Plant Archives Vol. 26, Supplement 2, 2026 pp. 1355-1361 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.162

EFFECT OF GROWTH RETARDANT ON GROWTH AND YIELD OF COTTON

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(Date of Receiving : 08-03-2026; Date of Revision : 21-04-2026; Date of Acceptance : 16-05-2026)

ABSTRACT

To investigate the effect of growth retardants on cotton growth and yield under a high-density planting system (HDPS), a field experiment was carried out during the *Kharif* season of 2024 at the Main Cotton Research Station, Navsari Agricultural University, Athwa-farm, Surat (Gujarat). Two cotton genotypes, G. Cot-34 and G. Cot-44 and six growth retardant treatments, including control, detopping, mepiquat chloride (45 ppm), cycocel (100 ppm) and their combinations with detopping at the 20th node, were used in the experiment, which was laid out in a Factorial Randomized Block Design (FRBD) with three replications. Findings showed significant differences in growth and yield parameters related to genotypes and growth retardant treatments. Genotype G. Cot-44 produced compact growth with significantly reduced plant height, lower biomass, more nodes, shorter internodal length and improved sympodial length and boll weight, resulting in a higher seed cotton yield (2075.87 kg ha^{-1}) under high-density planting conditions. Whereas G. Cot-34 produced more bolls per plant and higher biomass, but with excessive vegetative growth and comparatively lower yield (1944.61 kg ha^{-1}). Among the growth retardant treatments, mepiquat chloride @ 45 ppm at 45 DAS combined with detopping at the 20th node was most effective in regulating vegetative growth by reducing plant height, biomass and internodal length, while significantly enhancing yield attributes such as boll weight, number of sympodia and seed cotton yield (2408.86 kg ha^{-1}) which was remained statistically at par with cycocel @ 100 ppm at 45 DAS. The interaction effect showed that G. Cot-44 produced optimum growth and maximum yield under HDPS when combined with mepiquat chloride @ 45 ppm and detopping. The study concludes that, in high-density planting conditions, applying growth retardants along with detopping is an efficient agronomic practice to reduce excessive vegetative growth and increase cotton yields.
***Keywords* :** Cotton, Growth retardants, Mepiquat chloride, Cycocel, Detopping, HDPS.

Introduction

Cotton (*Gossypium hirsutum* L.) belongs to the family *Malvaceae* and is one of the most important commercial fibre crops in India and worldwide. India is considered one of the first users of cotton, with mentions in the *Rig-Veda* and Dharma Shastra and the word *karpasa* is often cited in historical texts (Brown and Ware, 1958). The genus *Gossypium* includes around 50 species; *G. hirsutum* and *G. barbadense* are identified as New World cottons, whereas *G. arboreum* and *G. herbaceum* are categorized as Old-World cottons (Hutchinson, 1947). Worldwide, cotton serves as a primary raw material for the textile sector. Despite India holding the second position in overall cotton production, its productivity is significantly lower compared to countries like China, Australia and Brazil. India is the second-largest cotton producer globally, cultivating cotton over about 11.36 million hectares with an estimated production of 299.26 lakh bales during 2024-25; however, the national productivity remains low compared to the global average (Anonymous, 2025). Gujarat is one of the leading cotton-producing states in India and plays a pivotal role in national cotton production. Along with

Maharashtra and Telangana, Gujarat contributes a major share to the total cotton area and production of the country, owing to favourable agro-climatic conditions and adoption of improved hybrids (Anonymous, 2025). The need for better agronomic practices to increase productivity is highlighted by recent data showing a decline in cotton production and cultivation in India (Anonymous, 2025). Cotton is a subtropical plant characterised by an indeterminate growth pattern, where excessive vegetative development is typically supported by high nitrogen, sufficient moisture and postponed fruiting. This abundant growth leads to inadequate boll retention, postponed maturity and decreased yield (Sabale *et al.*, 2017). To address this, plant growth regulators (PGRs) are utilized to control plant height, enhance source-sink equilibrium and promote reproductive development (Prakash *et al.*, 2011). Growth inhibitors such as mepiquat chloride and chlormequat chloride (CCC) impede gibberellin production, minimize internode elongation and redirect nutrients toward reproductive structures (Rademacher, 2000). Mepiquat chloride has been noted to lower plant height and internode length while promoting reproductive branching (Koler, 2010), while CCC causes dwarfing, consistent growth and enhanced stress resilience (Thomas, 1964). While these growth inhibitors are commonly utilized, their impacts differ based on genotype, dosage and timing of application and detailed data in high-density planting systems is scarce

