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Impact of Different Plant Densities and Fertilizer Levels on Yield Attributes, Yield and Fibre Quality Characters of Bt Cotton in HDPS

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Adopting a high-density planting system in cotton cultivation has resulted in increased yields compared to traditional methods. Despite the clear benefits, farmers face various challenges throughout the cultivation process, from sowing to harvesting. However, selecting appropriate plant spacings, fertilizer levels and implementing tailored cultivation techniques can significantly enhance productivity. A field experiment was conducted at Siddapur research farm, Regional Agricultural Research Station, Warangal, Telangana, India during kharif 2023 to investigate the "Impact of different plant densities and fertilizer levels on yield attributes, yield and fibre quality characters of cotton in high density planting system (HDPS)". The experiment was laid out in randomized block design (factorial) and replicated thrice, consisting of 12 treatment combinations comprising of three plant spacings S1: 80 x 20 cm (62,500 plants ha^{-1}), S2: 90 x 15 cm (74,074 plants ha^{-1}), S3: 90 x 60 cm in factor I and four fertilizer levels (F1: 100%RDF, F2: 125%RDF, F3: 100%RDF + Microbial consortia, F4: Control) in factor II. Both the factors significantly influenced the number of bolls per plant, number of bolls m^{-2} and seed cotton yield per hectare. The results revealed that higher no. of bolls plant^{-1} were recorded in 90 x 60 cm (18,518 plants ha^{-1}) however, higher no. of bolls m^{-2}, seed cotton yield (2233 kgha^{-1}) obtained from higher plant density (74,074 plants ha^{-1}) with the spacing 90 x 15 cm. Boll weight was not significantly influenced by varied plant spacings and fertilizer levels. Among the different levels of fertilizer, 125%RDF recorded highest no. of bolls per plant, no. of bolls m^{-2} and seed cotton yield (2362 kgha^{-1}). Fibre quality characters *viz.,* Upper half mean length(mm), micronaire(µginch^{-1}), tenacity(gtex^{-1}) and uniformity index (%) were not significantly influenced by both plant spacings and fertilizer levels as they are primarily governed by genetic makeup of cotton genotypes. For optimum seed cotton yield, cotton should be sown at closer spacing 90 x 15 cm and the application of 125%RDF was economically feasible in high density planting system.

Keywords: High Density Planting System (HDPS); cotton; fibre quality; genotype.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important commercial cash crop and fibre crop of global significance and cultivated in more than seventy countries. It is referred to as "White gold" or the "King of fibers" because it is a vital raw material for the economy that generates employment and foreign exchange.

"According to the United States Department of Agriculture (USDA), globally, cotton area and production are projected as 35.5 million hectares and 115.7 million bales during 2022-23" (PJTSAU, 2023) [1]. "India has the largest area under cotton cultivation with 13.0 million hectares with the production and productivity of 34.3 million bales and 447 kg ha^{-1}, respectively during 2022-23. In Telangana, the area of cotton during 2021-22 was 1.8 million hectares with the production and productivity of 4.8 million bales and 439 kg ha^{-1}, respectively (Indiastat) [2]. The average lower productivity of cotton in India in general or Telangana state in particular can be primarily attributed to the fact that a majority of the cotton-growing zones are reliant on rainfed conditions [3]. Most of the research findings revealed that heavy soils are more suitable for cotton cultivation" [4]. However, in the state of Telangana, most of the farmers are cultivating cotton as a rainfed crop on light textured soils characterized by shallow depth, poor fertility, vulnerable to water and soil erosion, producing notably low yields. Further, monocropping, low plant population, imbalanced application of fertilizers and delayed sowing due to late onset of rainfall, intermittent and terminal dry spells.

"Almost 95 per cent Indian cotton farmers cultivated the genetically modified Bt cotton. But the farmers are facing a problem of stagnating yields from Bt cotton hybrids due to increased labour demand, increased labour costs and increased costs for cotton picking and nutrient requirements. All these facts point to the direct need for sustainable practices. So, to sustain the productivity, high density planting systems, with narrow and ultra narrow spacing for rainfed soils and developing suitable management options for improving yields and to improve input use efficiency is the need of the hour" [5].

