

## Effect of mepiquat chloride on growth parameters and yield of *Bt* cotton (*Gossypium hirsutum*) under high-density planting system

BRIJAL R. PATEL<sup>1</sup>, P.P. CHAUDHARI<sup>2</sup>, M.M. CHAUDHARY<sup>3</sup> AND KASHYAP N. PATEL<sup>4</sup>

Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University,  
Sardarkrushinagar, Gujarat 385 006

Received: September 2020; Revised accepted: January 2021

### ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 2018 and 2019 at Sardarkrushinagar, Gujarat, to study the productivity enhancement of *Bt* cotton (*Gossypium hirsutum*) grown under high-density planting system using mepiquat chloride. The experiment was laid out in split-plot design, with planting density in main plots and mepiquat chloride treatments in subplots. Pooled data of 2 years revealed that, *Bt* cotton grown with lower plant density (37,037 plants/ha) recorded significantly higher sympodial branches/plant, sympodial length at 50% height, number of bolls/plant and average boll weight, while high-plant density (74,074 plants/ha) resulted in the maximum seed-cotton (3,544 kg/ha) and stalk yield (3,740 kg/ha) as well as net realization (79.1 × 10<sup>3</sup> ₹/ha). The magnitude of increase in seed-cotton yield owing to higher plant density over lower plant density was 68.53%, on pooled basis. Application of 3 sprays of mepiquat chloride @ 0.4 ml/litre (one each at 45, 60 and 75 days after sowing) resulted in the least growth parameters, viz. plant height, dry-matter accumulation, crop-growth rate, relative growth rate and stalk yield with a highest yield attributes, viz. sympodial branches/plant, sympodial length at 50% height, bolls/plant, average boll weight, seed-cotton yield (3,186 kg/ha) and net realization (66.8 × 10<sup>3</sup> ₹/ha). Three sprays of mepiquat chloride @ 0.4 ml/l at 45, 60 and 75 days after sowing resulted in 28.8% higher seed-cotton yield than control treatment in pooled mean.

**Key words:** *Bt* cotton, Growth attributes, High-density planting system, Mepiquat chloride, Yield

Cotton is grown in 80 countries in the world, of which United States, China and India contribute about 80% total yield in the world. India ranks first in area and production of cotton in the world. It plays a vital role in the national economy by contributing 29.8% India's agricultural gross domestic production.

With large-scale cultivation of hybrid cultivars from mid-90's and adoption of bollworm resistance *Bt* technology since 2002 aided for achieving current average productivity of 474 kg lint/ha. But still our productivity is low compared to world average (765 kg lint/ha). In spite of introduction of improved hybrids over the years we have started witnessing the plateauing of yield levels (Blaise *et al.*, 2014). One of the alternative options to break this plateauing and to increase the productivity levels is through exploring higher planting densities (Blaise *et al.*, 2020). Cotton is a sub-tropical plant with indeterminate growth

habit with simultaneously vegetative and reproductive growth. The growth habit of present hybrids coupled with high availability of nutrients and assured moisture can encourage excessive vegetative growth. This can lead to severe production problems like fruit abortion, delayed maturity, boll rot and difficulty in harvesting.

Plant population is one of the most important factors for efficient utilization of available sources. The manipulation of plant density and crop geometry is a time-tested agronomic technique for achieving high crop yield. The manipulation of row spacing, plant density and the spatial arrangements of cotton plants, for obtaining higher yield have been attempted for several decades in many countries. In wider spacing, yield reduces due to less plant per unit area, and closer spacing reduces yield due to competition within the plants (Khetre *et al.*, 2018).

The physiological efficiency of a plant can be improved by prolonging photosynthesis, reducing photorespiration, better partitioning of photo-assimilates, improving mineral ion uptake and stimulating nitrogen metabolism. All these processes are inter-linked through several interactions lead-

<sup>1</sup>Corresponding author's Email: patelbrijal1994@gmail.com

<sup>1</sup>Principal Scientist, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110 012

ing to influence on growth and productivity. Plant-growth regulators influence these processes in one or the other way and also known to minimize the interplant competition by arresting the excess vegetative growth (Prakash and Korekar, 2017). Regulation of plant growth and canopy with application of any promising growth regulator may provide an opportunity to modify the plant geometry and density per unit area which affects the economic yield of the crop.