Materials and Methods

Experimental site and climate

A field experiment was conducted during the *Kharif* season of 2024 at the Main Cotton Research Station, Navsari Agricultural University (NAU), Athwa Farm, Surat, Gujarat, while laboratory analysis was carried out in the Department of Soil Science and Agricultural Chemistry, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The experimental site is located in the South Gujarat Heavy Rainfall Zone-II (AES-III) at 21°16′90″ N latitude and 72°79′88″ E longitude, with an altitude of 9 m above mean sea level. The region experiences a humid tropical climate, with monsoon rainfall from June to September. Weather conditions during the crop period were conducive for normal cotton growth.

Physico-chemical properties of soil

The study was conducted at the Main Cotton Research Station located in Surat, situated in the South Gujarat. The region is characterized by 'Deep Black Soils' which commonly referred as 'Black Cotton Soils,' primarily derived from basalt and dolerite. These soils vary from dark grey to black in colour, possess a clay-like texture and contain a high level of montmorillonite clay minerals. According to the data collected, the experimental field had clayey soil with normal electrical conductivity (0.40 dS m^{-1}) and a mildly alkaline pH of 7.69. The soil showed a deficiency in available nitrogen (218 kg ha^{-1}), moderate in available phosphorus (34.27 kg ha^{-1}) and high in available potassium (565.38 kg ha^{-1}).

Experimental design and treatments

The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. Treatments consisted of two cotton genotypes (*Gossypium hirsutum* L.) G. Cot-44 and G. Cot-34 and six growth-retardant treatments, resulting in 12 treatment combinations. Growth-retardant treatments included control, detopping at the 20^{th} node, mepiquat chloride @ 45 ppm at 45 DAS, mepiquat chloride @ 45 ppm + detopping, cycocel @ 100 ppm at 45 DAS and cycocel @ 100 ppm + detopping.

Factor 1: Cotton genotypes

G_1 : G. Cot-44
G_2 : G. Cot-34

Factor 2: Growth retardants

T_1 : Control
T_2 : Detopping at 20^{th} Node
T_3 : Mepiquat chloride@45 ppm at 45DAS
T_4 : Mepiquat chloride@45 ppm at 45DAS + Detopping at 20^{th} Node
T_5 : Cycocel @ 100 ppm at 45 DAS
T_6 : Cycocel @ 100 ppm at 45 DAS + Detopping at 20^{th} Node

Table 1: Details of treatment combinations

Treatment no.	Treatment combinations	Treatment Detail	
		Genotype (G)	Growth retardants (T)
T_1	G_1T_1	G. Cot-44	Control
T_2	G_1T_2		Detopping at 20^{th} Node
T_3	G_1T_3		Mepiquat chloride@45 ppm at 45DAS
T_4	G_1T_4		Mepiquat chloride@45 ppm at 45DAS + Detopping at 20^{th} Node
T_5	G_1T_5		Cycocel @ 100 ppm at 45 DAS
T_6	G_1T_6		Cycocel @ 100 ppm at 45 DAS+ Detopping at 20^{th} Node

T_7	G_2T_1	G. Cot-34	Control
T_8	G_2T_2		Detopping at 20th Node
T_9	G_2T_3		Mepiquat chloride@45 ppm at 45DAS
T_{10}	G_2T_4		Mepiquat chloride@45 ppm at 45DAS + Detopping at 20th Node
T_{11}	G_2T_5		Cycocel @ 100 ppm at 45 DAS
T_{12}	G_2T_6		Cycocel @ 100 ppm at 45 DAS+ Detopping at 20th Node

Crop management

Cotton was sown on 1st July 2024 by hand dibbling at a spacing of 90 × 15 cm, using a seed rate of 9 kg ha^{-1}. The recommended dose of fertilizer (240-00-00 kg N-P_2O_5-K_2O ha^{-1}) was applied through urea, with nitrogen split into five equal applications at 30, 60, 75, 90 and 105 DAS. Standard agronomic practices including gap filling, thinning, interculturing, hand weeding and earthing up were followed uniformly for all treatments.

