Effect of various growth retardants and detopping techniques on *Bt* cotton (*Gossypium hirsutum* L.) for source sink manipulation

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Abstract: A field experiment to study the manipulation of source sink through growth regulators was carried out during *kharif*, 2023 at Agricultural Research Station, Dharwad Farm. The experiment was laid out in Randomized Block Design with ten treatments and three replications. The treatments include foliar spray of maleic hydrazide, cycocel, mepiquat chloride and detopping in isolation and control. The study revealed that the significant impacts of growth retardants and detopping on morphological parameters such as plant height, monopodial and sympodial branch count. The study found that significant variations in physiological parameters such as SPAD values and dry matter production. Among different treatments the application of maleic hydrazide, cycocel and mepiquat chloride as growth retardants along with detopping, resulted in increased seed cotton yield, attributed to delayed senescence of leaves, leading to an extended period of photosynthate supply to the reproductive parts. Whereas, the treatment with maleic hydrazide at 30 ppm after 80 days of sowing showed superior growth and productivity compared to other treatments. The study concluded that the application of growth retardants and detopping techniques can optimize dry matter allocation, enhance photosynthetic activity and improve crop productivity in *Bt* cotton.

Key words: Growth, Morphological, Source sink, SPAD values, Yield parameters

Introduction

Cotton (Gossypium hirsutum L.) is a major commercial cash and fiber crop grown in over 70 countries. It is a key raw resource for the economy regarding job creation and foreign exchange and referred as "white gold," or "king of fibers." Cotton belongs to the Malvaceae family and the genus Gossypium. Cotton is one of India's most important crop, contributing considerably to export profits and jobs. India accounts for around 25% of the world's cotton productivity. Cotton covers around 12.7 million hectares, produces 260.5 lakh bales and productivity of 439 kg ha⁻¹ (USDA Foreign Agriculture Service 2024). Gujarat, Maharashtra, Andhra Pradesh and Karnataka are the top cotton-producing states. Cotton is grown on 6.95 lakh hectares in Karnataka, producing 16.38 lakh bales and yielding 414.12 kg ha⁻¹.

Plant growth regulators (PGRs) can be used to modulate plant growth and development by applying them in small amounts, allowing for precise management of crop productivity and quality. Following herbicides, insecticides and fertilizers in the agrochemical hierarchy, they are regarded as the next generation inputs. Under field conditions, plant growth regulators can raise output by 10% to 15% (Kumar et al., 2005). Organic molecules known as plant growth regulators either stimulate, inhibit or alter the plant's physiological and/or morphological activities. By encouraging crop earliness, enhancing square, flower and boll retention, raising nitrogen absorption and preserving a balance between vegetative and reproductive growth, they have the potential to increase yield and quality (Deol et al., 2018).

Enhancing cotton productivity is largely dependent on cultural practices, such as detopping. The primary goal of detopping is to optimize plant architecture, allowing for optimal solar radiation and little mutual shadowing. This will boost picking efficiency when the crop reaches maturity. Cotton field duration can be shortened by using the detopping technique, according to research by Rathinavel (2003) and Dai *et al.* (2022) in the Journal Pre-proof 3. Detopping of plant height (75 cm) improves the number of fruiting branches, the percentage of boll on sympodial branches, boll number, boll weight and seed cotton yield (Obasi and Msaakpa, 2005). Detopping enhances seed cotton output by 15.1 to 21.1 percent, as well as the number of bolls plant and sympodial branches plant (Kataria and Valu, 2018).

Material and methods

The present investigation was carried out to study the influence of plant growth retardants and detopping for optimization of source sink for enhancing the product of Bt cotton during kharif 2023. The experiment was layed out in RBD and the genotype used for the experiment was RCH-659. The treatments comprised of ten treatments *i.e.* T₁. Control; T₂: Detopping; T₂: Mepiquat chloride @45ppm at square initiation; T₄: Mepiquat chloride @ 45ppm at square initiation +Detopping;T₅: Mepiquat chloride @ 45ppm at square initiation and 15 days after first spray; T₆: Mepiquat chloride @ 45ppm at square initiation and 15 days after first spray + Detopping; T₂: Mepiquat chloride @ 45ppm at square initiation and 15 days after first spray and 15 days after second spray; T₈: Mepiquat chloride @ 45ppm at square initiation and 15 days after first spray and 15 days after second spray + Detopping; T₉: Cycocel @ 60ppm after 80 Days of sowing; T₁₀: Maleic hydrazide @ 30 ppm after 80 Days of sowing. Five plants were selected randomly from each replication and data was recorded for the characters viz., plant height (cm) at harvest, monopodia