Keeping these points in view, an investigation was undertaken identify optimum planting density and mepiquat chloride spray to realize higher productivity in *Bt* cotton hybrid with existing plant architecture.

### MATERIALS AND METHODS

The experiment was carried out during the rainy (*kharij*) seasons of 2018 and 2019 at the Agronomy Instruction Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (24°–19' N, 72°–19' E and 154.52 m above the mean sea-level), district Banaskantha, Gujarat. Soil of the experimental field was loamy sand, low in organic carbon (0.18%) and available nitrogen (154 kg/ha), medium in phosphorus (42 kg/ha) and high potassium (280 kg/ha) status. There were 20 treatment combinations, comprising 4 plant density treatments, i.e. 60 cm × 30 cm (55,556 plants/ha), 60 cm × 45 cm (37,037 plants/ha), 45 cm × 30 cm (74,074 plants/ha) and 45 cm × 45 cm (49,383 plants/ha), and 5 mepiquat chloride treatments, i.e. mepiquat chloride @ 0.2 ml/litre (3 spray at 45, 60 and 75 days after sowing), Mepiquat chloride @ 0.2 ml/litre (2 spray at 45 and 60 days after sowing), mepiquat chloride @ 0.4 ml/litre (3 spray at 45, 60 and 75 days after sowing), Mepiquat chloride @ 0.4 ml/l (2 spray at 45 and 60 days after sowing) and control (no spray), were tested in split-plot design with 3 replications. Four plant densities as main plots and five mepiquat chloride treatments as sub-plots were replicate 3 times. The allotment of treatments to various plots in each replication was done by referring random number. Size of the gross plot was 6.3 m × 5.4 m. *Bt* cotton hybrid GTHH 49' ('BG II') were used and sowing was done in the third week of June during both the years. The crop was fertilized with nitrogen (320 kg N/ha) in 5 equal splits (64 kg N/ha each at basal, 30, 60, 75 and 90 DAS) according to soil-moisture availability in the form of urea and potash @ 120 kg K<sub>2</sub>O/ha as a basal in the form of muriate of potash. Other standard packages of practices of the region were followed raise the crop.

Data were recorded on plant height, number of monopodial and sympodial branches/plant, sympodial length at 50% height, dry-matter accumulation, crop-growth rate and relative growth rate at periodical intervals. Data on seed-

cotton and stalk yields (kg/ha) were collected and subjected for statistical analysis. Gross and net returns were calculated based on the seed-cotton, stalk yields and prevailing market prices of cotton in respective seasons. The benefit: cost ratio of *Bt* cotton was calculated by dividing the gross returns from the total cost of cultivation. The experimental data obtained from 2 years were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for design to test the significance of overall difference among treatments by the F test and conclusion were drawn at 5% probability level.

### RESULTS AND DISCUSSION

#### *Plant density*

Higher plant density (74,074 plants/ha) resulted in significantly tallest plant at 60, 90 and 120 DAS over the other plant densities in 2-year pooled data, whereas plant height at 30 days after sowing (DAS) was not reach upto level of significance due to plant densities (Table 1). Plant height was increased with the increase in plant density. Plant height measured at 120 DAS with higher plant density (74,074 plants/ha) increased by 23.5% over lower plant density (37,037 plants/ha). It was observed that shorter plant height under lower plant density was due to suppression of apical dominance as against higher plant density which induced more vertical growth due to congestion of plant per unit area. The maximum plant height was noted with plant spacing of 90 cm × 15 cm over rest of spacing (Khetre *et al.*, 2018). Mahil and Lokanadhan (2018) also found that spacing of 80 cm × 10 cm resulted in significantly highest plant height over 90 cm × 45 cm.

The different plant densities did not exert significant effect on number of monopodial branches/plant of cotton. Shekar *et al.* (2015) also observed non-significant variation in monopodial branches due to plant densities.