Application of growth retardants

Mepiquat chloride and cycocel (chlormequat chloride) were applied as foliar sprays at 45 DAS according to treatment specifications. Detopping was performed manually at the 20th node where applicable.

Observations recorded

Growth parameters such as plant height, number of monopodia and sympodia, sympodial length, number of nodes, node length, biomass, number of bolls per plant, boll weight and seed cotton yield were recorded from five randomly selected plants per plot.

Statistical analysis

The recorded data were analysed using OPSTAT (O. P. Sheoran Programmer, Computer Section, CCS HAU, Hisar) statistic software. The critical difference (CD) among the variances was calculated at $p \leq 0.05$.

Results and Discussion

Effect of genotypes

The data on growth and yield of cotton genotypes recorded at harvest are presented in Tables 2 and 3, which clearly indicate the significant effect of genotype on growth and yield of cotton. Plant height at harvest differs significantly between the two genotypes, with G. Cot-44 achieve shorter height (129.59 cm), while G. Cot-34 recorded a relatively taller plant height (139.28 cm), indicates inherent genetic variations in vegetative growth characteristics. Genotypic variation also significantly affected the number of sympodia per plant. Among the genotypes, G. Cot-34 recorded the significantly highest number of sympodia (19.75 per plant), whereas G. Cot-44 produced a slightly lower sympodia (18.79 per plant). However, there was no significant difference in the number of monopodia per plant at harvest between genotypes, indicating that genotype has a limited effect on monopodial branching.

Sympodial length had a significant effect on genotype, with G. Cot-44 having significantly longer sympodial length (31.15 cm) than G. Cot-34 (29.40 cm). It indicates that G. Cot-44 has better sympodial development, which might lead to increased boll production. Biomass production also differed significantly between the genotypes, with G. Cot-34 producing more biomass (975.16 g) than G. Cot-44 (921.62 g), indicating variations in dry matter partitioning.

Furthermore, the number of nodes per plant varied significantly, with G. Cot-44 exhibiting higher numbers of nodes per plant (20.74) than G. Cot-34 (19.51). Conversely, node length was significantly shorter in G. Cot-44 (16.86 cm) compared to G. Cot-34 (17.69 cm), showing that G. Cot-44 is genetically more efficient in reducing excessive internodal elongation, which is important for controlled vegetative growth.

Genotype also has significant effects on yield attributes. The number of bolls per plant was significantly higher in G. Cot-34 (30.46) than in G. Cot-44 (28.42), indicating that G. Cot-34 has superior boll-setting ability. However, G. Cot-44 had significantly greater boll weight (3.91 g) than G. Cot-34 (3.71 g), indicating improved boll development in G. Cot-44. The combined effect of yield components resulted in significant variation in seed cotton yield between genotypes. G. Cot-44 had a significantly higher seed cotton yield (2075.87 kg ha^{-1}) than G. Cot-34 (1944.61 kg ha^{-1}), which indicates improved yield performance under experimental conditions.

Table 2: Effect of various genotypes and growth retardants on plant height, number of sympodia and monopodia per plant, sympodial lengths and on biomass (g)

Treatments	Plant height (cm)	No. of sympodia /plant	No. of monopodia /plant	Sympodial lengths (cm)	Biomass (g)
Factor 1: Cotton genotype (G)					
G_1: G. Cot-44	129.55	18.79	1.85	31.15	921.62
G_2: G. Cot-34	139.32	19.75	1.87	29.40	975.16
S.Em ±	2.01	0.31	0.01	0.60	18.24
CD at 5%	5.90	0.91	NS	1.75	53.49
Factor 2: Growth retardants (T)					
T_1: Control	173.18	16.23	1.99	42.81	1034.48
T_2: Detopping at 20^{th} node	163.03	16.69	1.95	35.30	1014.75
T_3: Mepiquat chloride @ 45 ppm at 45 DAS	127.92	18.53	1.91	26.15	903.46
T_4: Mepiquat chloride @ 45 ppm at 45 DAS + Detopping at 20^{th} node	105.96	23.07	1.71	25.76	907.08
T_5: Cycocel @ 100 ppm at 45 DAS	127.16	19.94	1.81	28.25	927.34
T_6: Cycocel @ 100 ppm at 45 DAS + Detopping at 20^{th} node	109.38	21.16	1.80	23.38	903.22
S.Em ±	3.31	0.53	0.02	1.03	31.39
CD at 5%	9.71	1.57	0.07	3.02	92.65
Interaction (G × T)					
S.Em ±	4.68	0.76	0.03	1.46	44.67
CD at 5%	13.73	2.22	NS	NS	NS
CV (%)	6.03	6.80	3.22	8.34	8.16

