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

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(12): 914-918
Received: 17-10-2025
Accepted: 19-11-2025

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Interactive effects of detopping and planting systems on growth dynamics and yield of *Bt* cotton (*Gossypium* spp.)

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i12m.4516

Abstract
An experiment entitled "Effect of De-topping and Planting System on Growth and Yield of Bt-Cotton" was conducted at Cotton Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani (M.S.) during the year 2019-20 in split-plot design with three replications. The experiment comprised of three main treatments consist of planting systems *viz.*, S_1 - (150 x 30 cm), S_2-(150 x 15 cm), S_3 - (150:75 x 30 cm) and four sub treatments *viz.* T_1- Control, T_2- De-topping of apical bud at 75 DAS, T_3-De-topping of apical buds at 75 DAS and removal of side branches at 90 DAS and T_4-De-topping of apical bud at 90 DAS. The results obtained from this experiment shows that the planting system of S_3 - (150:75 x 30 cm) along with de-topping of apical buds at 75 DAS recorded significantly higher all the growth characters and yield attributes such as number of functional leaves, leaf area plant^{-1}, monopodial and sympodial branches, dry matter plant^{-1}, picked boll and seed cotton yield plant^{-1}, and straw yield as compared to plant density of S_2 and S_1 and no topping. Adoption of planting system of S_3 (150:75 x 30 cm) along with de-topping of apical buds at 75 DAS for obtaining higher seed cotton yield and found productive, remunerative and profitable under rainfed condition of Marathwada region of Maharashtra.

Keywords: Cotton, de-topping, planting system, growth, yield, yield attributes

Introduction
Cotton (*Gossypium hirsutum* L.) is the most important fibre crop of India and backbone of textile industry. In India, cotton is cultivated over an area of approximately 126.80 lakh hectares, with a total production of 325 lakh bales and an average productivity of 436 kg ha^{-1} (CICR, Annual Report 2023-24) [1]. Although India ranks first globally in cotton acreage, accounting for nearly 39% of the world's cotton area (about 125 lakh hectares), it contributes only 22% to global cotton production, highlighting a substantial gap in yield realization. Maharashtra, one of the leading cotton-producing states in the country, accounts for 42.34 lakh hectares under cotton cultivation, producing 80.45 lakh bales, with a relatively low productivity of 323 kg ha^{-1}. Within Maharashtra, the Marathwada region plays a significant role, covering 14.05 lakh hectares and producing 20.04 lakh bales of cotton; however, the productivity in this region remains considerably lower at 265 kg ha^{-1} (CICR, 2023-24).
Cotton seed contain 15.20 percent oil which can used for edible purpose after refining and left over cake is nutritious feed for livestock and concentrated organic manures which contains 6.4% N, 2.9% P and 2.2% K.
Plant population is one of the most important factors for efficient utilization of available sources like light, soil moisture, nutrients and CO_2 which ultimately influences yield. So there must be optimization of plant population for increasing production. De-topping of cotton terminal bud and side pruning of branches considered as important adjustment for plant geometry of cotton plants. De-topping practice reduces lodging and increases yield of Bt-Cotton. Therefore a field experiment entitled "Effect of de-topping and planting system on the growth and yield of Bt-cotton was planned.

Materials and Methods
A field experiment was conducted during *Kharif* season the year 2019-20 in split-plot design

replicated thrice on the experimental farm of Cotton research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The topography of experimental field was fairly uniform, leveled with a good drainage and the soil was clayey in texture, low in available nitrogen and phosphorous and very high in available potash and slightly alkaline in reaction. Agro-climatically Parbhani is situated at latitude, longitude and altitude of 19^0 16' N, $76^0$47' E and 409 m above MSL respectively.

The climate of the Parbhani is tropical and average annual precipitation of last 35 years was 960.7 mm. The monsoon commenced in the second week of June and sowing of cotton experiment was under taken on June 21th. The amount of rainfall received during the cropping season was 934.9 mm in 49 rainy days.