Sympodial branches/plant, sympodial length at 50% height (cm) and dry-matter accumulation (g/plant) at 60, 90 and 120 DAS were significantly increased with the decrease in plant density except at dry matter accumulation at 30 DAS in pooled results (Tables 1, 2). The least plant density (37,037 plants/ha) recorded significantly maximum number of sympodial branches/plant, sympodial length at 50% height and highest dry matter at 60, 90 and 120 DAS than rest of the plant densities in 2-year pooled mean. Dry-matter accumulation/plant was higher with low plant densities might be due to more canopy development under low plant densities (Nagender *et al.*, 2017 and Khetre *et al.*, 2018). The increase in number of sympodial branches/plant and sympodial length at 50% height at low plant density might be mainly owing to vigorous plant growth as a result of more availability of space and less competition among crop plants for sunlight, soil moisture as well as

nutrients. Sankat *et al.* (2017) reported that, wider spacing (60 cm × 10 cm) recorded significantly higher number of sympodial branches/plant and values of sympodial length at 50% plant height during 2014–15, 2015–16 and also in pooled analysis as against narrow spacing (45 cm × 10 cm).

Dry-matter production per ground area, i.e. CGR increased significantly with increase in age and crop-growth period up to 60–90 DAS, and subsequently, it reduced remarkably. Crop-growth rate increased with the increase in plant density. The crop-growth rate data revealed that higher plant density (74,074 plants/ha) resulted in significantly highest CGR (g/m<sup>2</sup>/day) at 0–30 DAS, 30–60 DAS, 60–90 DAS and 90–120 DAS over the other plant densities. Crop-growth rate is derived with biomass over time unit, hence these parameters improved with the corresponding increase in dry-matter accumulation with increasing plant density. The plant density treatments significantly affected the relative growth rate (mg/g/day) at 0–30 and 30–60 DAS in pooled analysis, while there was non-significant effect at 60–90 and 90–120 DAS. Relative growth rate increased with the decrease in plant density. At lower plant density (37,037 plants/ha) significantly highest relative growth rate was observed at 0–30 and 30–60 DAS. Relative growth rate was declined at later stages of crop growth which might be due to partitioning of extra photo-

synthates towards the developing sink during reproductive development. At higher planting densities, growth rate was significantly lower compared with that of minimum plant densities. Mahil and Lokanadhan (2018) found that spacing of 80 cm × 10 cm resulted in significantly highest crop-growth rate between 30-60, 60-90, 90-120 DAS to harvesting, relative growth rate between 90 DAS and harvesting while, the relative growth rate between 30-60 DAS and 60-90 DAS were observed maximum under spacing 90 cm × 45 cm.

Data (Table 3) revealed that significant differences in the number of bolls/plant and average boll weight in *Bt* cotton due to different plant densities (Table 3). Significantly, more number of bolls/plant and average boll weight were found under least plant density (37,037 plants/ha; 60 cm × 45 cm) over other high plant densities. The increased yield attributes under lesser plant density might be due to less competition exerted for light, moisture and nutrients. Sufficient interception of sunlight promotes efficient photosynthetic activities and ultimately greater accumulation of photosynthates under wider spacing with lower plant density. Biradar *et al.* (2010) also reported higher number of harvested bolls/plant and boll weight with 90 cm × 60 cm spacing than 90 cm × 30 cm.

Significantly differences in seed-cotton and stalk yield in *Bt* cotton was found owing to the different plant densi-

**Table 1.** Effect of plant density and mepiquat chloride on plant height, number of monopodial and sympodial branches/plant as well as sympodial length at 50% height of *Bt* cotton (pooled data of 2 years)