Effect of growth retardants

The data presented in Tables 2 and 3 clearly indicate that growth retardant treatments significantly influenced cotton growth and yield. Plant height at harvest was markedly reduced by the application of growth retardants, with the minimum plant height recorded under T_4 (Mepiquat chloride @ 45 ppm at 45 DAS + detopping at the 20th node; 105.96 cm), which was statistically at par with T_6 (CCC @ 100 ppm at 45 DAS + detopping at the 20^{th} node; 109.38 cm). While the control treatment (T_1) recorded the maximum plant height (173.18 cm). Similar reductions in plant height due to growth retardants have been reported earlier by.

The number of sympodia per plant was significantly enhanced by growth retardant treatments, with T_4 recording the significantly highest number (23.07), followed by T_6 (21.16), while the control recorded the lowest (16.23). Conversely, monopodial branches were significantly reduced with growth retardant application, with T_4 recording the minimum number of monopodia (1.71). Sympodial length was significantly highest under the control (42.81 cm) and progressively decreased with detopping and growth retardant treatments, indicating effective suppression of excessive vegetative growth.

Biomass accumulation was significantly affected by growth retardants applications, with the significantly lowest biomass was recorded under T_6 (903.22 g), which was remained statistically at par with T_3, T_4 and T_5. Node formation was significantly increased by growth retardants and detopping, with the significantly maximum number of nodes recorded in T4 (31.07), while the lowest (11.73) was observed with the control. Node length was significantly reduced by CCC-based treatments, with the minimum node length observed in T_6 (14.21 cm).

Yield attributes were also significantly affected by growth retardant application. The significantly highest number of bolls per plant was recorded under T_6 (32.41), followed closely by T_5 and T_4, whereas the control recorded fewer bolls. Boll weight was significantly higher under T_4 (4.12 g), followed by T_6 (4.01 g), while the control recorded the lowest boll weight (3.40 g). Consequently, seed cotton yield was significantly improved by combined growth retardant and detopping applications, with the significantly highest yield was recorded in T_4 (2408.86 kg ha^{-1}), followed by T_6 (2345.69 kg ha^{-1}), whereas the control produced the lowest yield (1534.38 kg ha^{-1}).

Table 3: Effect of various genotypes and growth retardants on number of node per plant, node lengths, number of boll per plant, boll weight and seed cotton yield.

Treatments	No. of node /plant	Node length (cm)	No. of boll/ plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Factor 1: Cotton genotype (G)					
G_1: G. Cot-44	20.74	16.86	28.42	3.91	2075.87
G_2: G. Cot-34	19.51	17.69	30.46	3.71	1944.61
S.Em ±	0.41	0.28	0.70	0.07	44.71
CD at 5%	1.21	0.82	2.04	0.21	131.12
Factor 2: Growth retardants (T)					
T_1: Control	11.73	17.18	25.56	3.40	1534.38
T_2: Detopping at 20th node	13.48	19.84	25.88	3.60	1834.98
T_3: Mepiquat chloride @ 45 ppm at 45 DAS	17.52	18.68	28.42	3.84	1873.56
Mepiquat chloride @ 45 ppm at 45 DAS + Detopping at 20th node	31.07	18.89	32.15	4.12	2408.86
T_5: Cycocel @ 100 ppm at 45 DAS	17.95	14.84	32.24	3.90	2063.98
Cycocel @ 100 ppm at 45 DAS + Detopping at 20th node	28.98	14.21	32.41	4.01	2345.69
S.Em ±	0.71	0.48	1.20	0.12	77.44
CD at 5%	2.09	1.41	3.53	0.36	227.11
Interaction (G × T)					
S.Em ±	1.01	0.68	1.70	0.17	109.51
CD at 5%	NS	2.00	NS	0.51	321.18
CV (%)	8.66	6.83	10.02	7.88	9.44

