

Original Research Article

SOWING TIME AND SPACING INFLUENCED YIELD, QUALITY AND ECONOMICS OF BT COTTON (*Gossypium hirsutum* L.)

ABSTRACT

A field study was conducted in the 2019 *kharif* season at the Agronomy Instructional Farm SDAU SKNagar, Gujarat, India. To investigate that the sowing time and spacing influenced yield, quality and economics of Bt cotton (*Gossypium hirsutum* L.) in loamy sand soil. Twelve treatment combinations were examined, involving three sowing times (T₁: 3rd week of May, T₂: 1st week of June, T₃: 3rd week of June) and four plant spacings (S₁: 90 cm × 60 cm, S₂: 90 cm × 45 cm, S₃: 60 cm × 60 cm, S₄: 60 cm × 45 cm). Four replications of a split plot design were used for the experiment. The third week of May was consistently the best time to sow cotton, according to the results, producing the maximum yields of seed cotton and stalk cotton. The quantity of monopodial branches/plant, harvest index and plant population as well as quality parameters such as oil content and ginning percentage were not significantly impacted by sowing time. The 3rd week of May sowing also yielded the highest benefit cost ratio and net realization. In terms of plant spacing, the spacing of 60 cm × 45 cm promoted highest plant population, taller plants and increased yield attributes like the bolls/plant, boll weight and seed cotton yield/plant. The highest seed cotton yield and stalk yield were achieved with this spacing. Harvest index and quality parameters were unaffected by plant spacing. The narrow spacing of 60 cm × 45 cm also resulted in the highest benefit cost ratio and net realization. The interaction effect between sowing time and plant spacing did not significantly influence growth, yield, yield attributes and quality parameters of Bt cotton. In conclusion, for optimal results in terms of seed cotton yield, net realization and BCR with Bt cotton, it is advisable to sow during the 3rd week of May and maintain a narrow spacing of 60 cm × 45 cm.

Keyword: Bt cotton, Economics, Plant spacing, Quality parameters, Sowing time, Yield parameters.

Introduction

Cotton is a significant cash crop in India and is frequently referred to as "White Gold" because it originated in Mexico and gets its name from the Arabic word "Quntun." Its seeds are a significant source of edible oil and fiber. Cotton cultivation has been practiced in India for more than 2000 years. The nation is unique in that it commercially cultivates all four *Gossypium* species. India's cotton sector is hugely important and has a significant economic impact. It is frequently referred to as the "King of the Fiber" and provides work for millions of people through trade, processing and farming. The cotton-related textile industry in India is extremely important, producing 7% of industry output, 2% of GDP, 15% of export revenues and employing nearly 45 million people (Anonymous, 2017-18). Since its introduction in 2002, Bt cotton that expresses an insecticidal protein from *Bacillus thuringiensis* has transformed cotton production in India. It boosted cotton production, considerably decreased the demand for chemical pesticides and was well-liked by farmers. Around the world, cotton is grown in 77 different

nations, with the United States, China and India providing 80% of the crop. India ranks first in terms of area and is the second-largest producer of cotton in the world, both of which are crucial to the local economy. Some of the top cotton-producing states in India include Gujarat, Maharashtra, Haryana, Punjab, Madhya Pradesh, Andhra Pradesh, Karnataka, Telangana, and Tamil Nadu. In conclusion, cotton is an important agricultural and industrial product in India, with a long history and major contributions to the economy and employment of the country. The introduction of Bt cotton has revolutionized cotton cultivation by increasing yields and minimizing its negative environmental effects. The use of high-yielding hybrids and enhanced agricultural practices can increase crop production potential, with planting time being a key consideration. Traditional cotton types planted in the late spring or summer frequently have severe bollworm infestations. Early cotton planting increases cotton output and fiber quality and with the right pest control practices, sucking pest protection can be attained. The bollworm issue has been effectively solved with transgenic cotton. Early cotton planting has various benefits over late planting, including a 10% increase in flower production, a 23% increase in open bolls and an 18% increase in seed yield (Arshad *et al.*, 2007). Early planting encourages vegetative development, but late planting, when temperatures drop too low, increases flowering and boll production, decreasing cotton yields (Khan *et al.*, 2017). Due to higher photosynthate buildup and prolonged boll development time, early planting also results in bigger boll size (Patel *et al.*, 2015). The phenological development, biomass conversion and financial returns of cotton plants are all considerably impacted by the timing of planting (Kaur *et al.*, 2019). Compared to late planting, which may cause poor crop stand and decreased yield potential, timely planting offers ideal conditions, such as adequate sun radiation, for higher biomass output. Considerations such as soil fertility, environment, genotype, planting time and season should all be taken into account when determining the plant population per unit area. By regulating light absorption, root patterning and moisture extraction, proper spacing affects crop output. High-density planting systems (HDPS), which offer greater productivity, profitability, efficiency, lower input costs and decreased risks, especially in rainfed situations, are becoming a more popular alternative production method in India. On some soil types, HDPS has been demonstrated to offer 25–30% better yields than suggested spacing (Venugopalan *et al.*, 2014). An established agronomic approach for increasing production and profitability is manipulating plant density and spacing (Hiwaleet *et al.*, 2018). A faster canopy closure, less soil water evaporation and less weed competition result from increasing plant density, which also improves sunlight, water and nutrient intake. These effects help address the issues associated with water scarcity. While broader spacing could promote the growth of weeds, excessively close spacing might impede proper root and plant development, reducing production. Considering the aforementioned characteristics, a field study titled “Sowing time and spacing influenced yield, quality and economics of bt cotton (*Gossypium hirsutum* L.)” with objective to study find out optimum sowing time and spacing for growth, yield, quality and economics of Bt cotton.