Treatments	Plant height (cm) at				Monopodial branches/plant	Sympodial branches/plant	Sympodial length (cm) at 50% height
	30 DAS	60 DAS	90 DAS	120 DAS			
<i>Plant density</i>							
60 cm × 30 cm (55,556 plants/ha)	37.3	78.7	98.5	126.6	3.2	22.4	20.9
60 cm × 45 cm (37,037 plants/ha)	34.2	74.4	89.5	111.4	3.3	27.4	30.2
45 cm × 30 cm (74,074 plants/ha)	37.9	84.8	104.5	137.6	3.1	20.0	19.4
45 cm × 45 cm (49,383 plants/ha)	35.5	76.6	92.1	119.4	3.1	24.2	23.7
SEm±	0.9	1.2	1.5	1.9	0.1	0.4	0.6
CD (P=0.05)	NS	3.7	4.7	5.8	NS	1.3	1.9
<i>Mepiquat chloride</i>							
Mepiquat chloride @ 0.2 ml/litre (3 sprays at 45, 60 and 75 days after sowing)	36.2	79.6	89.9	117.2	3.2	24.2	23.6
Mepiquat chloride @ 0.2 ml/litre (2 sprays at 45 and 60 days after sowing)	36.5	79.6	99.0	127.8	3.2	22.5	22.4
Mepiquat chloride @ 0.4 ml/litre (3 spray at 45, 60 and 75 days after sowing)	35.2	72.9	86.5	113.8	3.1	26.1	25.5
Mepiquat chloride @ 0.4 ml/litre (2 spray at 45 and 60 days after sowing)	35.5	74.1	97.5	123.6	3.2	23.5	24.5
Control (no spray)	37.7	87.0	112.7	136.4	3.3	21.2	21.9
SEm±	0.7	1.2	1.5	1.4	0.1	0.3	0.6
CD (P=0.05)	NS	3.4	4.3	4.0	NS	0.8	1.6

DAS, Days after sowing

ties (Table 3). Seed-cotton and stalk yield increased progressively with the increase in planting density. High plant density of 74,074 plants/ha resulted in produced significantly highest seed-cotton and stalk yield (kg/ha) of *Bt* cotton than rest of the plant densities. The magnitude of increase in seed-cotton yield and stalk yield owing to higher plant density (74,074 plants/ha) over lower plant density (37,037 plants/ha) was 68.5 and 35.2% in pooled data, respectively. The ultimate seed-cotton yield is the manifestation of yield-contributing characters. These yield-attributing characters were significantly affected by different plant populations. Though the per plant yields were higher at wider spacing, the total seed-cotton yield was less compared to that of closer plant populations, as it could not compensate the loss in number of plants/ha. Higher yields at closer spacing might be owing to more number of bolls/unit area. Similar observations were reported by Bhalerao and Godavari (2010), who found that 90 cm × 45 cm spacing recorded 50.5 and 17.7% higher seed-cotton yield than 90 cm × 90 cm and 90 cm × 60 cm spacing, respectively. Similar trend in case of seed-cotton yield was also observed by Bhalerao *et al.* (2012). Ghule *et al.* (2013) reported that, plant geometry of 90 cm × 60 cm recorded significantly higher number of picked bolls/plant, seed-cotton yield/plant and seed cotton yield/ha over 120 cm × 45 cm and 180 cm × 30 cm. Nagender *et al.* (2017) reported that, plant density of 55,555 plants/ha at 60 cm × 30 cm spacing recorded significantly highest seed-cotton yield over 18,518 plants/ha (90 cm × 60 cm) and 1,48,148 plants/ha (45 cm × 15 cm) plant densities, but highest stalk yield was recorded with 45 cm × 15 cm over rest of spacings. Venugopalan and Blaise (2001) also noted that dry-matter production of rainfed upland cotton increased with the increase in planting density.

### Mepiquat chloride

Mepiquat chloride treatments did not significantly influenced the plant height (cm) of *Bt* cotton at 30 DAS. This is because all mepiquat chloride treatments were imposed from 45th day after sowing and its effect was seen from 50th DAS onwards. Plant height measured at 60, 90 and 120 DAS was influenced significantly due to the different mepiquat chloride treatments (Table 1). The plant height measured at 60, 90 and 120 DAS was significantly lower with when 3 mepiquat chloride @ 0.4 ml/litre was sprayed at 45, 60 and 75 days after sowing and incase of plant height at 60 DAS was at par with 2 sprays of same concentration at 45 and 60 days after sowing,

**Table 2.** Effect of plant density and mepiquat chloride on dry-matter accumulation, crop-growth rate and relative growth rate of *Bt* cotton (pooled data of 2 years)