Interaction effect

The interaction between genotypes (G) and growth retardant treatments (T) significantly influenced several growth and yield parameters of cotton, as depicted in Figures 1-5. Plant height was significantly affected by the G × T interaction (Fig. 1), with the significantly shortest plant height recorded with treatment G_1T_4 (G. Cot-44 + Mepiquat chloride @ 45 ppm at 45 DAS + detopping at the 20th node; 101.44 cm), which was at par with G_1T_6, G_2T_4 and G_2T_6. These results confirm the effectiveness of growth retardants combined with detopping in controlling excessive vegetative growth, in agreement with Priyanka and Dalvi (2019), Khetre *et al.* (2018) and Patel *et al.* (2021).

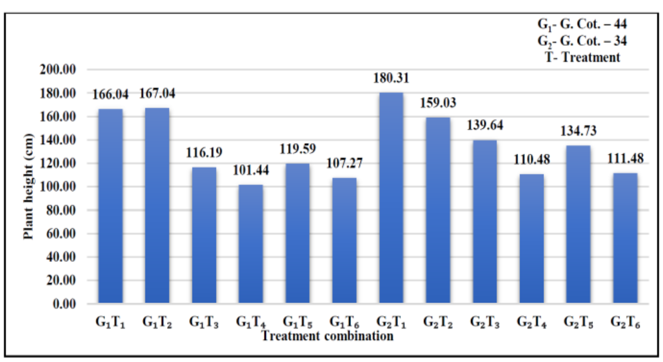

Fig. 1: Interaction effect (G x T) on plant height at harvest

The G × T interaction also had a significant effect on the number of sympodia per plant (Fig. 2), indicating genotype-specific responses to growth retardant treatments. The significantly highest number of sympodia was recorded under treatment G_1T_4 (23.25), which was at par with G_1T_6 and G_2T_4. Similar genotype-dependent responses were reported by Ahmed (1994), Shekar *et al.* (2015) and Kamboj and Verma (2024). However, the interaction effect on the number of monopodia per plant was non-significant, suggesting a uniform response of genotypes across treatments, as also observed by Gadakh *et al.* (1992), Brar *et al.* (2020) and Patel *et al.* (2021).

The interaction between genotypes and treatments had a non-significant effect on sympodial length and biomass accumulation, indicating similar responses of both genotypes to growth retardant application and detopping. These findings corroborate earlier reports by Patel *et al.* (2021) and Tung et al. (2018). Likewise, the number of nodes per plant was not significantly influenced by the G × T interaction, suggesting consistent nodal response across genotypes and treatments. Similar results reported by Kerby *et al.* (1986).

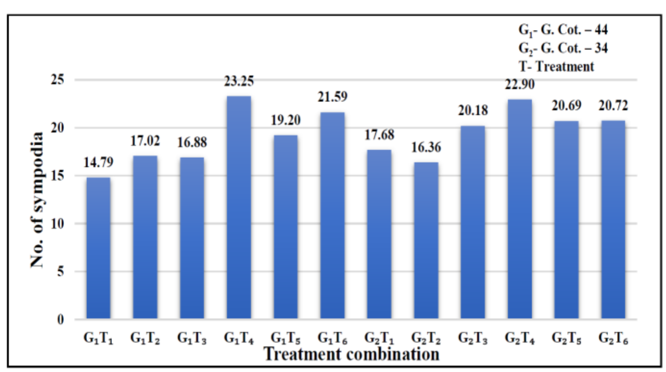

Fig. 2: Interaction effect (G x T) on number of sympodial branches per plant at harvest

In contrast, node length at harvest was significantly influenced by the G × T interaction (Fig. 3). The significantly lowest node length was observed in treatment G_1T_6 (12.80 cm), which was at par with G_1T_5, indicating the effectiveness of Cycocel, particularly in combination with detopping, in suppressing internodal elongation. Similar findings were reported by Virk *et al.* (1984) and Seshadri (1989).