Table 1. Effect of foliar application of plant growth retardants and detopping on plantheight at different growth stages in Bt cotton

Treatments	P	Plant height (cm)	
	90 DAS	120 DAS	At harvest
T, Control	71.45ª	102.75a	114.07a
T, Detopping	38.59°	57.38°	56.07^{d}
T ₃ Mepiquat chloride @ 45 ppm at square initiation	53.49 ^{cd}	74.65 ^b	83.53 ^b
T ₄ Mepiquat chloride @ 45 ppm at square initiation + detopping	37.43°	56.35 ^{cd}	$66.40^{\rm cd}$
T ₅ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray	46.65^{de}	65.81 ^{bc}	80.13 ^{bc}
T ₆ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray + detopping	37.59°	43.37^{d}	52.27^{d}
T ₇ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and 15 days	45.29 ^{de}	63.99^{bc}	73.13 ^{bc}
after second spray			
T ₈ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and 15	37.35°	41.90^{d}	54.53 ^d
days after second spray + detopping			
T _o Cycocel @ 60 ppm after 80 days of sowing	61.41 ^{bc}	94.39ª	103.87a
T ₁₀ Maleic hydrazide @ 30 ppm after 80 days of sowing	66.58^{ab}	95.61ª	106.53a
Mean	49.58	69.62	79.05
S.E m. (±)	3.10	4.41	4.98
C.D. at 5%	9.22	13.11	14.79

branches, sympodia branches, total dry matter, number of bolls, bolls weight per boll and seed cotton yield. The data was analyzed to find out the superior treatment with growth retardants for development of good quality cotton suitable for maximizing yield.

Results and discussion

The application of anti-gibberellin agents like, cycocel, maleic hydrazide and mepiquat chloride, reduced plant height by suppressing a transverse cell division and source sink balance. The higher plant height (cm) was observed in control

Table 2. Effect of foliar application of plant growth retardants and detopping on SPAD values (SCMR) at different stages in *Bt* cotton

Treatments	SPAD val	SPAD values (SCMR)	
	90 DAS	120 DAS	
T ₁ Control	35.07 ^d	36.7°	
T, Detopping	39.75^{bcd}	38.6 ^{bc}	
T ₃ Mepiquat chloride @ 45 ppm	44.21 abc	40.9^{abc}	
at square initiation			
T ₄ Mepiquat chloride @ 45 ppm at	46.03^{ab}	38.9 ^{bc}	
square initiation +detopping			
T ₅ Mepiquat chloride @ 45 ppm at square	46.58^{ab}	40.5^{abc}	
initiation and 15 days after first spray			
T ₆ Mepiquat chloride @ 45 ppm at	48.49^{a}	41.1 ^{abc}	
square initiation and 15 days after			
first spray + detopping			
T ₇ Mepiquat chloride @ 45 ppm at	49.09^{a}	43.5ab	
square initiation and 15 days after			
first sprayand 15 days after second spra	у		
T ₈ Mepiquat chloride @ 45 ppm at	48.79a	45.0^{a}	
square initiation and 15 days after first			
spray and 15 days after second spray +			
detopping			
T ₉ Cycocel @ 60 ppm after 80 days	34.45^{d}	38.2^{bc}	
of sowing			
T ₁₀ Maleic hydrazide @ 30 ppm after	36.61^{cd}	37.0°	
80 days of sowing			
Mean	42.91	40.02	
S.Em(±)	2.60	1.69	
C.D. at 5 %	7.71	5.03	

followed by T_{10} (maleic hydrazide @ 30 ppm after 80 DAS) and T_9 (cycocel @ 60 ppm after 80 DAS) relative to other treatments in all growth stages. The plant height was found significantly lowest in treatment T_8 (mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and 15 days after second spray + detopping) closely followed by T_6 (mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray + detopping) as compared to other treatments in different growth

Table 3. Effect of foliar application of plant growth retardants and detopping on monopodial and sympodial branches at harvest stages in *Bt* cotton