The land was prepared by tilling once by tractor driven cultivar, one harrowing were done by Disc harrow to obtain the desirable fine seed bed. RDF (120:60:60 kg NPK) was applied in two split doses. The treatments combinations consist of three main plot treatments of planting systems *viz*., S_1 - (150 x 30 cm), S_2-(150 x 15 cm), S_3 - (150:75 x 30 cm) and four sub plot treatments *viz*. T_1- Control, T_2- De-topping of apical bud at 75 DAS, T_3-De-topping of apical buds at 75 DAS and removal of side branches at 90 DAS and T_4-De-topping of apical buds at 90 DAS. To protect the crop from sucking pests, crop was sprayed by Neem ark 5% and Triazophos 60% EC.

Results and Discussion

Growth attributes

Planting Systems

Data on mean plant height (cm), number of functional leaves plant^{-1}, number of sympodial branches plant^{-1}, leaf area plant^{-1} and mean total dry matter plant^{-1}(g) as influenced by different treatment combinations recorded periodically and presented in Table.01. A glance of data indicate that growth parameters significantly influenced by various planting systems. A planting system of 150:75 X 30 cm (S_3) recorded significantly more plant height (132.02 cm) at harvest, maximum number of leaves plant^{-1} (92.90) at 120 DAS, leaf area plant^{-1} (49.69 dm^2) at 120 DAS, more number of sympodial branches plant^{-1} (25.15) at harvest and highest mean total dry matter (76.34 g) as compared to S_1 and S_2 planting systems. Similar results were observed by Paslawar *et al*., (2015) [6], Pendharkar *et al*., (2011) [8] and Jagtap and Bhale (2010) [3].

De-topping

Growth parameters are significantly influenced by de-topping of apical buds at 75 DAS. Plant height was significantly reduced in T_2-de-topping at 75 DAS (133.83 cm at harvest) as compared to control plot T_1 (147.17 cm). Topping at 75 DAS (T_2) significantly increased highest number of leaves plant^{-1} at 120 DAS, leaf area plant^{-1} (44.94 dm^2), number of sympodial branches plant^{-1}(25.54) at harvest and total dry matter (67.03 g) as compared to rest of the treatments.

Interaction

In Interaction effect, treatment combination of S_3T_1 was found to be significant and recorded maximum plant height (152.30 cm at harvest) and maximum no. of leaves plant^{-1} (97.41 at 120 DAS) whereas treatment combination of S_3T_2 recorded significantly highest number of sympodial branches plant^{-1} at harvest (29.00) and dry matter accumulation plant^{-1} (100.49 gm at 150 DAS) as compared to rest of the treatments.

Yield attributes and yield

Planting Systems

Yield attributing characters such as number of bolls per plant^{-1}, boll weight, ginning percentage, seed index and seed cotton yield as influenced by different treatments are presented in Table no.02. Significantly highest number of bolls plant^{-1}(36.75), boll weight (2.54 gm) and maximum seed cotton yield (2305 kg/ha) was recorded in S_3 (150:75X 30 cm) planting system as compared to rest of the treatments whereas seed index and ginning percentage was found to be non significant. Such type of findings were also reported by Pawar *et al*., (2010) [7], Chavan *et al*., (2011) [2] and Mohapatra and Nanda (2011) [4].