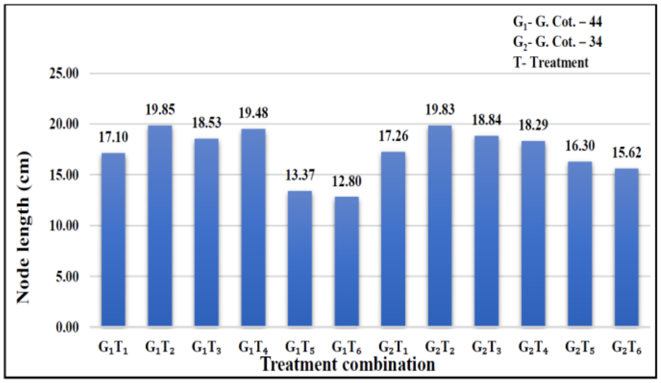

Fig. 3: Interaction effect (G x T) on node length (cm) at harvest

The interaction effect on the number of bolls per plant was non-significant, indicating that boll number was not markedly altered by specific genotype-treatment combinations. These results are in line with the findings of Maheswari *et al.* (2019), Abbas *et al.* (2022) and Kamboj and Verma (2024). However, boll weight was significantly influenced by the G × T interaction (Fig. 4), with the significantly highest boll weight recorded under treatment G_1T_4, which was at par with G_1T_6 and G_2T_5, highlighting genotype-dependent efficiency of growth retardants in improving boll development. Similar observations were reported by Kaur *et al.* (2021), Murtza *et al.* (2022) and Abbas *et al.* (2022).

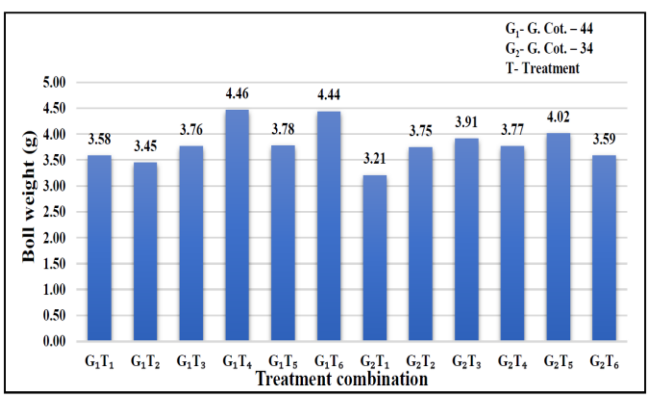

Fig. 4: Interaction effect (G x T) on boll weight at harvest

Seed cotton yield was significantly influenced by the interaction between genotypes and growth retardant treatments (Fig. 5). The signifcantly highest yield was recorded under G_1T_4, which was at par with G_1T_6, G_2T_4 and G_2T_6, indicating that optimal genotype-treatment combinations are crucial for maximizing productivity. These results are in close agreement with earlier findings of Priyanka and Dalvi (2019), Gobi *et al.* (2019), Patel *et al.* (2021) and Kamboj and Verma (2024).

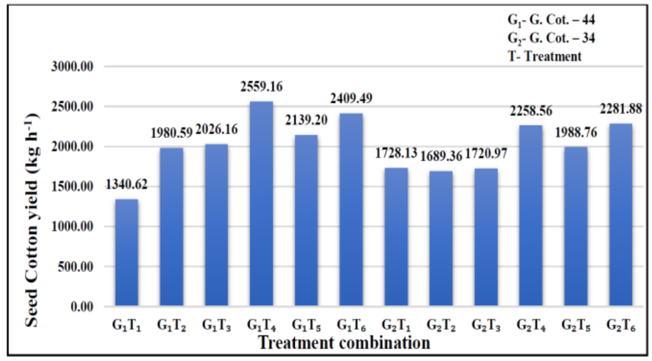

Fig. 5: Interaction effect (G x T) on seed cotton yield at harvest

Conclusion

The study revealed that genotype and growth-retardant treatment have significant effects on cotton growth and yield in high-density planting. G. Cot-44 performed better than the other genotypes in terms of compact growth, boll weight and seed cotton production. The application of 45 ppm mepiquat chloride at 45 DAS with detopping at the 20th node, was found most effective in inhibiting excessive vegetative development, enhancing yield attributes and seed yield of cotton. G. Cot-44 with mepiquat chloride + detopping was found to be the best combination for optimum growth regulation and increased productivity in HDPS conditions, based on genotype × treatment interaction study. Thus, the combination of proper genotype, growth retardant, and detopping can be recommended under similar agro-climatic conditions as an effective agronomic practice for increasing cotton production.

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