60 cm x 30 cm) and 83,333 plants ha^{-1} (60 cm x 20 cm). The highest density (D_4) was comparable with 1,11,111 plants ha^{-1} (D_3 - 60 cm x 15 cm). Similar results were reported by Pawar *et al.* (2010) [12]. Increase in seed cotton yield in higher density without affecting ginning out turn has resulted to increased lint yield in closer spacing.

Stalk yield (kg ha^{-1}): The spacing 60 cm × 10 cm (density 1,66,666 plants ha^{-1}) had remarkable effect on cotton stalk yield (Table 1). It might be due to increased number of plants per unit area in higher plant density. The treatment spacing 60 cm x 10 cm (D_4- 7715 kg ha^{-1}) recorded highest cotton stalk yield over lower spacing. These results corroborate the view of Chavan *et al.* (2011) [4] and Solanki *et al*. (2020) [19].

Economics: Spacing 60 cm ×10 cm (D_4 - ₹ 81,788 ha^{-1}) recorded significantly greater cost of cultivation over spacing 60 cm × 15 cm, 60 cm × 20 cm and 60 cm × 30 cm (Table 2). It was due to increase treatment cost in highest plant density of 1,66,666 plants ha^{-1} which was majorly due to increased charges of seed for dense population. However, highest density *i.e.* spacing 60 cm × 10 cm (D_4 - ₹ 144825 ha^{-1}) recorded significantly higher gross monetary returns over spacing 60 cm × 30 cm (D_1). It was due to higher seed cotton yield under higher plant density than lower density. These results are in agreement with Kumar *et al.* (2017) [8] and Patel *et al.* (2021) [11]. Increasing cost of treatments in higher densities didn't influence the net monetary returns (NMR). The spacing 60 cm ×10 cm (D_4) recorded highest net monetary returns (₹ 63037 ha^{-1}) and was significantly superior over wider spacing (D_1 - 60 cm x 30 cm). Increase in profitability in higher density was also reported by many researchers (Kumar *et al.*, 2017, Raut *et al.*, 2019, Pandagale *et al*., 2020 and Patel *et al.*, 2021) [8, 14, 9, 11]. Spacing 60 cm × 10 cm (D_4) recorded highest Benefit: Cost (B: C) ratio (1.77) over other spacing. Thus, it suggests that higher plant density is more remunerative than lower densities. These results are in conformity with Kumar *et al.* (2017) [8] and Patel *et al.* (2021) [11].

Mepiquat chloride

HNR: The height to node ratio (HNR) was reduced in Mepiquat chloride sprayed treatments (Fig. 2). Venugopalan *et al*. (2016) [23] commented that HNR should be low when cotton crop is planted at closer spacing with higher density. Two sprays of Mepiquat chloride had lowest HNR and was followed by one spray. Control produced significantly higher height to node ratio than two sprays of Mepiquat chloride and on par with one spray of Mepiquat chloride. Siebert and Steward (2006) [15] reported that application of Mepiquat chloride reduce plant height, increase number of main stem nodes thus in turn lower the HNR. Results obtained in present study are in line with Raut *et al. (*2019) [14].

Leaf area(dm^2): Two sprays of Mepiquat chloride recorded reduction in number of leaf area due to lower number of functional leaves (Table 1). Control spray produced greater leaf area and was on par with one spray of Mepiquat chloride. Application of Mepiquat chloride, two sprays at square and flowering stage was found to reduce leaf area significantly throughout growth period which is resulted in alteration of cotton plant growth and development like reduction in internode length, reduction in leaf size as documented by Siebert and Steward (2006) [15], Borge, & Dalvi, (2019) [3] and Raut *et al.* (2019) [14].

Yield attributes: Yield attributes were found to be increased due to foliar application of PGR - Mepiquat chloride (Table 1). These results are in conformity with Shekhar (2011) [18], Thakur (2020) [21] and Srikala *et al.* (2023) [20]. Two sprays of Mepiquat chloride (P_2) were found to increase number of bolls plant^{-1}. Lower HNR in two sprays of PGR might have resulted in diversion of photosynthates to reproductive parts resulting in increased number of picked bolls plant^{-1}. These results are in conformity with Raut *et al.*, (2019) [14], Gobi and Valyapuri (2013) [5], Singh *et al.* (2017) [16]. Significant improvement in boll weight with application of two sprays was observed over control. Boll weight was significantly lower in control. Increase in boll weight in two sprays of Mepiquat chloride treatment might be due to diversion of energy flow towards fruiting bodies by reducing its utilization on vegetative growth. Increase in boll weight due to application of Mepiquat chloride was also noted by Venugopalan *et al*. (2016) [23], Singh *et al.* (2017) [16] and Srikala *et al.* (2023) [20]. Number of PGR spray had significantly influenced seed cotton yield plant^{-1}. Two sprays of Mepiquat chloride (P_2 - 25.32 g) was found significantly superior over one spray of Mepiquat chloride for yield plant^{-1}. Brar *et al.* (2003) [2] commented that yield components *viz.* number of bolls plant^{-1} and boll weight (g) has a greater influence on yield plant^{-1}.

