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

www.agronomyjournals.com
2024; 7(12): 59-64
Received: 08-10-2024
Accepted: 12-11-2024

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Assessment of canopy management technologies in *Bt* cotton under drip irrigation

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i12a.2096

Abstract
The field investigation entitled ‘‘Assessment of canopy management technology in *Bt* cotton (*Gossypium hirsutuam* L.) under drip irrigation’’ was conducted during *Kharif* season 2023-2024 at Irrigation and water management scheme (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, M.S., India). The experiment was laid out in Randomized Block Design with three replications and eight treatments *viz*., T_1-Control wider planting, T_2-Control dense planting (90×30 cm), T_3-Removal of monopodia at 60 DAS(DP), T_4-De-topping at 75 DAS (DP), T_5-Removal of Monopodia at 60 DAS (DP) + De-toping at 75 DAS (DP), T_6-Spraying of Mapiquate Chloride @ 25gm *a.i*. at 60 DAS (DP), T_7-Use of Polymulch (DP) T_8-Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP). Result of the experiment shows, that use of Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP) T_8. found helpful for more number of bolls plant^{-1} (41.80), yield plant^{-1} (162.50 g), seed cotton yield (4530 kg ha^{-1}), lint yield (1009 ka ha^{-1}) and GMR (₹ 3,39,725), which was at par with Use of Polymulch (DP) (T_7). Whereas plant height (126.42 cm), number of sympodia (16.23) were found higher in T_7 treatment (Use of Polymulch (DP)) and NMR (₹ 1,74,059) and B:C ratio (2.43) was recorded higher in T_5 treatment (Removal of Monopodia at 60 DAS (DP) + De-toping at 75 DAS (DP)).

Key words: *Bt* cotton, drip irrigation, dens planting, removal of monopodia, detopping, polymulch

Introduction
Cotton often termed "white gold," plays a pivotal role in both the industrial and agricultural sectors, providing essential raw materials for the textile industry and significantly contributing to economic development. In India, major cotton-producing states include Maharashtra, Gujarat, Telangana, Rajasthan, and Haryana, encompassing an area of approximately 120 lakh hectares with a production of 323.11 lakh bales for the 2023-24 season. Globally, India leads in cotton cultivation area, accounting for 37% of the world total. However, its yield remains relatively low at 469 kg per hectare, compared to higher yields in the USA and China, which produce 951 kg and 1892 kg per hectare, respectively. The International Cotton Advisory Committee anticipates a 9% increase in global cotton production, aligning with projected consumption levels of 25.6 million tonnes.

Cotton is integral to India's textile industry, which consumes 59% of the country's total fiber production and contributes 34% to its exports, generating approximately Rs. 50,000 crores annually. The area under *Bt* cotton has increased from 0.29 lakh hectares in 2002-03 to 119.40 lakh hectares by 2014-15, indicating a remarkable adoption rate of over 93% (Anonymous, 2019) [2]. Moreover, the high-density planting system (HDPS) has emerged as an innovative approach to enhance productivity and profitability, particularly in regions with limited resources. (Sabesh *et al.,* 2014) [9]. The rising input costs underscore the need for improved cotton productivity, with targets of 1000 kg per hectare under irrigated conditions and 500-600 kg under rainfed conditions (Kranthi, 2013) [5]. Drip irrigation has been identified as an effective method for enhancing water use efficiency, delivering precise water application to plant root zones and minimizing wastage, thus supporting sustainable cotton production. Additionally, the use of mulch enhances soil moisture conservation and microclimate regulation, further contributing to the sustainability of cotton farming (Pedda *et al*., 2020) [8].

Materials and Methods

The field investigation entitled ''Assessment of canopy management technology in *Bt* cotton (*Gossypium hirsutuam* L.) under drip irrigation'' was conducted during *Kharif* season 2023-2024 at Irrigation and water management scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani with a view. To study the effect of canopy management technologies and economicsof various treatment in *bt* cotton under drip irrigation. Agro-climatically Parbhani is situated at latitude, longitude and altitude of 190 16' N, 76047' E and 409 m above MSL respectively. Parbhani comes under sub-tropical climate with average annual rainfall of 960.7 mm. The experiment was laid out in Randomized Block Design with three replications and eight treatments *viz*., T_1-Control wider planting, T_2-Control dense planting (90×30 cm), T_3-Removal of monopodia at 60 DAS(DP), T_4-De-topping at 75 DAS(DP), T_5-Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP), T_6-Spraying of Mapiquate Chloride @25gm a.i.at 60 DAS(DP), T_7-Use of Polymulch (DP) T_8-Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP).

