Original Research Article

Yield enhancement of *Bt* cotton through canopy management under rainfed condition

Abstract:

Cotton, the ‘White gold’ is an important commercial crop in India and central India in particular. Sustainable yield can be achieved by increasing plant density and canopy management. Hence an experiment was conducted at Cotton Research Station, Nanded, (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, M.S., India) during *kharif* 2023 on medium black cotton soil in randomized block design. The field trail was conducted with three replications and seven treatments *viz.,*T_1 : Cotton in HDPS - 90 x 30 cm (37,037 plants ha^{-1}), T_2 : HDPS + De-topping at 90 DAS, T_3 : HDPS + De-topping at 75 DAS, T_4 : HDPS + Pruning of monopodia at square formation stage, T_5 : HDPS + Pruning of monopodia at square formation stage and de-topping at 75 DAS, T_6 : HDPS + two sprays of Mepiquat chloride @ 25 g *a.i.* at square formation followed by 15 days and T_7: HDPS + Polymulch + pruning of monopodia at square formation stage and de-topping at 75 DAS.

The results showed that growing of cotton with polythene mulch along with pruning of monopodia at square formation stage and de-topping at 75 DAS treatment recorded highest plant height (109.80 cm), no. of sympodia plant^{-1} (16.53), leaf area (58.16 dm^2 and 109.99 dm^2 at 60 and 90 DAS, respectively), leaf area index at 120 DAS (0.2107), seed cotton yield (2734 kg ha^{-1}) and GMR (` 1,87,767 ha$^{-1}$) as compared to all other treatments. Seed cotton yield was increased by 48.66 per cent, significantly over HDPS planting (90 x 30 cm spacing). While treatment HDPS + pruning of monopodia at square formation stage and de-topping at 75 DAS recorded highest NMR (` 48,896 ha^{-1}) and HDPS + de-topping at 90 DAS recorded highest B:C ratio (1.60) as compared to all other treatments respectively. Treatment HDPS + poly mulch + pruning of monopodia and de-topping recorded highest labour requirement per hectare (112.8 man days) as well as seed cotton yield per labour unit (24.24 kg).

***Key words**: Bt cotton, canopy management, monopodia pruning, detopping, Mepiquat chloride, HDPS*

1. Introduction:

Cotton (*Gossypium hirsutum* L.) is a principal cash crop in India, contributing significantly to agriculture and textile sectors. Significant advancements in hybrids made available, agronomic practices and technologies have resulted in an increase in productivity from 88 kg lint ha^{-1}at independence to approximately 441 kg lint ha^{-1} today (Anonymous) [1]. This improvement can be attributed to the adoption of hybrid cultivars, genetically modified technology, effective pest management strategies, enhanced irrigation infrastructure and integration of crop production technologies.

India ranks first in area (124.69 lakh ha) and second largest cotton producer globally (323.11 lakh bales) and Maharashtra state accounting for approximately 34 per cent area (42.22 lakh ha) and 23.4 per cent production (75.73 lakh bales) of the country during 2023-24 season (Anonymous) [1]. However, regions such as Marathwada in Maharashtra experience persistent challenges, including erratic rainfall and soil moisture deficits which hinder its productivity. It is imperative to optimize agronomic practices to improve cotton productivity and enhance the economic condition of farmers. Implementing high-density planting strategies, particularly the Ultra Narrow Row (UNR) system and High Density Planting System (HDPS) has been shown significant enhancement in yield compared to conventional spacing (Rossi et al., [2] and Khetre et al., [3]).

Innovative agronomic interventions, such as pruning of monopodial branches and the application of plant growth regulators (PGRs) like Mepiquat chloride, play a crucial role in improving seed cotton yield. These practices facilitate optimal plant architecture, enhance photosynthetic efficiency and promote boll retention. Additionally, techniques such as de-topping and use of polymulch can create favourable microclimate for accelerated plant growth. By employing this evidence based agronomic strategies, India can booster its cotton production and enhance its competitive position in the global fiber market.