Material and methods

The field experiment was conducted in 2019's *kharif* season at the Agronomy Instructional Farm, SDAU, Sardarkrushinagar. In addition to having a loamy sand texture, the soil in the experimental plot also exhibited low levels of accessible N (156.9 kg/ha), medium levels of P₂O₅ (38.6 kg/ha), high levels of K₂O (254.3 kg/ha), and low levels of organic carbon (0.18%). Its pH was also somewhat alkaline at 7.6.

There were twelve treatment combinations comprising of three sowing times *i.e.* T₁: 3rd week of May, T₂: 1st week of June and T₃: 3rd week of June and four spacings *i.e.* S₁: 90 cm × 60 cm (18,518 plants/ha), S₂: 90 cm × 45 cm (24,691 plants/ha), S₃: 60 cm × 60 cm (27,777 plants/ha) and S₄: 60 cm × 45 cm (37,037 plants/ha) were tested in a split plot design with four replications. Growth information, such as plant population/ha, plant height and the number of monopodial and sympodial branches/plant, were measured at regular intervals. The number of bolls per plant, average boll weight, seed cotton yield per plant, seed cotton and stalk yield and harvest index were all measured during harvest. After harvest, quality measurements, including the ginning percentage and oil content, were taken. During the crop period, agronomic practices are applied in a timely manner and in accordance with requirements. A random sample technique was applied throughout the experiment to record observations. A composite soil sample's condition was evaluated prior to seeding. According to the split plot design, the experimental data was statistically evaluated using the analysis of variance method (Cochran and Cox, 1957). At a 5% level of significance, the calculated value of "F" was compared to the value of table "F". The benefit cost ratio (BCR) was determined using the methodology below.

$$\text{BCR} = \frac{\text{Gross realization (₹ /ha)}}{\text{Total cost of cultivation (₹ /ha)}}$$

Results and discussion

Effect of sowing time

There was no obvious difference in plant population/ha between 30 DAS and harvest due to the different planting dates. The different sowing times of Bt cotton considerably affected the plant height (cm), with the highest plant heights being recorded at 60, 90 and 120 DAS and at the last picking, respectively, when the crop was planted during the third week of May. Due to different seeding timings, no discernible impact on the quantity of monopodial branches/plants was discovered. The sowing of Bt cotton during the third week of May has greatly enhanced the number of sympodial branches/plants at the time of the last cotton picking time. The number of bolls per plant, average boll weight and seed cotton output per plant were all significantly higher when planting took place in the third week of May. The third week of May was the least important sowing period to record the maximum seed cotton yield and stalk yield. Different sowing times had a major impact on the seed cotton and stalk yield of Bt cotton. During the course of the experiment, it was determined that the impact of different sowing periods on the harvest index (%) was not significant. There was no discernible impact of planting time on quality criteria like ginning percentage and oil content (%). The sowing time of the third week of May resulted in the highest gross realization, net realization and BCR, while the sowing time of the third week of June resulted in the lowest gross realization, net realization and BCR. The early planted crop's higher values of all yield-attributing features, such as the number of sympodial branches/plant, the number of bolls/plant and the average boll weight, exhibited a positive link with seed cotton output per plant and per hectare. This could explain why there is more seed cotton produced per hectare and plant. By being sown early in the season, cotton can develop its canopy earlier and absorb more sunlight for photosynthesis and growth. A crop that was sowed early began its reproductive growth earlier, developed more bolls and yielded more as a result. Because of the crop's shorter overall crop lifetime, the reproductive process may have been significantly influenced, which might also account for the reduced yield from late sowing. The seed cotton yield may also be impacted by early-crop boll retention that is higher and late-crop

floral structure loss. These outcomes are very consistent with those of Arshad *et al.* (2007), Ali *et al.* (2009), Hallikeriet *al.* (2009), Kumar *et al.* (2014), Wahab *et al.* (2014), Patel *et al.* (2015), Khan *et al.* (2017^a), Kaur *et al.* (2019) and Singh *et al.* (2019).