Seed cotton yield: Two sprays of Mepiquat chloride (P_2) recorded significantly higher seed cotton yield (2116 kg ha^{-1}) over control *i.e.* water spray (1920 kg ha^{-1}). However, one spray of Mepiquat chloride (2032 kg ha^{-1}) was on par with two sprays. These results are in conformity with Borge and Dalvi (2019) [3], Thakur (2020) [21] and Srikala *et al.* (2023) [20].

Lint yield: Significant increase in seed cotton yield as well as numerical improvement in ginning out turn in two sprays of PGR has resulted in increased lint yield in two sprays of PGR over control (Table 1). Increase in lint yield due to application Mepiquat chloride sprays also reported by Kumar *et al.* (2005) [7].

Stalk yield (kg ha^{-1}): Control (P_0) recorded highest stalk yield (6702 kg ha^{-1}). It was superior over two sprays of Mepiquat chloride (P_2 - 5728 kg ha^{-1}) and one spray of Mepiquat chloride (P_1 - 6101 kg ha^{-1}). It indicates that Mepiquat chloride foliar application reduces stalk yield over control (Table 1).

Economics: PGR spray treatments differed significantly for cost of cultivation (Table 2). Two sprays of Mepiquat chloride (P_2) recorded significantly higher cost of cultivation (₹ 81,956 ha^{-1}) over control (P_0 - ₹ 76,956 ha^{-1}) and one spray of Mepiquat chloride (P_1 - ₹ 79,583 ha^{-1}). Increase in cost of cultivation in two sprays of PGR was due to increased input prices and additional labour charges incurred for spraying. Two sprays of Mepiquat chloride recorded highest gross monetary returns (P_2 - ₹ 145322 ha^{-1}) and was significantly superior over control (P_0 - ₹ 131880 ₹ ha^{-1}). Increase in seed cotton yield in this treatment has resulted to increased GMR. These results are similar with Patel *et al.* (2021) [11] and Udikeri (2017) [22]. Two sprays of PGR (P_2) was significantly profitable in terms of net monetary returns (₹

63366 ha^{-1}) and had recorded higher Benefit: Cost (B: C) ratio (1.76) over control (P_0 - 1.71) and one spray of Mepiquat chloride (P_1 - 1.74). It suggests that two sprays of PGR has given more returns without much increase in cost of production. These results are similar with Shekar *et al*. (2011), Kumar *et al.* (2017) [8] and Patel *et al*. (2021) [11].

The effect of plant densities and number of PGR sprays didn't interacted each other for yield contributing characters, yield and economics.

Table 1: Yield contributing characters, seed cotton yield, lint and stalk yield of *Bt* cotton variety as influenced by plant densities and number of PGR sprays

Treatments	Leaf area at 120 DAS (dm^2)	No. of picked bolls plant^{-1}	Yield plant^{-1} (g)	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
A. Plant density (D)							
D_1: 55,555plants ha^{-1} (60 ×30 cm)	142.55	14.69	35.82	2.45	1896	707	5090
D_2: 83,333 plants ha^{-1} (60 × 20 cm)	135.27	10.62	24.27	2.42	2031	758	5772
D_3: 1,11,111 plants ha^{-1} (60 ×15 cm)	127.55	10.42	19.22	2.23	2056	763	6131
D_4: 1,66,666 plants ha^{-1} (60 × 10 cm)	118.55	8.04	12.82	2.13	2109	813	7715
SE ±	4.62	0.46	0.90	0.05	40.97	15.38	197.40
CD at 5%	15.98	1.58	3.12	0.17	141.8	53.22	683.11
CV (%)	10.58	12.51	11.75	6.47	6.08	6.07	9.59
B. No. of PGR spray (P)							
P_1: One spray of PGR	132.12	11.00	23.05	2.25	2033	756	6101
P_2: Two sprays of PGR	121.39	11.77	25.32	2.45	2116	802	5728
P_0: Control (water spray)	139.44	10.07	20.73	2.22	1921	723	6702
SE ±	4.75	0.39	0.56	0.05	49.92	14.88	179.26
CD at 5%	14.24	1.17	1.67	0.15	149.67	44.60	537.44
CV (%)	12.56	12.36	8.40	7.46	8.55	6.78	10.05
Interaction D x P							
SE ±	9.50	0.78	1.12	0.10	99.84	29.75	358.52
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
GM	130.98	10.94	23.03	2.31	2023	760	6177