De-topping

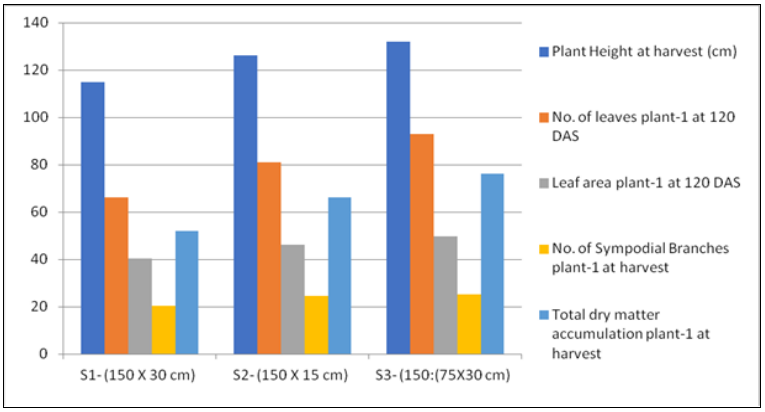
De-topping of apical buds at 75 DAS (T_2) recorded significantly higher number of bolls plant^{-1} (27.60), maximum boll weight (2.70 g) and seed cotton yield (2177 kg/ha) over no topping (T_1) and was at par with rest of the treatments.

Interaction

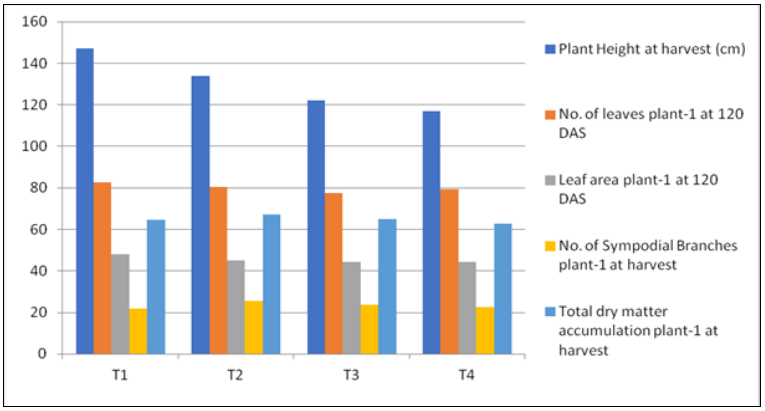
Interaction effect found to be significant with respect to seed cotton yield. Treatment combination of planting system of S_3 and de-topping of apical buds at 75 DAS recorded high seed yield (2402 kg/ha) which was significantly higher over rest of the treatments.

Table 1: Growth attributing characters of cotton as influenced by different treatments

Treatment Details		Plant Height at harvest (cm)	No. of leaves plant^{-1} at 120 DAS	Leaf area plant^{-1} at 120 DAS	No. of Sympodial Branches plant^{-1} at harvest	Total dry matter accumulation plant^{-1} at harvest
Planting systems						
S_1	150 X 30 cm	115.02	66.25	40.56	20.32	52.09
S_2	150 X 15 cm	126.09	81.11	46.11	24.75	66.32
S_3	150:(75X30 cm)	132.02	92.90	49.69	25.15	76.34
S.E m±		0.06	0.08	0.03	0.87	0.14
C.D. at 5%		0.017	0.25	0.09	2.58	0.43
De-topping						
T_1	Control	147.17	82.60	48.19	21.80	64.57
T_2	De-topping of apical buds at 75 DAS	133.83	80.60	44.94	25.54	67.03
T_3	De-topping of apical buds and side branches at 90 DAS	122.23	77.66	44.50	23.66	65.16
T_4	De-topping of apical buds at 90 DAS	116.93	79.49	44.19	22.62	62.90
S.E m±		0.25	0.08	0.04	0.87	0.13
C.D. at 5%		0.75	0.25	0.12	2.58	0.39
Interaction						
S.E m±		0.44	0.14	0.07	1.51	0.23
C.D. at 5%		1.30	0.44	0.22	4.48	0.69
GM		130.04	80.09	45.45	23.40	64.91



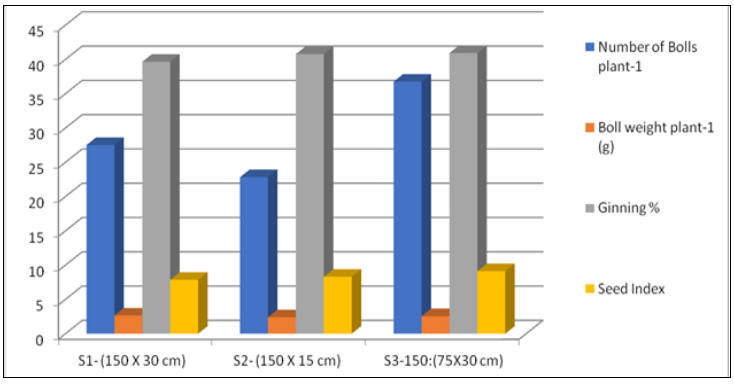
Graph 1: Growth attributing characters of cotton as influenced by different planting systems.