Treatment	Dry-matter accumulation (g/plant) at			Crop-growth rate (g/m <sup>2</sup> /day) at			Relative growth rate (mg/g/day)					
	30 DAS	60 DAS	90 DAS	120 DAS	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS
<i>Plant density</i>												
60 cm × 30 cm (55,556 plants/ha)	32.5	80.3	133.1	162.1	6.0	8.8	9.8	5.4	116.0	29.9	16.4	6.5
60 cm × 45 cm (37,037 plants/ha)	34.2	94.6	161.9	198.1	4.2	7.5	8.3	4.5	117.7	33.7	17.4	6.7
45 cm × 30 cm (74,074 plants/ha)	30.5	69.2	113.1	137.3	7.5	9.8	10.8	6.0	113.6	27.2	16.0	6.4
45 cm × 45 cm (49,383 plants/ha)	33.0	83.7	141.0	172.1	5.4	8.3	9.4	5.1	116.5	30.8	17.0	6.6
SEM±	0.8	1.8	2.5	3.3	0.2	0.3	0.3	0.2	0.9	0.8	0.5	0.1
CD (P=0.05)	NS	5.6	7.7	10.2	0.6	0.8	0.8	0.5	2.8	2.4	NS	NS
<i>Mepiquat chloride</i>												
Mepiquat chloride@ 0.2 ml/l (3 spray at 45, 60 and 75 days after sowing)	32.7	84.7	125.8	153.4	5.8	9.0	7.1	4.8	116.0	31.7	13.1	6.5
Mepiquat chloride@ 0.2 ml/litre (2 spray at 45 and 60 days after sowing)	32.7	85.6	152.1	185.6	5.8	9.4	11.5	5.8	116.2	31.8	19.2	6.6
Mepiquat chloride@ 0.4 ml/litre (3 spray at 45, 60 and 75 days after sowing)	32.2	71.2	102.3	124.1	5.7	6.7	5.4	3.8	115.5	26.4	11.9	6.4
Mepiquat chloride@ 0.4 ml/litre (2 spray at 45 and 60 days after sowing)	32.5	72.6	127.6	155.6	5.8	6.9	9.5	4.9	115.9	26.6	18.7	6.6
Control (no spray)	32.9	95.6	178.5	218.5	5.8	11.0	14.4	7.0	116.2	35.6	20.7	6.7
SEM±	0.6	1.2	1.5	1.86	0.11	0.2	0.2	0.1	0.6	0.7	0.4	0.1
CD (P=0.05)	NS	3.4	4.3	5.3	NS	0.6	0.7	0.3	NS	2.0	1.2	NS

mepiquat chloride (0.2 ml/litre) at 90 and 120 DAS. The control treatment (no spray) registered significantly highest plant height at 60, 90 and 120 DAS. The decrease in plant height of cotton plants sprayed with mepiquat chloride could be due to the interference of this chemical as growth regulator in biosynthetic pathway of gibberellic acid. The reduced amount of gibberellins in the plant system affects the growth and decrease plant height. Khetre *et al.* (2018) also showed that significantly minimum plant height of cotton was recorded with application of mepiquat chloride (50 g/ha) at square formation and flowering.

Different mepiquat chloride treatments were found non-significant for number of monopodial branches/plant in pooled mean (Table 1). Mepiquat chloride failed to influence number of monopodial branches/plant because treatments were applied after the monopodial branches arise from lower nodes of the plant during the earlier stages of crop growth. Prakash and Korekar (2017) and Khetre *et al.* (2018) also reported similar non-significant effect of mepiquat chloride on monopodial branches/plant.

The mepiquat chloride treatments significantly influenced the number of sympodial branches/plant and sympodial length at 50% height in *Bt* cotton (Table 1). Three sprays of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing resulted in significantly maximum number of sympodial branches and sympodial length at 50% height over rest of the treatments. Shekar *et al.* (2015) and

Khetre *et al.* (2018) also reported that, sympodial branches/plant of *Bt* cotton were increased with the increase spray of mepiquat chloride.