"In cotton, wider intra row spacing often creates the problem of wider gaps when the plant stand is affected either by heavy rainfall or due to high temperature with prolonged or intermittent dry spell during seedling development. So, the poor plant stands results in low seed cotton yield. Hence, to maintain optimum plant populations the intra-row spacing must be reduced and short compact genotypes can be grown which produce higher yield at closer intra-row spacing" [6,7]. A possible way for redefining cotton productivity is through the manipulation of row spacing to increase plant density and their spatial arrangement with an appropriate plant geometry, which is termed as high-density planting system (HDPS) in cotton.

"Among the various factors of cotton production, the plant density and fertilizer dose plays a significant role. Plants may show better growth and development and give highest yield per plant but may not give maximum yield per unit area because of inadequate plant population. Thus, for increasing economic yield, optimum spacing is essential" [8,9,10].

Management aspects like plant density and nutrient management are two important agronomic practices for getting higher productivity in cotton. Establishing an appropriate plant stand is paramount to obtain higher yields as lower plant density will be wastage of resources while, high plant density limits individual plant growth.

The study on the impact of varying plant densities and fertilizer levels on yield attributes, yield, and fiber quality of Bt cotton in HDPS is vital for the scientific community. This research can optimize crop management practices, boost productivity, and improve fiber quality, all crucial for the sustainable growth of the cotton industry. The findings will aid farmers in selecting optimal planting densities and fertilizer applications to maximize yields and ensure economic viability, enhancing the overall efficiency and competitiveness of cotton production.

"The yield and yield attributing parameters of cotton vary with the plant spacings" [10-13]. "Balanced fertilization is one of the major key factors for enhancing the cotton yields" [5]. The maximum yield potential of Bt cotton hybrids can only be realized by proper agronomic techniques, such as correct plant spacing and balanced nitrogen fertilizer, whether under irrigated or rainfed circumstances. Given the increased area of Bt cotton as well as farmer-specific tests with various plant geometries, it was deemed necessary to undertake the current experiment to specify appropriate plant geometry and fertilizer levels. As a result, the current study was conducted to determine appropriate plant geometry and fertilizer levels under a high density planting scheme.

2. MATERIALS AND METHODS

The experiment was conducted at Siddapur research farm, Regional Agricultural Research Station, Warangal, Telangana during kharif 2023. The soil of the experimental site was sandy loam in texture. It was low available N (250 kg ha^{-1}), medium in available P (21.3 kg ha^{-1}) and organic carbon content (0.52%), high in available K (361.2 kg ha^{-1}) and pH (7.3). The total rainfall received during the cropping season was 873.8 mm. The experiment was laid out in randomized block design (factorial) and replicated thrice, consisting of 12 treatment combinations comprising of three plant spacings S1: 80 x 20 cm (62,500 plants ha^{-1}), S2: 90 x 15 cm (74,074 plants ha^{-1}), S3: 90 x 60 cm in factor I and four fertilizer levels (F1: 100%RDF, F2: 125%RDF, F3: 100%RDF + Microbial consortia , F4: Control)in factor II. Seed of cotton hybrid, RCH-665 was sown by dibbling as per treatments on 6 July of 2023. A full dose of phosphorus was applied as basal application at the time of sowing. The required amount of nitrogen along with potassium was applied to the surface of soil as band placement at 20, 40, 60 and 80 (DAS) according to treatments. Microbial consortia include Azotobacter (500gm), Phosphorous Solubilizing Bacteria-PSB (500 gm) and Potassium Releasing Bacteria-KRB (500gm) are mixed with 50kg vermicompost and applied to the soil of respective treatments. All the recommended agronomic practices and need-based plant protection measures were followed to establish a better and healthy crop. The growth and yield observations were recorded as per standard procedures.