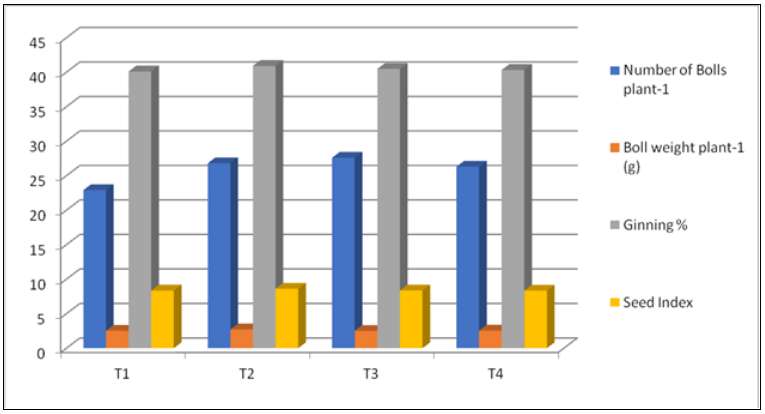
Graph 2: Growth attributing characters of cotton as influenced by de-topping systems.

Table 2: Yield attributes and yield of cotton as influenced by different treatments

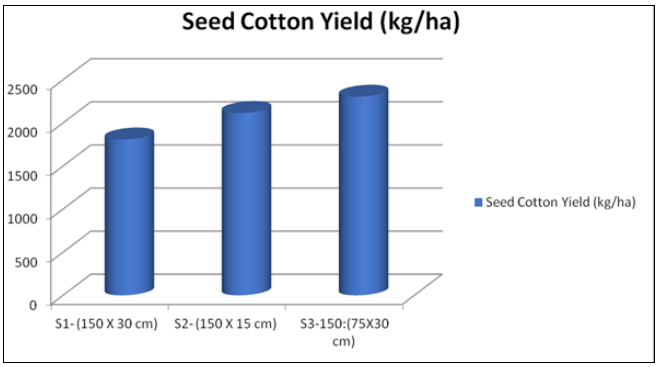
Treatment Details		Number of Bolls plant^{-1}	Boll weight plant^{-1} (g)	Ginning %	Seed Index	Seed Cotton Yield (kg/ha)
Planting systems						
S_1	150 X 30 cm	27.50	2.64	39.65	7.85	1808
S_2	150 X 15 cm	22.82	2.39	40.77	8.30	2115
S_3	150:(75X30 cm)	36.75	2.54	40.92	9.11	2305
S.E m±		0.67	0.01	0.19	0.06	63.86
C.D. at 5%		2.00	0.03	NS	NS	189.47
De-topping						
T_1	Control	22.90	2.52	40.10	8.35	2081
T_2	De-topping of apical buds at 75 DAS	26.80	2.70	40.91	8.62	2177
T_3	De-topping of apical buds and side branches at 90 DAS	27.60	2.50	40.47	8.37	2028
T_4	De-topping of apical buds at 90 DAS	26.30	2.54	40.32	8.34	2018
S.E m±		1.01	0.05	0.66	0.22	74.46
C.D. at 5%		2.99	0.15	NS	NS	220.89
Interaction						
S.E m±		1.75	0.15	1.15	0.038	128.97
C.D. at 5%		NS	NS	NS	NS	382.60
GM		26.69	2.52	40.45	8.42	2076