The gross plot size of experiment plot was 7.5m x 7.2m and net plot size was 4.5m x 6.0m. Experimental field was leveled and well drained. The soil was clayey in texture, low in nitrogen (124 kg ha^{-1}), medium in phosphorus (9.26 kg ha^{-1}) and high in potassium (323 kg ha^{-1}) and alkaline in reaction (pH 7.8). The environmental conditions prevailed during experimental period was favorable for normal growth and maturity of *Bt* cotton. Sowing was done on 27rd Jun 2023 by dibbling of (Moksh hybrid) seeds. The recommended cultural practices plant and protection measures were undertaken. Picking was done on 24th October, 16th November and 26th November 2023.

Table 1: Plant height (cm), Sympodial branches $plant^{-1}$, Number of bolls $plant^{-1}$, as influenced by different treatments

Symbol	Treatment Details	Plant Height (Cm)	Sympodial Branches $Plant^{-1}$	Functional Leaves $Plant^{-1}$	Dry matter At Harvest
		At Harvest	At Harvest	At 90 DAS	
T_1	Control wider planting (150 ×30)	113.58	15.21	67.00	170.65
T_2	Control Dense planting (90×30 cm)	122.97	15.87	77.53	183.12
T_3	Removal of monopodia at 60 DAS (DP)	105.68	15.13	72.03	156.42
T_4	De-topping at 75 DAS (DP)	93.63	15.02	72.33	172.89
T_5	Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP)	92.62	14.72	73.61	158.97
T_6	Spraying of Mapiquate Chloride @25gm a.i.at 60 DAS(DP)	89.62	14.68	73.27	152.36
T_7	Use of Polymulch (DP)	126.42	16.23	81.07	192.46
T_8	Polymulch + Removal of monopodia at 60 DAS + De-topping at 75 DAS (DP).	90.83	14.97	76.20	165.59
	SE(m) ±	7.01	0.53	1.59	3.98
	CD at 5%	21.18	3.33	4.80	12.04
	General Mean	104.41	15.16	74.13	169.05

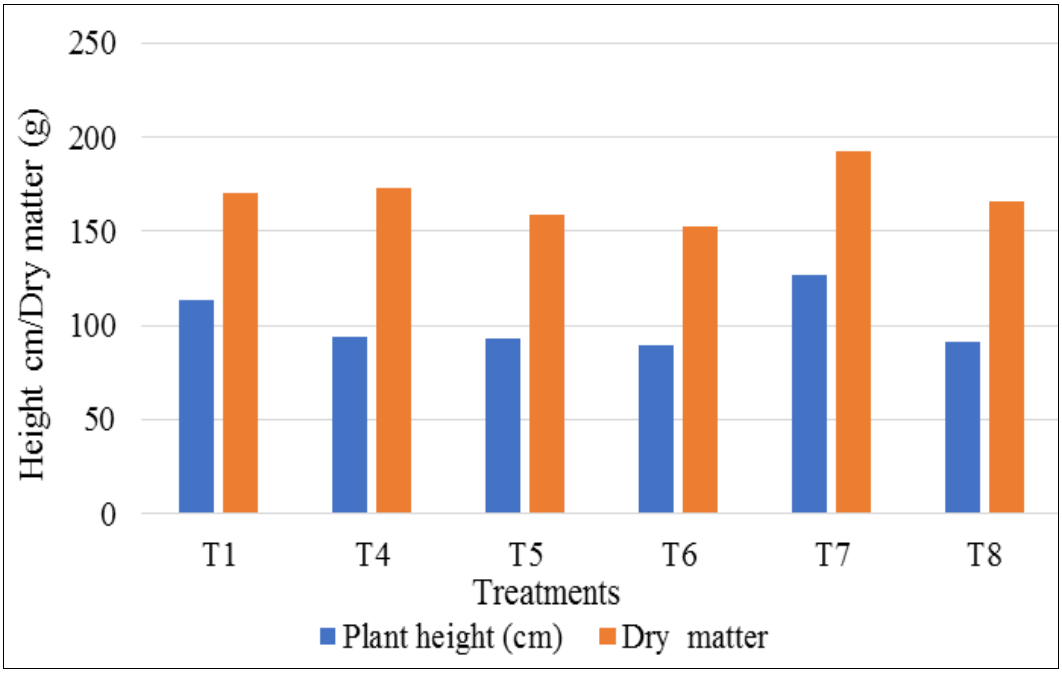

Fig 1: Plant height (cm) and plant dry matter (g) as influenced by different treatments