	Number of	Number of
	monopodial	sympodia
	branches	branches
T ₁ Control	1.3 ^b	22.00ab
T, Detopping	1.1 ^{bc}	13.93 ^d
T ₃ Mepiquat chloride @ 45 ppm at square initiation	1.2 ^{bc}	21.13 ^{ab}
T ₄ Mepiquat chloride @ 45 ppm at square initiation + detopping	1.0°	16.40 ^{cd}
T ₅ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray	1.3 ^b	21.20 ^{ab}
T ₆ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray + detopping	1.3 ^b	14.27 ^d
T ₇ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and 15 days after second spray	1.1 ^{bc}	19.47 ^{bc}
T ₈ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and 15 days after second spray + detopping	1.3 ^b	15.47 ^d
T ₉ Cycocel @ 60 ppm after 80 days	1.00	22 27sh
of sowing	1.8a	22.27ab
T ₁₀ Maleic hydrazide @ 30 ppm after 80 days of sowing	1.9ª	23.93ª
Mean	1.3	19.01
S. $Em(\pm)$	0.08	1.11
C.D. at 5 %	0.25	3.29

Effect of various growth retardants and detopping.....

Table 4. Effect of foliar application of plant growth retardants and detopping on total dry matter (TDM) at different growth stages in Bt cotton

Treatments	Total dry matter (TDM)(g pla		
	90 DAS	120 DAS	At harvest
T, Control	25.78°	77.88°	132.67 ^{de}
T, Detopping	31.57^{ab}	$96.62^{\rm cd}$	164.17 ^b
T ₃ Mepiquat chloride @ 45 ppm at square initiation	24.17°	76.63°	140.33^{cde}
T ₄ Mepiquat chloride @ 45 ppm at square initiation +detopping	28.17^{bc}	89.47^{d}	155.98 ^{bc}
T ₅ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray	24.37°	75.92°	125.33°
T ₆ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray + detopping	28.05^{bc}	$94.95^{\rm cd}$	150.00^{bcd}
T ₂ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and	28.35^{bc}	99.53°	162.00^{bc}
15 days after second spray			
T ₈ Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and	26.31°	77.44°	130.70^{de}
15 days after second spray + detopping			
T _o Cycocel @ 60 ppm after 80 days of sowing	30.73^{ab}	109.48 ^b	186.78a
T ₁₀ Maleic hydrazide @ 30 ppm after 80 days of sowing	$34.70^{\rm a}$	122.87a	192.77ª
Mean	28.22	92.08	154.07
$S.Em(\pm)$	1.29	3.06	7.21
C.D. at 5%	3.84	9.10	21.42

stages which presented is Table 1. Results are similar to the earlier studies (Kaur and Patil (2013), Kumar *et al.* (2005), Patil *et al.* (2005) and Mondino *et al.* (2004)).

The SPAD values, serve as an indicator of leaf greenness and relative chlorophyll concentration (Kariya *et al.* 1982; Torres-netto *et al.* 2005). This parameter has a significant impact on photosynthesis rate, dry matter production as well as cotton. This study found that T_8 (mepiquat chloride @45 ppm at square initiation and 15 days after first spray and 15 days after second spray + detopping) resulted in the highest chlorophyll content and lower chlorophyll content observed in control presented in Table 2 and supporting the conclusions of Heilman and Brown (1981), Reddy *et al.* (2000), Kumar *et al.* (2005) and Koler *et al.* (2008).

The number of monopodia and sympodia was affected by the application of plant growth retardants and detopping in the treatments. Mepiquat chloride, conversely, resulted in fewer monopodia than the control and thus supports the results of previous investigations (Kumar *et al.* (2001), Vistro *et al.* (2017) and Brar *et al.* (2020), Kamboj *et al.* (2023). The data on monopodia and sympodia branches was influenced

significantly due to different treatments. The treatment T_{10} (maleic hydrazide @ 30 ppm after 80 DAS) followed by T_9 (cycocel @ 60 ppm after 80 DAS) proved to be significantly superior in efficacy compared to other treatments. While treatment, T_2 (detopping) recorded the lower monopodia and sympodia branches among the treatments (Table 3).