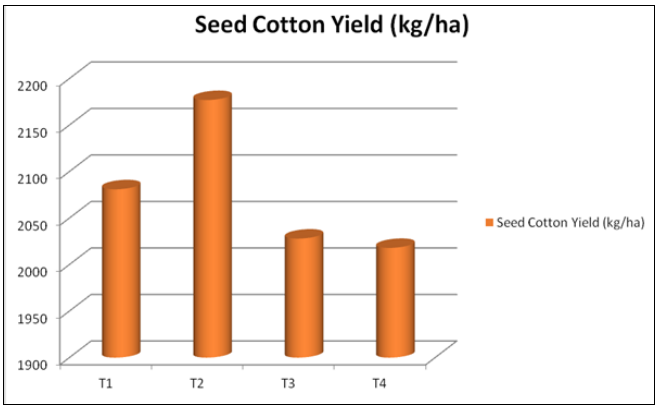
Graph 3: Yield attributing characters of cotton as influenced by different planting systems.



Graph 4: Yield attributing characters of cotton as influenced by de-topping systems.



Graph 5: Seed cotton yield as influenced by different planting systems.



Graph 6: Seed cotton yield as influenced by de-topping systems.

Table 3: Mean plant height (cm) of cotton as influenced by S X T interaction at harvest.

S X T	T_1	T_2	T_3	T_4
S_1	121.40	117.47	112.23	108.93
S_2	136.90	127.83	121.70	117.93
S_3	152.30	136.83	122.50	116.43
S.E m±	0.44			
C.D. at 5%	1.30			

Table 4: Mean number of leaves plant^{-1} of cotton as influenced by S X T interaction at 120 DAS.

S X T	T_1	T_2	T_3	T_4
S_1	67.70	67.03	63.81	66.46
S_2	82.70	81.03	80.13	80.58
S_3	97.41	93.74	89.06	91.42
S.E m±	0.14			
C.D. at 5%	0.44			

Table 5: Mean number of sympodial branches plant^{-1} of cotton as influenced by S X T interaction at 120 DAS.

S X T	T_1	T_2	T_3	T_4
S_1	20.11	21.98	21.03	19.99
S_2	24.01	26.34	25.40	23.32
S_3	22.47	29.00	25.61	24.89
S.E m±	1.51			
C.D. at 5%	4.48			

Table 6: Mean dry matter plant^{-1} of cotton as influenced by S X T interaction at 150 DAS.

S X T	T_1	T_2	T_3	T_4
S_1	69.46	73.19	69.45	71.96
S_2	87.19	87.83	86.35	83.60
S_3	99.28	100.49	96.18	99.21
S.E m±	2.30			
C.D. at 5%	6.83			

Conclusion

The present investigation clearly demonstrated that growth, yield attributes and seed cotton yield were significantly influenced by planting systems and de-topping practices, both individually and in interaction. Among the planting systems, wider paired row planting of 150:75 × 30 cm (S_3) proved superior by promoting better crop growth in terms of plant height, number of functional leaves, leaf area, sympodial branches and total dry matter accumulation. This favourable growth environment translated into significantly higher yield attributes such as number of bolls per plant, boll weight and ultimately resulted in maximum seed cotton yield.

De-topping of apical buds at 75 DAS (T_2) effectively modified plant architecture by reducing excessive vertical growth and enhancing lateral branching, leaf production and dry matter accumulation. This led to improved reproductive efficiency, reflected through increased number of bolls per plant, higher boll weight and superior seed cotton yield compared to no topping.

The interaction effects further confirmed that the combined adoption of S3 planting system with de-topping at 75 DAS (S_3T_2) was the most productive treatment combination, recording the highest sympodial branches, maximum dry matter accumulation and significantly higher seed cotton yield. Thus, the study concludes that paired row planting at 150:75 × 30 cm along with de-topping of apical buds at 75 DAS is an effective agronomic strategy for optimizing growth and maximizing productivity of cotton under the given agro-climatic conditions.

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