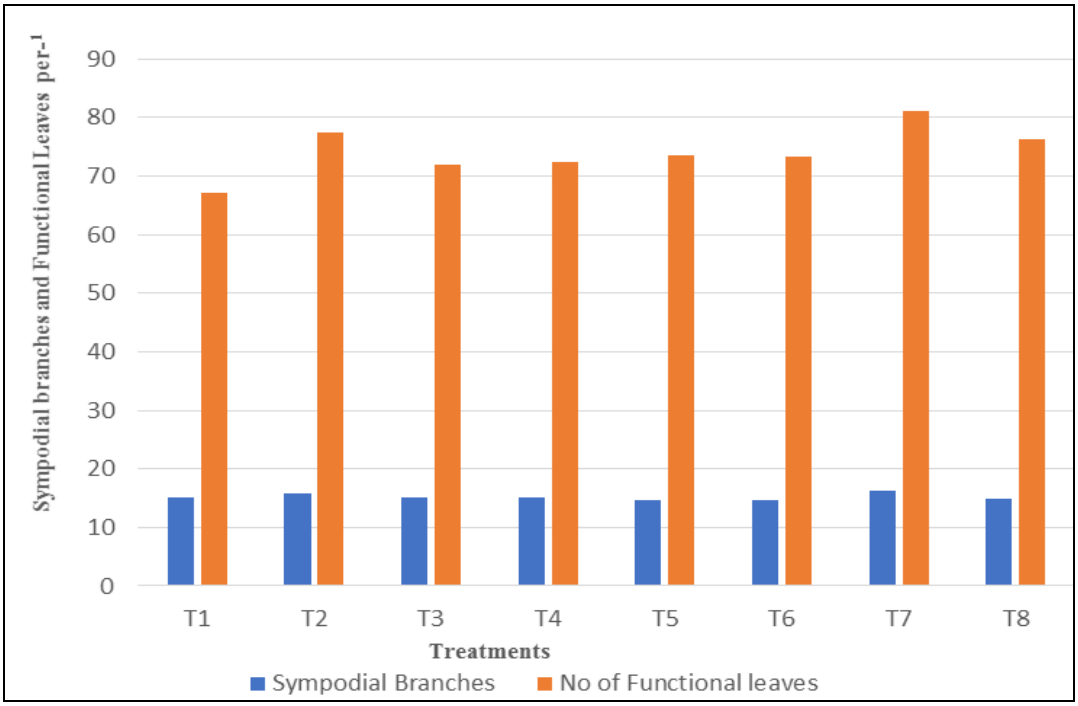

Fig 2: Functional leaves plant^{-1}, sympodial branch plant^{-1}, as influenced by different treatments

