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

www.agronomyjournals.com
2024; SP-7(10): 753-756
Received: 04-08-2024
Accepted: 10-09-2024

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Yield maximization of Bt cotton by integrated crop management techniques

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i10Sk.1893

Abstract
A field experiment was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season of 2023-2024 to study the effect of integrated crop management techniques on growth, yield and economics of Bt cotton. The experiment was laid out in randomised block design with three replications. There were nine treatments having HDPS planting and different canopy management practices. The results revealed that, T_1 (recommended spacing) had better crop growth, Dry matter accumulation per plant, number of sympodial branches per plant, number of picked bolls per plant, seed cotton yield per plant, and harvest index when compare to other treatments under rainfed condition. The seed cotton yield (kg/ha) was significantly highest in T_9-T_2 + Detopping at 100 cm height + Pruning of monopodia at 45 DAS + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS (2690 kg/ha) which was found significantly superior over other treatments. T_9 (T_2 + Detopping at 100 cm height + Pruning of monopodia at 45 DAS + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS) also reflected in maximum GMR (182113 Rs ha^{-1}), NMR (114033 Rs ha^{-1}) and B:C ratio (2.67) than other treatments.

Keywords: Bt cotton, HDPS planting, canopy management practices

Introduction
Cotton is derived from the Arabic term 'Quntun'. Cotton (*Gossypium* sp.) is a major cash crop in India, sometimes known as 'White Gold' or 'King of Fibre'. It has an important role in the rural, national, and global economies.

Cotton is a member of the order Malvales, family Malvaceae, and genus Gossypium, which has 50 wild and cultivated species, only four of which are farmed commercially worldwide. G. hirsutum and G. barbadense account for over 95% and 3% of global production, respectively, while G. arboreum and G. herbaceum contribute for approximately 2% of global production. Egyptian, Pima (American Egyptian), and Sea Island are extralong staple cottons from the G. barbadense species. The Northern hemisphere accounts for around 90% of global cotton output, with cotton grown in over 100 nations.

According to the second advance estimates 2023-24, Government of India cotton crop is estimated at 323.11 lakh bales as compared to 336.60 lakh tonnes in 2022-23. Among the states, Gujarat is leading in cotton production with 89.65 lakh bales followed by Maharashtra (82.43 lakh bales), Telangana (48.12 lakh bales), Rajasthan (27.43 lakh bales) and Madhya Pradesh (17.97 lakh bales). Indian Cotton Scenario As on 21 st September 2023, area under cotton during 2023-24 was 123.42 lakh ha as against 127.57 lakh ha in 2022-23. Among the states, Maharashtra is leading in cotton acreage with 42.22 lakh ha followed by Gujarat (26.82 lakh ha), Telangana (18.22 lakh ha), Rajasthan (7.91 lakh ha) and Haryana (6.65 lakh ha).

Cotton (*Gossypium hirsutum* L.) is indeterminate in nature. For getting higher Productivity of Bt cotton under HDPS in rainfed condition some improved agronomic production technologies are needed. Growth modification practices become important by converting its phase of vegetative to reproductive growth to ensure a proper nutrient source-sink relationship. Induction of higher number of sympodial branches and thereby increase in number of square, bolls are essential for yield maximization of seed cotton. Therefore, there is need to manipulate the growth of cotton to get a good architecture so that the plant can get required sunlight with minimal mutual shading.

To improve the productivity several agro techniques like detopping, removal of monopodia is important. Excessive vegetative growth leads to severe production problem like fruit abortion, delay maturity, boll rot and harvest difficulties. Plant growth regulator are substance when added in small amount modify the growth of the plant usually by inhibiting part of natural growth regulation. The most commonly used growth regulator in cotton is mepiquat chloride, which is an inhibitor of gibberellic acid. Growth retardant like mepiquat chloride reduce internodal length, therefore decrease plant height, which increase the number of node and bolls per plant which result in increase in yield.

Materials and Methods

The field experiment was carried out at Cotton Research Unit Field, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the kharif season of 2023-2024. The topography of the field was rather uniform and level. The soil was medium black cotton of Vertisols.