Dry-matter accumulation was significantly influenced due to various mepiquat chloride treatments at all the stages of crop growth, except at 30 DAS (Table 2). Since the mepiquat chloride treatments were imposed from 45<sup>th</sup> day after sowing. At later crop growth stages, 3 sprays of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing registered significantly lowest dry-matter accumulation at 60, 90 and 120 DAS in pooled analysis, whereas, dry-matter accumulation at 60 DAS was at par with 2 sprays of mepiquat chloride (0.4 ml/litre) at 45 and 60 days after sowing in pooled analysis. The significantly highest dry-matter accumulation at 60, 90 and 120 DAS was observed under control (no spray) treatment. The minimum dry-matter production was observed due to mepiquat chloride is due to the fact that mepiquat chloride restricts the vegetative growth of plants and increases the partitioning of assimilates towards fruiting bodies. Borge and Dattatraya (2019) reported significantly lowest dry-matter/plant/mepiquat chloride @ 10 ml/10 litres and 15 ml/10 litres spray at 45 DAS + 80 DAS.

Mepiquat chloride significantly influenced the crop-growth rate (g/m<sup>2</sup>/day) and relative growth rate (mg/g/day) at all the stages of crop growth, except crop-growth rate at 0–30 DAS and in relative growth rate at 0–30 and 90–120

**Table 3.** Effect of plant density and mepiquat chloride on number of bolls/plant, average boll weight, seed-cotton and stalk yield (kg/ha) as well as economics of *Bt* cotton (pooled data of 2 years)

Treatment	Bolls/ plant	Average boll weight (g)	Yield (kg/ha)		Net realization (× 10 <sup>3</sup> ₹/ha)	Benefit: cost ratio
			Seed cotton	Stalk		
<i>Plant density</i>						
60 cm × 30 cm (55,556 plants/ha)	35.1	3.1	2,979	6,173	58.8	1.8
60 cm × 45 cm (37,037 plants/ha)	42.5	3.5	2,161	5,101	31.4	1.5
45 cm × 30 cm (74,074 plants/ha)	31.7	2.8	3,642	6,895	79.1	2.0
45 cm × 45 cm (49,383 plants/ha)	39.3	3.3	2,765	6,013	51.7	1.7
SEM±	0.6	0.1	69	118		
CD (P=0.05)	1.7	0.2	211	364		
<i>Mepiquat chloride</i>						
Mepiquat chloride @ 0.2 ml/litre (3 spray at 45, 60 and 75 days after sowing)	38.0	3.2	2,949	5,961	57.5	1.8
Mepiquat chloride @ 0.2 ml/litre (2 spray at 45 and 60 days after sowing)	35.8	3.1	2,797	6,244	51.7	1.7
Mepiquat chloride @ 0.4 ml/litre (3 spray at 45, 60 and 75 days after sowing)	39.8	3.5	3,186	5,495	66.8	1.9
Mepiquat chloride @ 0.4 ml/litre (2 spray at 45 and 60 days after sowing)	38.2	3.3	3,029	5,948	61.0	1.9
Control (no spray)	34.0	2.9	2,473	6,582	39.3	1.6
SEM±	0.3	0.1	43	82		
CD (P=0.05)	1.0	0.2	120	232		

DAS, Days after sowing

DAS (Table 2). Three sprays of mepiquat chloride @ 0.4 ml/litres at 45, 60 and 75 days after sowing recorded significantly the least crop-growth rate at 30–60, 60–90 as well as 90–120 DAS and relative growth rate at 30–60 DAS and 60–90 DAS in 2 year pooled results, but crop-growth rate and relative growth rate at 30–60 DAS was at par with 2 sprays of mepiquat chloride @ 0.4 ml/litre at 45 and 60 days after sowing. The significantly maximum crop-growth rate and relative growth rate were registered under the control (no spray) treatment. The crop-growth rate and relative growth rate in cotton were more closely associated with vegetative growth. Hunnur (2007) also noted similar trend and revealed that, significantly lowest crop-growth rate and relative growth rate with mepiquat pentaborate @ 6,000 ppm followed by mepiquat chloride @ 100 ppm as compared to other mepiquat pentaborate and control treatments.