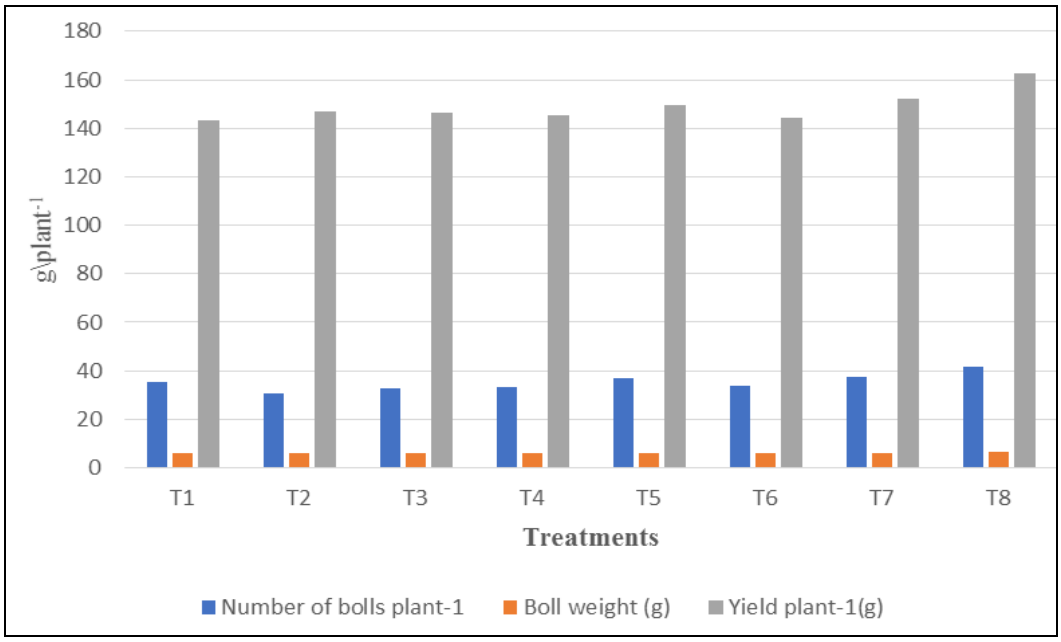

Fig 3: Number of bolls plant^{-1}, Boll Weight (g) and yield plant^{-1} (g) as influenced by different treatments

Table 2: Boll weight (g), Dy matter at harvest, Yield plant^{-1}(g), Seed cotton yield (kg ha^{-1}) as influenced by different treatments.

Symbol	Treatment Details	Boll Weight (G)	Number of bolls plant^{-1}	Yield plant^{-1} (g)	Seed cotton yield (kg ha^{-1})
T_1	Control wider planting (150 ×30)	6.11	35.18	143.27	3171
T_2	Control Dense planting (90×30 cm)	5.88	30.82	147.17	3511
T_3	Removal of monopodia at 60 DAS (DP)	5.98	32.58	146.17	3574
T_4	De-topping at 75 DAS (DP)	6.01	33.15	145.22	3602
T_5	Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP)	6.08	36.72	149.67	3948
T_6	Spraying of Mapiquate Chloride @25gm a.i.at 60 DAS(DP)	5.95	33.85	144.23	3622
T_7	Use of Polymulch (DP)	6.05	37.22	152.17	4175
T_8	Polymulch + Removal of monopodia at 60 DAS + De-topping at 75 DAS (DP).	6.30	41.80	162.50	4530
	SE(m) ±	0.04	1.29	2.54	56
	CD at 5%	N.S	3.95	7.71	169
	General Mean	6.04	35.17	148.89	3767

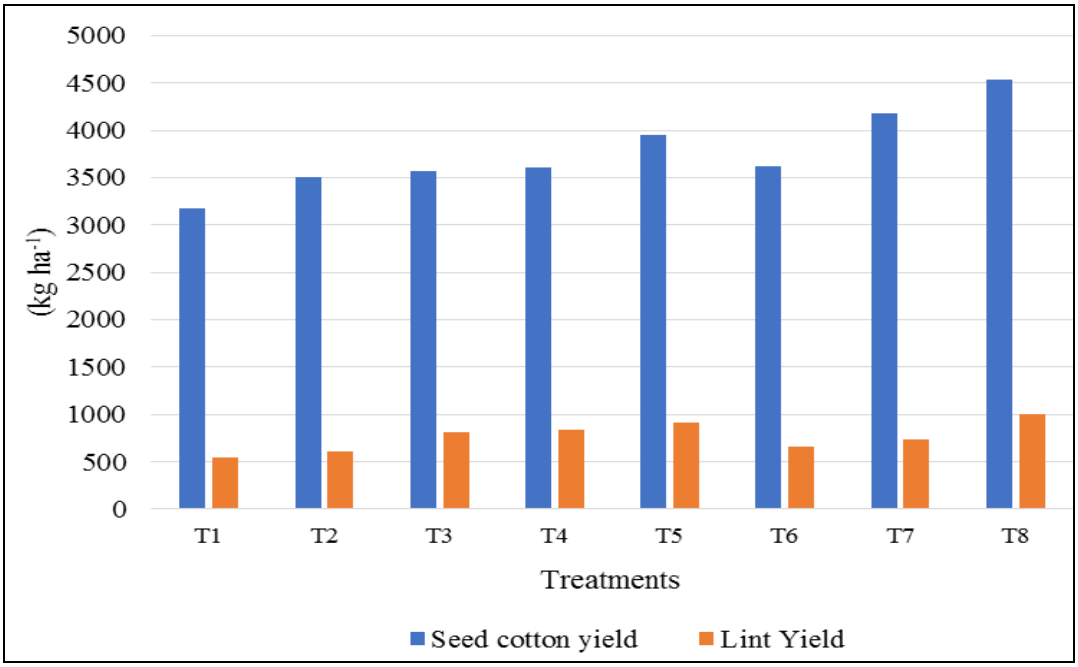

Fig 4: Seed cotton yield and lint yield (kg ha^{-1}) as influenced by different treatments