Table 2: Treatment cost, cost of cultivation, gross monetary returns, net monetary returns and B: C ratio of *Bt* cotton variety as influenced by different treatments

Treatments	Cost of cultivation (₹ ha^{-1})	GMR (₹ ha^{-1})	NMR (₹ ha^{-1})	B:C ratio
A) Plant density (D)				
D_1: 55,555plants ha^{-1} (60 ×30 cm)	77139	130175	53036	1.69
D_2: 83,333 plants ha^{-1} (60 × 20 cm)	79096	139492	60396	1.76
D_3: 1,11,111 plants ha^{-1} (60 ×15 cm)	79973	141216	61243	1.76
D_4: 1,66,666 plants ha^{-1} (60 × 10 cm)	81788	144825	63037	1.77
SE ±	409.76	2814	1943	-
CD at 5%	1418	9737	6725	-
CV (%)	1.55	6.08	9.81	-
B) No. of PGR spray (P)				-
P_1: One spray of PGR	79583	139577	59995	1.74
P_2: Two sprays of PGR	81956	145323	63367	1.76
P_0: Control (water spray)	76959	131881	54922	1.71
SE ±	499	3428	2166	-
CD at 5%	1497	10278	6494	-
CV (%)	2.18	8.55	12.63	-
Interaction D x P				-
SE ±	998	6857	4332	-
CD at 5%	N.S.	N.S.	N.S.	-
GM	79499	138927	59428	1.74

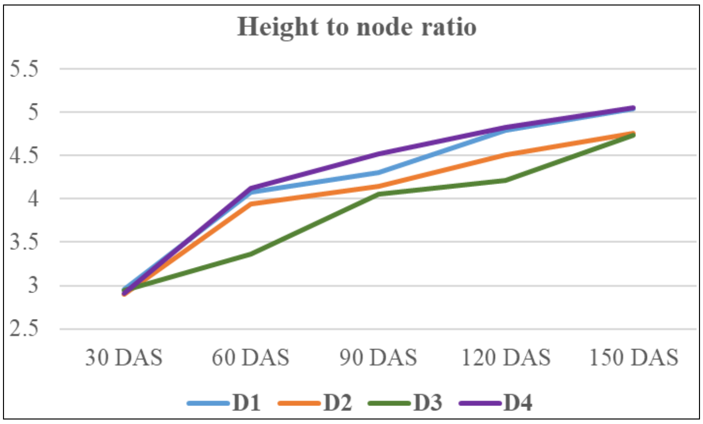

Fig 1: Height to node ratio as influenced by plant density

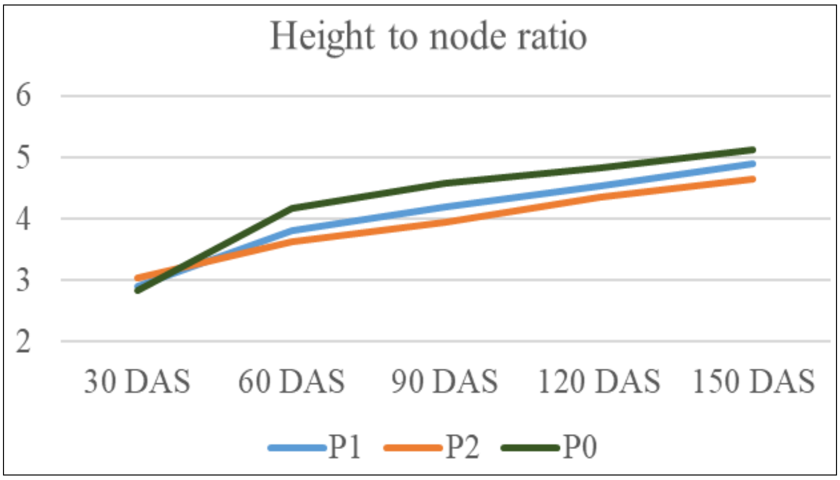

Fig 2: Height to node ratio influenced due to number of PGR sprays

Conclusion

On the basis of field investigation, it can be concluded that plant density 1,11,111 plants ha^{-1} *i.e.* spacing 60 cm × 15 cm was found optimum to increase seed cotton yield and net returns of straight variety of *hirsutum Bt* cotton. Two sprays of PGR (Mepiquat chloride @ 25 g *a.i.* ha^{-1}) at square formation and followed by 15 days has increased yield attributes, seed cotton yield and monetary returns of *Bt* variety of *hirsutum* cotton.