Effect of spacing

The maximum plant population for Bt cotton at 30 DAS and harvest was notably found at a plant spacing of 60 cm × 45 cm. Bt cotton was sown with a close spacing of 60 cm × 45 cm, which resulted in plants that were noticeably taller at 60, 90, 120 DAS and at last picking time. Due to different plant spacings, no discernible effect on the no. monopodial branches/plant was discovered. However, with a spacing of 90 cm × 60 cm, the highest no. of sympodial branches/plant was observed. With sowing of Bt cotton at plant spacing of 90 cm × 60 cm, higher values of the yield features of Bt cotton, such as number of bolls/plant, average boll weight and seed cotton yield/plant, were recorded. With an increase in plant density, the yield of stalk and seed cotton increased dramatically. With a small spacing of 60 cm × 45 cm, seed cotton output and stalk yield were found to be significantly the highest. During the course of the experiment, In terms of harvest index, it was found that there was no discernible difference in plant spacings. Due to different plant spacings, quality measures including ginning percentage and oil content were determined to be non-significant. Under spacing of 60 cm × 45 cm, higher values of gross realization, net realization and BCR were attained. While spacing of 90 cm × 60 cm yielded the lowest gross realization, net realization and BCR. The culmination of yield-contributing traits is the seed cotton yield. Different plant populations had a big impact on these yield-attributing traits. Wider spacing increased per-plant yields, but because it was unable to offset the drop in plants per hectare, the overall seed cotton yield was lower than that of populations of plants that were closer together. More bolls per unit area may account for higher yields at closer spacing. According to similar findings, larger plant densities produce more seed cotton than lower densities, as reported by Aruna and Reddy (2009), Biradar *et al.* (2010), Manjunatha *et al.* (2010), Devraj *et al.* (2011), Shukla *et al.* (2013), Malavathet *al.* (2014), Basavaraj *et al.* (2017), Charjanet *al.* (2017), Kumar *et al.* (2017), Madavi *et al.* (2017), Nagenderet *al.* (2017), Udikeri and Shashidhara (2017), Hargilas and Saini (2018), Hiwaleet *al.* (2018) and Malavthet *al.* (2018).

Interaction effect

On growth, yield characteristics and quality criteria, no appreciable interaction between sowing time and spacing was found to affect any of these variables. Under treatment combination T₁S₄ (sowing during the third week of May with spacing of 60 cm × 45 cm), the maximum gross, net realization and BCR were attained. While the treatment combination T₃S₁ had the lowest gross realization, net realization and BCR (sowing in the third week of June with a spacing of 90 cm × 60 cm).

Conclusion

In light of the investigation's findings, it is concluded that the crop should be planted in the third week of May with a narrow spacing of 60 cm × 45 cm in the loamy sand of North Gujarat in order to obtain higher seed cotton yield, net realization and benefit cost ratio from Bt cotton [var. GTHH 49 (BG II)].

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Table 1 : Effect of sowing time and spacing on growth and yield attributes