Results and Discussion

Growth attributing characters

Plant Height: Data on plant height as influenced by various treatments is presented in Table 1. And depicted in fig 1. Significantly highest plant height (126.42 cm) was recorded in T_7-Use of Polymulch (DP) and it was at par with the treatments T_1-Control Wider Planting (150 X 30 cm), T_2-Control Dense Planting (90 x 30 cm) and T_3-Removal of monopodia at 60 DAS (DP). The minimum plant height (89.62 cm) was recorded in (Spraying of Mapiquate Chloride @25gm *a.i.* at 60 DAS (DP) (T_6) treatment. These results are in conformity with Choudhary *et al*. (2021).

Sympodial branches plant^{-1}: The data on mean number of sympodial branches is presented in Table 1 and Figure 2. Use of Polymulch (DP) (T_7) recorded (16.23) significantly maximum number of sympodial branches plant^{-1} than other treatments. This result found similar with findings of Sohair *et al*. (2018) [11].

Number Functional leaves plant^{-1}: The effect of different treatments on the number of functional leaves plant^{-1} of *Bt* cotton is presented in table 1. and Fig 2. Use of Polymulch (DP) (T_2) recorded significantly higher number of leaves(81.07) than other treatments which was on par with Control Dense planting (90×30 cm) (T_2). These results found similar with the findings of Merghany *et al*. (2019) [6].

Dry Matter Plant^{-1} (g): Maximum dry matter of cotton crop was recorded Use of Polymulch (DP) (T_7) which was significantly higher (192.46) than all other treatments except which was on par with (T_2) Control Dense planting (90×30 cm). this findings were similar with findings of Midde *et al.* (2021) [7].

Yield attributing Character

Number of bolls plant^{-1}: The application of Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP) T_8 was found to be significantly superior over all other treatment in recording more number of bolls plant^{-1}. The higher response may be due to the effect of polymulch, dettoping and removal of monopodia led to production of sympodial branches, which increases in number of boll per plant to increase seed cotton yield. This trends is harmony with Taiz and Zeiger (2010) [12].

Boll weight (g): The data regarding boll weight (g) influenced by different treatments are presented in Table 1. and fig 2. The mean boll weight was 6.04 g. the boll weight was not influenced significantly due to various treatments.

Seed cotton yield plant^{-1} (g): The data regarding mean seed cotton yield plant^{-1} (g) as influenced by the different treatments is presented in Table 1. Treatment T_8-Polymulch + Removal of monopodia at 60 DAS + De-topping at 75 DAS (DP) recorded (162.50 g) seed cotton yield plant^{-1} witch was significantly higher than any other treatment. Such type of finding was also reported by Dadgale *et al*. (2014) [4].

Seed cotton yield (kg ha^{-1}): The seed cotton yield as influenced by various treatments is shown in Table 1 and Figure 3. Use of Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP), (T_8). produced maximum seed cotton yield of 4530 kg ha^{-1}, which was significantly superior over rest of the treatments except it was on par with Use of Polymulch (DP) (T_7) (4175 kg ha^{-1}). Control wider planting (150 ×30) (T_1) was recorded lowest seed cotton yield (3175 kg ha^{-1}). Data clearly shows that the application of mulch, removal of monopidia and detoping at 75 DAS significantly increase the seed cotton yield. Similar findings were also observed by Midde *et al.* (2021) [7], Samanta *et al*. (2022) [10].

Post-harvest studies

Data regarding ginning percentage, seed index, lint index and harvest index is presented in Table 2. Non-significant effect of various treatment on ginning percentage, seed index, lint index and harvest index were recorded.

Lint yield (kg ha^{-1})

The lint yield of cotton was influenced significantly with different treatments which was given in Table 2 and Figure 3.