The experiment was laid out in randomised block design with three replications. There were nine treatments having HDPS planting and different canopy management practices. The treatments comprised of HDPS planting and different canopy management practices viz, T_1 (Recommended spacing 90 × 60), T_2 (HDPS planting 90 × 30), T_3 (T_2 + Detopping at 100 cm height), T_4 (T_2 + Pruning of monopodia at 45 DAS), T_5 (T_2 + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS), T_6 (T_2 + Pruning of monopodia at 45 DAS + Detopping at 100 cm height), T_7 (T_2 + Detopping at 100 cm height + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS), T_8 (T_2 + Pruning of monopodia at 45 DAS + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS), T_9 (T_2 + Detopping at 100 cm height + Pruning of monopodia at 45 DAS + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS). The Bt cotton used was Ajeet 155 BG II hybrid suitable for rainfed condition with a spacing of 90 cm x 60 cm and 60 cm x 30 cm.

During the course of investigation, in order to know the effect of integrated crop management techniques on growth, yield and economics of Bt cotton, the observations were recorded at different stages of the crop growth.

Results and Discussion

Effect on Growth and Yield parameters

Table 1: Growth and Yield attributes of cotton as influenced by HDPS planting and different canopy management practices

Treatments	Plant height (cm)	Number of sympodial branches plant^{-1}	Total dry matter accumulation plant^{-1}	Seed cotton yield (kg ha^{-1})	Biological yield (kg ha^{-1})
	At harvest	At harvest	At harvest	At harvest	At harvest
T_1	86.2	25.04	121.74	1805	4074
T_2	90.6	17.72	92.22	2125	5539
T_3	75.27	19.11	95.05	2365	5887
T_4	90.38	19.36	97.56	2243	5856
T_5	78.08	21.78	115.71	2307	6408
T_6	78.49	19.7	110.71	2589	6875
T_7	70.93	21.92	111.70	2330	6467
T_8	80.1	21.84	113.81	2277	6492
T_9	78.54	22.03	119.37	2690	7111
SE(m)±	3.18	1.13	3.85	84.06	223.75
CD at 5%	9.54	3.38	11.55	252.18	607.8
GM	80.95	20.94	108.65	2303.57	6078

DAS = Days after Sowing

The table presents the effects of HDPS planting and different canopy management practices treatments on plant height, numer of sympodial branches per plant, total dry matter accumulation per plant, seed cotton yield (kg ha^{-1}) and biological yield (kg ha^{-1}). The results revealed that significantly higher plant height (90.60 cm) was recorded in HDPS planting 90 cm × 30 cm. However T_1 (86.20 cm) and T_4 (90.38 cm) were found significantly at par with T_2 (HDPS planting 90 cm × 30 cm). Lowest plant height (70.93 cm) was recorded in T_7. Significantly higher number of sympodial branches per plant (25.04) and dry matter accumulation per plant (121.74 g) were recorded in T_1 (recommended spacing 90 cm × 60 cm). However T_5, T_7, T_8 and T_9 were found significantly at par with T_1 (recommended spacing 90 cm × 60 cm). Lowest number of sympodial branches per plant (17.72) and dry matter accumulation per plant (92.22 g) were recorded in T_2 (HDPS planting 90 cm × 30 cm). The seed cotton yield (kg ha^{-1}) and biological yield (kg ha^{-1}) were influenced significantly due to HDPS planting and different canopy management practices. Among different treatments, significantly highest seed cotton yield (2690 kg ha^{-1}) and biological yield (7111 kg ha^{-1}) were recorded in T_9 (HDPS planting + pruning of monopodia at 45 DAS + detopping at 100 cm height + Two spray of mepiquat chloride @ 25 g a.i. at 45 and 60 DAS) treatment. However T_6 was found significantly at par with T_9 in respect of seed cotton yield. The lowest seed cotton yield of cotton (1805 kg ha^{-1}) and biological yield (4074 kg ha^{-1}) was recorded with T_1 (recommended spacing).

The taller plants which were observed at closer spacing were due to higher interplant competition. Decrease in plant height was due to termination of apical dominance by detopping and interference of mepiquat chloride as growth regulator in Gibberellic acid biosynthetic pathway. The reduced amount of gibberellins in the plant system affects the growth and decrease plant height. These results are in confirmity with the results reported by Brar *et al*. (2000) [3], Manjunatha (2009) [11], Virdia (2011) [14], Dodiya *et al*. (2018) [5].

The distribution of dry matter in different plant parts showed that at early stages, leaves contributed to a greater proportion of total dry matter but at later stages stem and reproductive parts contributed more. The investigation of Meredith and Wells (1989) [15] showed the same results.