Bolls/plant and average boll weight in *Bt* cotton were considerably affected by different mepiquat chloride treatments (Table 3). Significantly more number of bolls/plant and average boll weight were noted with 3 sprays of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing in pooled data compared with rest of the treatments. This might be owing to reduction in the abscission of buds and bolls. In addition, mepiquat chloride might have completely counteracted the effect of abscisic acid and thus reduced the shedding of reproductive structures over the control. Shekar *et al.* (2015) observed that, bolls/plant, boll weight and seed-cotton yield were significantly higher with 2 sprays of chloro mepiquat chloride @ 0.2 ml/litre at 50–60 and 80–90 DAS compared to de-topping and the control. Malakannavar *et al.* (2018) were also agreed that, bolls/plant and average boll weight of *Bt* cotton were increased positively with the increase spray of mepiquat chloride.

Data (Table 3) show that marked effect of mepiquat chloride treatments on the seed-cotton and stalk yield (kg/ha). Three sprays of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing registered significantly higher seed-cotton yield than rest of the treatments and recorded 28.8% higher seed-cotton yield over the control (no spray) treatment. The increase in yield might be because of spray of mepiquat chloride and cumulative effect of more sympodial branches/plant and bolls/plant as compared to rest of the treatments. Mepiquat chloride has shown to increase the rate of photosynthesis by increasing size of mesophyll cells and chlorophyll content in leaves of cotton, thereby leading to more rapid exchange of CO<sub>2</sub> into mesophyll cell by virtue of their large surface area. Mepiquat chloride also increased the source: sink ratio and sympodial branches. Spray of mepiquat chloride favourably affected to development and retention of fruiting bodies, so increased seed-

cotton yield. Shekar *et al.* (2015) found that seed-cotton yield was significantly higher with 2 sprays of chloro mepiquat chloride @ 0.2 ml/lit at 50–60 and 80–90 DAS compared to de-topping and the control. Malakannavar *et al.* (2018) also reported such results. In case of stalk yield, 3 spray of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing resulted in the lowest stalk yield, which was 16.5% lower than the control (no spray). However, significantly highest stalk yield was registered under the control (no spray) treatment. This may be attributed to its ability to reduce above-ground vegetative growth. The stalk yield produced was significantly higher with the control followed by de-topping at 50–60 DAS when compared to single spray of chloro mepiquat chloride @ 0.2 ml/litre at 50–60 DAS and 2 sprays of chloro mepiquat chloride @ 0.2 ml/litre at 50–60 and 80–90 DAS (Shekar, 2011).

### Economics

The plant density of 74,074 plants/ha resulted in the maximum net realization (79.1×10<sup>3</sup>₹/ha) with the benefit : cost ratio (BCR) of 2.0 on 2-year mean basis. This increase in profitability was mainly owing to higher seed-cotton yield. These results are in conformity with the results reported by Ghule *et al.* (2013). In case of mepiquat chloride, maximum net realization 66.8 × 10<sup>3</sup>₹/ha and BCR of 1.9 were secured with 3 sprays of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing. This might be attributed owing to higher seed-cotton yield under this treatment. Similar result was also found by Shekar *et al.* (2013).

Thus, it may be concluded that *Bt* cotton (hybrid GTHH 49 (BG II) grown under high-density planting system at 45 cm × 30 cm spacing (74,074 plants/ha) with 3 spray of mepiquat chloride @ 0.4 ml/litre at 45, 60 and 75 days after sowing gave higher seed-cotton yield and fetched the maximum net realization under loamy sand soil.

### REFERENCES

- Bhalerao, P. D. and Godavari Gaikwad, S. 2010. Productivity and profitability of *Bt* cotton (*Gossypium hirsutum*) under various plant geometry and fertilizer levels. *Indian Journal of Agronomy* 55(1): 60–63.
- Bhalerao P.D., Deshmukh, P.W., Gaikwad Godavari, S. and Imade, S.R. 2012. Response of *Bt* cotton (*Gossypium hirsutum*) to spacing and fertilizer levels under rainfed conditions. *Indian Journal of Agronomy* 57(2):176–179.
- Biradar, V., Rao, S. and Hosamani, V. 2010. Yield and quality of late sown *Bt* cotton (*Gossypium hirsutum* L.) as influenced by different plant spacings, fertilizer levels and NAA applications under irrigation. *International Journal of Agricultural Sciences* 6(1): 152–156.
- Blaise, D., Kranthi, K.R., Ravindran, C.D. and Thalal, K. 2020. High plant density can improve productivity of Asiatic cotton (*Gossypium arboreum* L.). *Archives of Agronomy and Soil Science* <https://doi.org/10.1080/03650340.2020.1741553>