Application of Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP). (T_8) produced maximum lint yield of 1009 kg ha^{-1}, which was significantly superior over rest of the treatments except it was on par with (T_5) Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP) (915 kg ha^{-1}). However, the treatment (T_1) Control wider planting (150 ×30) was found to be lower lint yield (551 kg ha^{-1}) which was at par with Control Dense planting (90×30 cm) (T_2) (665 kg ha^{-1}).

Table 2: Ginning percentage, seed index (g), lint yield (kg ha^{-1}), lint index (%), and harvest index as influenced by different treatments

Symbols	Treatment Details	Ginning (%)	Seed Index (G)	Lint Yield (Kg Ha^{-1})	Lint Index (%)	Harvest Index (HI)
T_1	Control wider planting (150 ×30)	38.33	11.00	551	6.80	50.76
T_2	Control Dense planting (90×30 cm)	38.22	11.34	612	7.02	47.44
T_3	Removal of monopodia at 60 DAS(DP)	39.67	11.66	807	7.60	39.45
T_4	De-topping at 75 DAS(DP)	39.70	12.00	838	7.90	38.60
T_5	Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP)	39.72	12.33	915	8.03	43.64
T_6	Spraying of Mapiquate Chloride @25gm a.i.at 60 DAS(DP)	38.58	11.33	665	7.10	38.86
T_7	Use of Polymulch (DP)	39.58	11.50	731	7.40	37.94
T_8	Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP).	40.53	13.67	1009	8.80	36.97
	SE(m) ±	0.26	0.15	53.03	0.13	-
	CD at 5%	NS	NS	163.40	NS	-
	General Mean	39.44	11.93	818	7.66	40.20

Economics

Gross monetary returns (₹ ha^{-1})

The data in Table 3 showed that the significantly highest gross monetary returns (₹ 33925 ha^{-1}) were recorded by application of Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP). (T_8) treatment over rest of treatments except it was on par with Use of Polymulch (DP) (T_7) (₹ 313150 ha^{-1}). The higher GMR of the cotton is due to the realization of maximum seed cotton yield achieved by the using of polymulch, detoping and removal of monopodia at 60 DAS. Similar kind of cost-effectiveness and economics was observed by Ajithkumar *et al.* (2021) [1].

Net monetary returns (₹ ha^{-1})

The differences in net monetary returns were significantly influenced due to different treatments. The data in Table 3 showed that the significantly higher net monetary returns (₹ 1,74,059 ha^{-1}) were recorded with Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP) (T_5). Treatment over rest of treatments except it was on par with Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP). (₹ 1,60,939 ha^{-1}) which was obtained similar with findings of Midde *et al.* (2021) [7].

B:C Ratio

B:C ratio as influenced by different treatments are enumerated in Table 3. Mean benefit cost ratio was 2.03. The higher B:C ratio recorded with application of Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP) (T5) except which was on par with De-topping at 75 DAS(DP) (at 30 & 60 DAS) (T4). Similar results were observed by Choudhary *et al.* (2021).

Table 3: GMR, NMR, and B:C ratio as influenced by different treatments

Symbol	Treatment	Gmr	Nmr	B:C Ratio
T_1	Control wider planting (150 ×30)	237800	128799	2.18
T_2	Control Dense planting (90×30 cm)	263350	149239	2.31
T_3	Removal of monopodia at 60 DAS(DP)	268050	152299	2.32
T_4	De-topping at 75 DAS(DP)	270125	153959	2.33
T_5	Removal of Monopodia at 60 DAS (DP) +De-toping at 75 DAS (DP)	296125	174059	2.43
T_6	Spraying of Mapiquate Chloride @25gm a.i.at 60 DAS(DP)	271675	154849	2.33
T_7	Use of Polymulch (DP)	313150	141079	1.82
T_8	Polymulch + Removal of Monopodia at 60 DAS + De-topping at 75 DAS (DP).	339725	160939	1.90
	SE(m) ±	6985	5588	-
	CD at 5%	21157	17114	-
	General Mean	282500	151903	2.20

Conclusion

Planting of cotton crop with polythene mulch along with removal of monopodia at 60 DAS and de-topping at 75 DAS is found to be beneficial for getting higher seed cotton yield and GMR in *Bt*-Cotton grown under drip irrigation. Whereas Removal of monopodia at 60 DAS and de-topping at 75 DAS found to be beneficial for getting highest net monetary returns and B:C ratio in *Bt*-cotton grown under drip irrigation.

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