The increase in number of sympodial branches might be due to cumulative effect of detopping, removal of monopodia and spray of mepiquat chloride. Growth modification practices become more important by converting its phase of vegetative to reproductive growth. Removing terminal portion by detopping

of cotton after prominent vegetative growth stage and removal of monopodia may be promising for encouraging growth of already formed sympodials as well as more formation and development of fruiting bodies. Removal of monopodia and suppressing plant height by detopping, helps in initiation of more lateral branches and improving the mobilization of assimilates to reproductive parts thus increasing sympodial branches plant^{-1}. The application of chloro mepiquat chloride provided seat for more number of nodes and internodes where sympodial branches emerged resulting in greater number of sympodia. The lower sympodial branches observed on plant at closer spacings was due to higher interplant competition at higher plant densities. These results are in accordance with those reported by Pothiraj *et al*. (1995) [12] Jones and Wells (1997) [9], Bednarz *et al*. (2000) [2], Brar *et al*. (2000) [3], Shwetha *et al*. (2009) [13], Kataria and Valu (2018) [10], Dodiya *et al*. (2018) [5] Chaudhari *et al*. (2021) [4].

The increase in yield might be because of detopping and removal of monopodial branches and cumulative effect of more number of sympodial branches per plant, number of bolls per plant and average boll wt. as compared to rest of treatments. Detopping resulted in better architectural plant which may increase penetration of sunlight in canopy because of reduced foliage and lodging resulted in higher photosynthetic activity, as well as more spread of plant which also harvest more sunlight and more photosynthesis. Growth modification practices become more important by converting its phase of vegetative to reproductive growth. Removing terminal portion by detopping of cotton after prominent vegetative growth stage may be promising for encouraging growth of already formed sympodias as well as more formation and development of fruiting bodies. Application of Mepiquat chloride can attributed to several physiological and agronomic factors that improve plants ability to focus its energy on reproductive growth rather than excessive vegetative growth. These results are in conformity with the results reported by Virdia (2011) [14], Shwetha *et al*. (2009) [13], Kataria and Valu (2018) [10], Jadhav *et al*. (2019) [8] and Chaudhari *et al*. (2021) [4].

Effect on Economic studies

The data pertaining to gross monetary returns, net monetary returns, cost of cultivation and B:C ratio of Bt cotton as influenced by HDPS planting and different canopy management practices were presented in table 2.

Considering the economics significantly higher gross monetary return, net monetary return, cost of cultivation were recorded in T_9 (HDPS planting + pruning of monopodia at 45 DAS + detopping at 100 cm height + Two spray of mepiquat chloride @ 25 g a.i. at 45 and 60 DAS) treatment.The highest B:C ratio was recorded in T_9 (HDPS planting + pruning of monopodia at 45 DAS + detopping at 100 cm height + Two spray of mepiquat chloride @ 25 g a.i. at 45 and 60 DAS) treatment. Similar results were recorded by Shwetha *et al*. (2009) [13].

Table 2: Gross monetary returns (Rs ha^{-1}), Net monetary returns (Rs ha^{-1}), cost of cultivation and B:C ratio as influenced by HDPS planting and different canopy management practices in cotton

Treatments	GMR	NMR	COC	B:C Ratio
T_1	122206	70085	52121	2.34
T_2	143885	86540	57345	2.51
T_3	160133	98875	61258	2.61
T_4	151866	87815	64051	2.37
T_5	156206	96387	59819	2.61
T_6	175253	107891	67362	2.6
T_7	157771	96391	61380	2.57
T_8	154130	88641	65489	2.35
T_9	182113	114033	68080	2.67
SE(m)±	5690.61	5690.61	_	_
CD at 5%	17060.45	17060.45	_	_
GM	155951.51	94073.18	_	_

Conclusion

Recommended Spacing (90 cm × 60 cm) had better crop growth, Dry matter accumulation per plant, number of sympodial branches per plant, number of picked bolls per plant, seed cotton yield per plant, and harvest index. HDPS planting + Detopping at 100 cm height + Pruning of monopodia at 45 DAS + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS showed improved yield attributes viz, Seed cotton yield (2690 kg ha^{-1}), lint yield (1002.27 kg ha^{-1}), stalk yield (4421.47 kg ha^{-1}), Biological yield (7111.48 kg ha^{-1}). HDPS planting + Detopping at 100 cm height + Pruning of monopodia at 45 DAS + Two spray of Mepiquat chloride @ 25 g a. i. at 45 and 60 DAS gave highest GMR(182113 Rs/ha), NMR(114033 Rs/ha) and B:C (2.67) ratio.

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