- Blaise, D., Venugopalan, M.V. and Raju, A.R. 2014. Introduction of *Bt* cotton hybrids in India: Did it change the agronomy? *Indian Journal of Agronomy* **59**(1): 157–176.
- Borge, Priyanka and Dattatraya, Dalvi. 2019. Physiological and biological parameters of *Bt* cotton as influenced by different plant growth regulators. *International Journal of Chemical Studies* **7**(3): 278–279.
- Ghule, P.L., Palve, D.K., Jadav, J.D. and Dahiphale, V.V. 2013. Plant geometry and nutrient levels effect on productivity of *Bt* cotton. *International Journal of Agricultural Sciences* **9**(2): 486–494.
- Hunnur, J.R. 2007. Studies on bio-efficacy of plant growth regulators in *Bt* cotton. M.Sc. (Agric) Thesis, Department of Crop Physiology, College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka.
- Khetre, O.S., Shinde, V.S., Asewar, B.V. and Mirza, I.A.B. 2018. Response of growth and yield of *Bt* cotton to planting densities as influenced by growth regulators. *International Journal of Chemical Studies* **6**(4): 485–488.
- Mahil, E.I.T. and Lokanadhan, S. 2018. Influence of plant geometry on performance of cotton variety Co 14 under winter irrigated condition. *International Journal of Pure and Applied Bioscience* **6**(2): 1,122–1,128.
- Malakannavar, S., Halepyati, A.S., Yadahalli, G.S., Chittapur, B.M., Narayanrao, K. and Ambika, V. 2018. Effect of macronutrient and morphoframe manipulation on growth, yield and economics of *Bt* cotton (*Gossypium hirsutum* L.). *Advances in Research* **13**(1): 1–8.
- Nagender, T., Raji Reddy, D., Leela Rani, P., Sreenivas, G., Surekha, K., Gupta, A. and Sreekanth, P. D. 2017. Productivity of *Bt* and non *Bt* cotton (*Gossypium hirsutum* L.) cultivars as influenced by plant geometry and fertilizer levels. *International Journal of Current Microbiology and Applied Sciences* **6**(9): 3,208–3,217.
- Prakash, Gowtham and Korekar, S.L. 2017. Impact of planting density and growth regulators on *Bt* cotton (*Gossypium hirsutum* L.) hybrid yield and component traits. *International Journal of Pure and Applied Bioscience* **5**(5): 1,273–1,278.
- Sankat, K.B., Patel, J.G., Patel, D.D., Vadodariya, K.V. and Pawar, S.L. 2017. Feasibility of high density planting system and its fertilizer requirement in cotton (*Gossypium hirsutum* L.). *AGRES - An International e. Journal* **6**(4): 666–674.
- Shekar, K. 2011. Effect of growth regulator chloro mepiquat chloride and high density planting on growth and yield of *Bt* cotton. M.Sc. (Agric) Thesis, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad.
- Shekar, K., Raman, M.V. and Kumari, S.R. 2015. Response of hybrid cotton to chloro mepiquat chloride and detopping under high density planting. *Journal of Cotton Research and Development* **29**(1): 84–86.
- Shekar, K., Ramana, M.V. and Sridevi, S. 2013. Enhancing the productivity of *Bt* cotton by planting geometry and chloro mepiquat chloride application. *Green Farming* **4**(1): 40–42.
- Venugopalan, M.V. and Blaise, D. 2001. Effect of planting density and nitrogen levels on productivity and N-use efficiency of rainfed upland cotton (*Gossypium hirsutum*). *Indian Journal of Agronomy* **46**(2): 346–356.