All the treatments resulted in maximum total dry matter production by harvest time. Among the growth retardants, $T_{\rm 10}$ (maleic hydrazide @ 30 ppm applied 80 DAS) the resulted in the maximum dry matter production relative to the control. Lower TDM was recorded in $T_{\rm 8}$ (mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and 15 days after second spray + detopping), which was lower than control which presented in Table 4. The reduction in dry matter accumulation may be due to reduced plant height and an increase in the source-sink relationship impacted by the application of various plant growth retardants and detopping. similar trends were also observed in studies on dry matter partitioning and yield by Prakash and Prasad (2000) Kataria and Khanpara (2012) and Priyank $\it et al.$ (2021).

Table 5. Effect of foliar application of plant growth retardants and detopping on number of bolls plant⁻¹, boll weight (g boll⁻¹) and yield (kg ha⁻¹) in *Bt* cotton

	Treatments	No.of bolls	Boll weight Yield	
		plant ⁻¹	(g boll-1)	(kg ha ⁻¹)
$\overline{T_1}$	Control	10.40 ^f	5.50abc	582.0°
T_2	Detopping	13.87 ^{de}	5.10°	704.00^{de}
T_3^2	Mepiquat chloride @ 45 ppm at square initiation	15.00^{cd}	$5.90^{ m abc}$	850.98^{cd}
T_4	Mepiquat chloride @ 45 ppm at square initiation +detopping	15.87 ^{bcd}	$6.00^{ m abc}$	924.46°
T_5	Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray	13.33^{def}	5.20^{bc}	690.77°
T_6	Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray + detopping	16.33 abcd	6.50a	1159.62 ^b
T_{7}^{0}	Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray	17.20^{abc}	6.30^{ab}	1196.36ab
,	and 15 days after second spray			
T_8	Mepiquat chloride @ 45 ppm at square initiation and 15 days after first spray and	11.47 ^{ef}	5.20^{bc}	676.08°
0	15 days after second spray + detopping			
T_9	Cycocel @ 60 ppm after 80 days of sowing	18.67ab	$6.00^{ m abc}$	1266.91ab
T_{10}	Maleic hydrazide @ 30 ppm after 80 days of sowing	18.93 ^a	6.60^{a}	1337.46a
	Mean	15.11	5.83	938.87
	$S.Em(\pm)$	0.93	0.33	51.10
	C.D. at 5 %	2.77	0.99	151.80

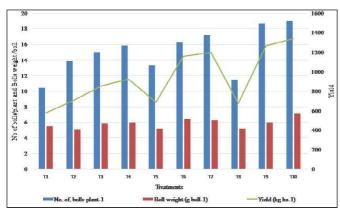


Fig 1. Effect of foliar application of plant growth retardants and detopping on number of bolls per plant, boll weight and seed cotton yield at harvest stages in *Bt* cotton

Among the treatments, T_{10} (maleic hydrazide @ 30 ppm applied 80 DAS) resulted in the maximum number of bolls plant¹, boll weight (g boll⁻¹) and yield (Kg ha⁻¹) compared to control. However lower number of bolls plant⁻¹, boll weight (g boll⁻¹) and yield (Kg ha⁻¹) was recorded in control and in treatment T_8 (mepiquat chloride @ 45 ppm at square initiation and 15 days

after first spray and 15 days after second spray + detopping) (Table 5). The application of maleic hydrazide, cycocel, and mepiquat chloride as growth retardants along with detopping resulted in increased yield, which can be attributed to the delayed senescence of leaves, leading to an extended period of photosynthate supply to the reproductive sink. Moreover, mepiquat chloride was found to increase leaf thickness, subsequently enhancing photosynthesis, has also been reported in various studies by Abro *et al.* (2004), Zakir (2006) Koler (2008) and Copur *et al.* (2019).

Conclusion

The application of anti-gibberell in agents, specifically cycocel, maleic hydrazide and mepiquat chloride, resulted in reduced plant height, increased chlorophyll content, and improved yield in cotton. The treatments T_{10} (maleic hydrazide @ 30 ppm after 80 DAS) and T_{9} (cycocel @ 60 ppm after 80 DAS) proved to be significantly superior in efficacy compared to other treatments, resulting in increased monopodia and sympodia branches, dry matter production and yield. The study suggests that the application of these growth retardants can be an effective in improving cotton yield and productivity.

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