Monopodial branches in cotton plants do not produce bolls and primarily compete for essential resources such as nutrients and water in early vegetative period. Similarly, terminal shoot utilize photosynthates which can be utilized for development of bolls. Therefore, practices such as de-topping, the terminal bud and removing monopodial branches are crucial adjustments for optimizing the plant geometry of cotton. De-topping reduces the risk of lodging and facilitates the translocation of nutrients towards boll development. This practice ultimately contributes to an increase in the yield of *Bt*cotton Kakade et al., [4]. Hence an experiment was designed for security forces.

2. Materials and methods:

A field experiment was conducted during *Kharif* 2023-24 in randomized block design with three replications at Cotton Research Station, Nanded, VNMKV, Parbhani (M.S.). The topography of experimental field was fairly uniform with a good drainage and the soil was clayey in texture, low in available nitrogen (138.30 kg ha^{-1}) and phosphorous (11.96 kg ha^{-1}) and very high in available potash (442.45 kg ha^{-1}) and slightly alkaline in reaction (pH 8.08). Nanded is situated at 19.13^0 N latitude, 77.34^0 E longitude and altitude of 984 feet above MSL. The climate of the Nanded is sub-tropical and average annual precipitation is 935.3 mm. The monsoon commenced in the second week of June and sowing of cotton crop was under taken on 07^{th} July, 2023. Sowing of cotton was done by dibbling. *Bt* cotton hybrid 'Moksh (KCH15K39 BGII)' was used for the experiment. Sowing of cotton was done under High Density Planting System (HDPS) recommended by university for medium to heavy soil at 90 x 30 cm spacing. The experiment was comprised of seven treatments T_1- Cotton in HDPS - 90 x 30 cm (37,037 plants ha^{-1}), T_2- HDPS + De-topping at 90 DAS, T_3-HDPS + De-topping at 75 DAS, T_4-HDPS + prunning of monopodia at square formation stage, T_5 - HDPS + prunning of monopodia at square formation stage and de-topping at 75 DAS, T_6 - HDPS + two sprays of Mepiquat chloride @ 25 g *a.i.* at square formation followed by 15 days, T_7 - HDPS + poly mulch + prunning of monopodia at square formation stage and de-topping at 75 DAS.

3. Results and Discussion

3.1 Growth Characters:

Data on plant height, number of monopodia and sympodia $plant^{-1}$, leaf area and leaf area index are presented in Table 1. Significantly highest plant height (109.8 cm) was recorded in HDPS + poly mulch + pruning of monopodia at square formation stage and de-topping at 75 DAS (T_7) treatment. Whereas, HDPS + two sprays of mepiquat chloride @ 25 g *a.i.* at square formation followed by 15 days (T_6) treatment recorded significantly lowest plant height (73.73 cm). Reduction in plant height due to Mepiquat chloride might be due to its anti-gibberellin action resulting reduction in internodal length. Reduced plant height due to spraying of Mepiquat chloride was also found by Kumari et al. [5]. There was 14.29 per cent increase in plant height in HDPS + poly mulch + pruning of monopodia and de-topping (T_7) treatment over cotton in HDPS - 90 x 30 cm (T_1). Increased plant height may be due to available moisture, regulation of temperature and slow mineralization of nutrients under poly mulch. Similar results were observed by Pandagale et al., [6].

Significantly highest number of leaves (9.33) at 30 DAS was recorded in treatment T_7: HDPS + poly mulch + pruning of monopodia and de-topping. It might be due togreater availability of moisture as well as resulted increased nutrient availability in poly mulch treatment might have lead to increased number of functional leaves in this treatment. Kumari et al. [7] also reported increase in number of functional leaves $plant^{-1}$ with polythene mulch on broad bed. Number of sympodia $plant^{-1}$ was not influenced by canopy management treatments however, numerically higher number of fruiting branches were found in HDPS + polymulch + pruning of monopodia and de-topping (T_7). Highest number of monopodia $plant^{-1}$ was found in HDPS + two sprays of Mepiquat chloride as well as HDPS