References

1. Anonymous. ICAR-AICRP (Cotton) Annual Report (2024-25). Coimbatore: ICAR-All India Coordinated Research Project on Cotton; 2025.
2. Brar ZS, Puri A, Deol JS. Growth, yield and quality of cotton cultivars as influenced by sowing time and mepiquat chloride application. J Cotton Res Dev. 2003;17(2):244-6.
3. Borge P, Dalvi D. Effect of plant growth regulators on yield and yield contributing characters of Bt cotton (*Gossypium hirsutum* L.) hybrid. J Pharmacogn Phytochem. 2019;8(3):132-4.
4. Chavan NH, Nagrare IM, Patil DB, Patil NA, Sathe HD. Effect of spacing and fertilizer levels on yield attributes and economics of Bt cotton. J Soils Crops. 2011;21(1):148-51.
5. Gobi R, Vaiyapuri V. Effect of growth regulators on growth, yield and economics of irrigated cotton (*Gossypium hirsutum* L.). Plant Arch. 2013;13(1):101-3.
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. Int J Chem Stud. 2018;6(4):485-8.
7. Kumar KA, Patil BC, Chetti MB. Effect of plant growth regulators on physiological components of yield in hybrid cotton (*Gossypium hirsutum* L.). Indian J Plant Physiol. 2005;10(2):187-90.
8. 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. Int J Curr Microbiol Appl Sci. 2017;6(3):233-8.
9. Pandagale AD, Baig KS, Rathod SS, Namade TB. Plant density and genotype evaluation for high density planting system of cotton under rainfed condition. Int J Curr Microbiol Appl Sci. 2020;9(9):1291-8.
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. Int J Curr Microbiol Appl Sci. 2018;7(12):2291-7.
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 J Agron. 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):182-5.
13. Rajkumar R. Cotton cultivation: Bt varieties and hybrids. Foundation for Agrarian Studies; 2016. Available from: https://agrarianstudies.org/cotton-cultivation-bt-varieties-and-hybrids/
14. 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. J Cotton Res Dev. 2019;33(1):136-9.
15. Siebert JD, Stewart AM. Influence of plant density on cotton response to mepiquat chloride application. Agron J. 2006;98:1634-9.
16. Singh K, Singh HP, Rathore, Mishra SK. Mepiquat chloride for enhancing cotton productivity and monetary returns in northwestern India. J Cotton Res Dev. 2017;31(1):62-8.
17. Singh P, George PJ, Ramtweke PW, Paul A. Performance of Bollgard I with different plant spacing and in the presence of refuge crops. J Pharmacogn Phytochem. 2020;9(2):78-81.
18. Shekhar K, Venkataramana M, Devi S. Effect of mepiquat chloride spray on Bt cotton yield with different spacing. Madras Agric J. 2011;100(4-6):429-31.
19. Solanki RM, Malam KV, Vasava MS, Chhodavadia SK. Response of Bt cotton to high density planting and nitrogen levels through fertigation. J Pharmacogn Phytochem. 2020;9(5):1952-8.
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. Int J Environ Clim Change. 2023;13(11). Available from: International Journal of Environment and Climate Change.
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. Int J Chem Stud. 2020;8(1):2741-53. doi:10.22271/chemi.2020.v8.i1ap.8685
22. Udikeri M. Effect of mepiquat chloride application at different stages on growth and yield of Bt cotton. J Cotton

Res Dev. 2017;31(2):280-3.
23. Venugopalan MV, Kranthi KR, Blaise D, Lakde S, Sankaranarayana K. Response of desi cotton (*Gossypium arboreum* L.) to plant geometry and mepiquat chloride under high density planting system. Indian J Agron. 2016;61(2):173-7.
24. Venugopalan MV. High density planting system in cotton—an agro-technique to reverse yield plateau. Cotton Stat News. 2019;3:1-9. https://caionline.in/uploads/publications/doc/03_16-04-2019.pdf
25. Wang X, Qi Y, Liu X, Xu J, Song X. Irrigation water management and productivity of cotton: A review. Sustainability. 2021;13(18):10070.