Treatments	Plant population/ha		Plant height (cm)				Number of monopodial branches/plant	Number of sympodial branches/plant	Number of bolls/plant	Average boll weight (g)	Seed cotton yield/plant(g)
	30 DAS	At harvest	60 DAS	90 DAS	120 DAS	At last picking					
Main plot : Sowing time (T)											
T₁ : 3 rd week of May	26186	25608	81.0	99.9	122.8	127.6	3.26	24.3	40.6	3.43	137.7
T₂ : 1 st week of June	25993	25415	66.0	84.0	107.5	112.0	3.22	20.3	37.7	3.05	111.2
T₃ : 3 rd week of June	25752	25174	57.1	71.9	88.0	93.1	3.13	18.0	35.4	2.95	99.7
S. Em. ±	366	395	1.34	1.83	2.82	2.81	0.09	0.49	0.74	0.09	2.77
C.D. at 5%	NS	NS	4.63	6.35	9.77	9.72	NS	1.70	2.55	0.31	9.60
C.V. %	5.64	6.22	7.87	8.60	10.64	10.13	11.45	9.43	7.78	11.26	9.55
Sub plot : Spacing (S)											
S₁ : 90 cm × 60 cm	17940	17554	64.2	79.1	99.1	103.0	3.25	22.4	41.4	3.45	141.2
S₂ : 90 cm × 45 cm	24113	23341	66.3	82.2	103.9	108.9	3.23	21.2	39.7	3.11	121.0
S₃ : 60 cm × 60 cm	26942	26170	68.9	87.2	106.6	111.6	3.20	20.3	35.9	3.06	105.9
S₄ : 60 cm × 45 cm	34915	34529	72.7	92.6	114.9	120.1	3.15	19.4	34.5	2.95	96.6
S. Em. ±	318	365	0.91	1.37	1.77	2.09	0.08	0.36	0.53	0.09	2.21
C.D. at 5%	921	1058	2.65	3.97	5.15	6.08	NS	1.04	1.52	0.25	6.40
Interaction (T × S)											
S. Em. ±	550	632	1.58	2.37	3.07	3.63	0.15	0.62	0.91	0.15	3.82
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	4.23	4.97	4.64	5.55	5.79	6.54	9.05	5.94	4.80	9.56	6.58

Table 2 : Effect of sowing time and spacing on yield, quality and economics of Bt cotton

Treatments	Seed cotton yield (kg/ha)	Stalk yield(kg/ha)	Harvest index (%)	Oil content (%)	Ginning percentage	Cost of cultivation (A+B+C) (₹ /ha)	Gross realization (₹ /ha)	Net realization (₹ /ha)	Benefit cost ratio
Main plot: Sowing time (T)									
T₁ : 3 rd week of May	3264	4970	39.6	16.6	37.4	78773	141379	62606	1.79
T₂ : 1 st week of June	2568	3970	39.3	16.5	37.2	69449	111261	41812	1.59
T₃ : 3 rd week of June	2319	3540	39.8	16.4	36.9	66119	100441	34322	1.51
S. Em. ±	82	120	1.05	0.17	0.55	-	-	-	-
C.D. at 5%	283	415	NS	NS	NS	-	-	-	-
C.V. %	12.05	11.52	10.62	4.23	5.93	-	-	-	-
Sub plot: Spacing (S)									
S₁ : 90 cm × 60 cm	2214	3357	40.1	16.3	37.0	66003	95891	29888	1.45
S₂ : 90 cm × 45 cm	2653	4102	39.3	16.5	37.1	70258	114935	44677	1.62
S₃ : 60 cm × 60 cm	2750	4272	39.2	16.6	37.3	71747	119162	47414	1.65
S₄ : 60 cm × 45 cm	3251	4908	39.8	16.7	37.3	77780	140789	63008	1.80
S. Em. ±	52	76	0.49	0.15	0.34	-	-	-	-
C.D. at 5%	152	221	NS	NS	NS	-	-	-	-
Interaction (T × S)									
S. Em. ±	91	132	0.84	0.25	0.59	-	-	-	-
C.D. at 5%	NS	NS	NS	NS	NS	-	-	-	-
C.V. %	6.69	6.35	4.27	3.07	3.16	-	-	-	-

Table 3 : Economics of different treatment combinations

Treatment combinations	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)	Cost of cultivation (A+B+C) (₹/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	Benefit cost ratio
T₁ : T₁S₁	2659	4099	73329	115209	41880	1.57
T₂ : T₁S₂	3261	5071	77584	141299	63715	1.82
T₃ : T₁S₃	3357	5139	79073	145417	66344	1.84
T₄ : T₁S₄	3779	5571	85106	163592	78486	1.92
T₅ : T₂S₁	2085	3168	64005	90310	26305	1.41
T₆ : T₂S₂	2480	3841	68260	107460	39200	1.57
T₇ : T₂S₃	2595	4101	69749	112484	42734	1.61
T₈ : T₂S₄	3112	4771	75782	134792	59010	1.78
T₉ : T₃S₁	1898	2803	60675	82153	21478	1.35
T₁₀ : T₃S₂	2217	3396	64930	96046	31116	1.48
T₁₁ : T₃S₃	2298	3577	66419	99584	33165	1.50
T₁₂ : T₃S₄	2862	4383	72452	123982	51529	1.71

Selling price : Seed cotton ₹ 42.55/kg, Stalk ₹ 0.5/kg