+ de-topping at 90 DAS (1.07, each). The treatments where pruning of monopodial branches was done (T_4, T_5 and T_7), recorded lowest (0.00) number of monopodia at harvest. Leaf area is one of the important factors for photosynthesis potential and harvesting of solar radiation. The leaf area expansion rate between 60 DAS to 90 DAS was 2.02 dm^2 day^{-1}. The significant improvement in leaf area $plant^{-1}$at 60 DAS and 90 DAS was observed in poly mulch treated plot (T_7) which might be due to a greater number of functional leaves and increase in size of leaves as influenced by moisture conservation in poly mulch, favourable microbial activity due to temperature regulation and improved nutrient availability that resulted in more cell division and cell enlargement. These results are in conformity with Kumar et al., [8]. The foliar trait of leaf area index is important for light harvesting capacity and potential of photosynthesis. Highest LAI at 120 DAS (0.2107) was recorded in HDPS + poly mulch + pruning of monopodia and de-topping (T_7) treatment. Increased leaf area in this treatment has depicted to increase in leaf area index. Nalayini et al., [9] also reported higher leaf area index in poly mulch laid cotton. Kumar et al., [8] and Thakur [10] found that LAI was highest with high density due to increase in leaf area per unit of land area.

3.2 Seed cotton yield:

Treatment HDPS + poly mulch + pruning of monopodia at square formation stage and de-topping at 75 DAS (T_7) treatment produced the highest seed cotton yield (2734 kg ha^{-1}) and was significantly superior over all other treatments (Table 2). Increase in plant height, leaf area and number of sympodia due to increased availability of moisture and nutrients leading to partitioning of assimilates in plant due to poly mulch might have increased photosynthesis resulting increased number of reproductive parts per plant and boll weight. Increase in seed cotton yield due to poly mulch, monopodia pruning and detopping were earlier noted by Isal et al., [11], Kakade et al. [4] and Jadhav and Jadhav [12].

3.3 Economics:

Significant increase in seed cotton yield in HDPS + poly mulch + pruning of monopodia and de-topping treatment (T_7) has resulted to significantly higher GMR (₹ 1,87,767 ha^{-1}) as compared to all other treatments (Table 2). Significant increase in gross monetary returns due to polymulch is earlier documented by Isal et al., [13] and Hargilas [14]. Treatment HDPS + pruning of monopodia and de-topping (T_5) was the most profitable treatment with numerically highest NMR (₹ 48,896 ha^{-1}). Pandagale et al., [14] worked out increased cost of poly mulch resulting lower NMR although poly mulch had significant increase in seed cotton yield and gross returns. Hence, NMR was statistically non-significant. Highest Benefit: Cost ratio (1.60) was recorded in treatment T_2 (HDPS + De-topping at 90 DAS). Lower cost of treatment resulted in greater monetary output without much increase in cost of cultivation. Increase in NMR and B:C ratio due to de-topping practice was earlier reported by Jadhav et al., [15] and Dodiya et al., [16].

3.4 Labour requirement:

The HDPS cotton only (T_1) needed significantly least (92.02) number of labours per ha whereas HDPS + poly mulch + monopodia pruning + detopping (T_7) was the most labour-intensive treatment (112.80 ha^{-1}) with significant increase in labour requirement to perform all the practices in the treatment. Pruning of monopodia has increased labour requirement by 6 labour units ha^{-1} whereas de-topping needed 3.2 labours ha^{-1}. Gradual increase in labour requirement was in HDPS + poly mulch + monopodia pruning + de-topping was due to land shaping for BBF, laying poly mulch, performing operations of pruning of monopodia and de-topping and additional labour needed for picking due to increased seed cotton yield in this treatment (T_7). However, it has reduced the manpower requirement for weeding as around 60 per cent area was covered by polyethene mulching paper as well as intercultural operations couldn't carried in poly mulch. Spraying of mepiquat chloride as growth retardant was effective to increase seed cotton yield with least increase in lobour requirement in treatment T_6. The HDPS + poly mulch + pruning of monopodia and de-topping (T_7) treatment recorded highest seed cotton yield per labour unit (24.24 kg man day^{-1}) whereas HDPS + pruning of monopodia and de-topping (T_5) treatment recorded lowest seed cotton yield kg per labour unit (18.90 kg man day^{-1}).

Table 1: Effect of canopy management treatments on plant growth attributes

Treatments	Plant height (cm)	No of sympodia Plant^{-1} at harvest	No of monopodia Plant^{-1} at harvest	No. of functional leaves at 30 DAS	Leaf area (dm^2)		Leaf area index at 120 DAS
					60 DAS	90 DAS	
T_1 : Cotton in HDPS - 90 x 30 cm (37037 plants ha^{-1})	96.07	16.20	1.03	7.47	29.76	97.26	0.1834
T_2 : HDPS + De-topping at 90 DAS	87.13	15.60	1.07	7.40	29.26	95.95	0.1776
T_3 : HDPS + De-topping at 75 DAS	86.80	15.00	0.93	7.57	29.37	91.08	0.1675
T_4 : HDPS + Pruning of monopodia at square formation stage	96.53	16.53	0.00	7.40	28.18	89.56	0.1625
T_5 : HDPS + Pruning of monopodia at square formation stage and de-topping at 75 DAS	87.93	14.93	0.00	7.27	28.92	85.61	0.1568
T_6 : HDPS + Two spray of mepiquat chloride @ 25 g *a.i.* at square formation followed by 15 days	73.73	15.87	1.07	7.37	29.98	89.46	0.1636
T_7: HDPS + Polymulch + Pruning of monopodia at square formation stage and de-topping at 75 DAS	109.80	16.53	0.00	9.33	58.16	109.99	0.2107
SE+	4	0.55	0.03	0.3	1.43	4.38	-
CD at 5%	12.31	1.71	0.10	0.92	4.42	13.51	-
CV (%)	7.59	6.07	9.62	6.76	7.45	8.07	-
GM	**91.14**	**15.81**	**0.59**	**7.68**	**33.38**	**94.13**	**0.1746**

Table 2: Effect of canopy management on seed cotton yield, economics and labour requirement

Treatments	Seed cotton yield (kg ha^{-1})	GMR (` ha^{-1})	NMR (` ha^{-1})	B:C ratio	Labour requirement ha^{-1}	SCY per labour unit (kg man day^{-1})
T_1 : Cotton in HDPS - 90 x 30 cm (37037 plants ha^{-1})	1839	126251	46415	1.58	92.02	19.98
T_2 : HDPS + De-topping at 90 DAS	1890	129779	48829	1.60	95.82	19.72
T_3 : HDPS + De-topping at 75 DAS	1835	125987	45589	1.56	94.97	19.32
T_4 : HDPS + Pruning of monopodia at square formation stage	1913	131353	47969	1.57	99.17	19.29
T_5 : HDPS + Pruning of monopodia at square formation stage and de-topping at 75 DAS	1939	133140	48896	1.58	102.57	18.90
T_6 : HDPS + Two spray of mepiquat chloride @ 25 g *a.i.* at square formation followed by 15 days	1907	130984	46019	1.54	94.49	20.19
T_7: HDPS + Polymulch + Pruning of monopodia at square formation stage and de-topping at 75 DAS	2734	187767	47957	1.34	112.80	24.24
SE±	122.48	8411	7186	0.07	1.84	-
CD at 5%	377.40	25916	N.S.	N.S.	5.67	-
CV (%)	10.56	10.56	26.27	8.36	3.23	-
GM	**2008**	**137895**	**47382**	**1.54**	**98.83**	**20.23**

4. Conclusion :

Based on one year study it can be concluded that sowing of *Bt* cotton hybrid at spacing 90 x 30 cm *i.e.* HDPS + poly mulch + pruning of monopodia at square formation stage and de-topping at 75 DAS increased plant growth characters, seed cotton yield and gross returns. HDPS + pruning of monopodia at square formation stage and de-topping at 75 DAS was most profitable in terms of net returns. The HDPS + Poly mulch + pruning of monopodia at square formation stage and de-topping at 75 DAS needed highest labours per ha however was most efficient treatment with highest seed cotton yield per labour unit use.

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