Number of bolls plant^{-1}: The total number of bolls which are present in boll development and opened bolls at picking from the five tagged plants from the net plot were counted, averaged and expressed as no. of bolls plant^{-1}.

Number of bolls m^{-2}: Number of bolls were counted from one square meter area of the net plot in each treatment before the harvest and expressed as number of bolls m^{-2}.

Boll weight (g boll-^{1}): The seed cotton yield obtained from bolls of tagged plants in each plot was weighed, averaged and expressed as boll weight in g boll^{-1}.

Seed cotton yield (kg ha^{-1}): After picking, seed cotton obtained from each treatment in net plot was weighed on an electronic balance. The seed cotton yield was obtained from picking of net plots in each treatment, was weighed in g plot^{-1} and yield was converted to kg ha^{-1}.

Fibre quality characters: Fiber characters like Upper half mean length(mm), uniformity index (%), micronaire (µg inch^{-1}) and tenacity (g tex^{-1}) of cotton in each treatment were measured using high volume instrument (HVI). For Fibre quality studies, 100 g lint from each treatment from net plot was collected and sent for analysis to Central Institute for Research on Cotton Technology (CIRCOT), Mumbai.

The data was statistically analyzed by adopting standard analysis of variance (ANOVA) as described by Gomez and Gomez, [14]. The significance difference was also tested using 'F' value at 5% level of significance. The value of critical difference (C.D.) for examining treatment means for their significance was done at 5% level.

3. RESULTS AND DISCUSSION

Effect of different Plant Spacings and Fertilizer levels on yield attributes of Cotton: "The results showed that yield attributes like number of bolls per plant, no. of bolls m^{-2} were significantly influenced by plant spacings. Cotton planted at 90 x 60 cm (18,518 plants ha^{-1}) produced more number of bolls per plant (22.2) (Table 1) compared to other two spacings. Reduced cotton plant densities typically produce a greater number of bolls outside the first and second position as well as sympodia arising from monopodial branches that may be due to less inter plant competition within the row" [15]. However, cotton planted with more plant density of 74,074 plants ha^{-1} (90 cm x 15 cm) produced more bolls m^{-2}(112.3) followed by 80 x 20 cm (62,500 plants ha^{-1})(108.8) proved to be superior over the normal spacing 90 x 60 cm (18,518 plants ha-1).The results are in conformity with findings of Kumar and Ramachandra [16,17], where high plant density per unit area increased the number of bolls relative to low plant densities.

Data on no. of bolls per plant and unit area revealed that significantly higher were recorded with application of 125%RDF (F2) and followed by 100%RDF + Microbial consortia (F3) and 100%RDF. Further, lower were recorded in the control treatment(F4). "Cotton plant produced more bolls per plant in wider rows because of substantial space available for growth, more photosynthetic efficiency, frequent availability of water and nutrients, less humidity for efficient control of insect pest attack and boll saving from rottening, which resulted in increase in fruiting points, fruiting period, fruit retention and ultimately greater bolls per plant and seed cotton yield per plant. The number of bolls per plant is a function of boll production and retention which mainly depends on leaf area development and its photosynthetic efficiency. The increase in the number of picked bolls per plant with higher doses of fertilizer might be due to greater nutrient availability and uptake, enhanced leaf formation, improved photosynthesis, and better translocation of assimilates to reproductive parts, leading to improved square and boll formation. These results are supported" by [18,19,9,20]. Whereas boll weight was not significantly affected by varied plant spacings and fertilizer levels.

Effect of different Plant Spacings and Fertilizer levels on Seed cotton yield (kg/ha): Seed cotton yield (SCY) (kg/ha) was significantly influenced by plant geometry and fertilizer levels (Table 1). Significantly maximum seed cotton yield (2233kg/ha)) recorded with S2-90 x 15cm due to optimum plant density per unit area increased the number of bolls per unit area and it was followed by S1-80 x 20 cm (2040kg/ha). The lowest seed cotton yield (1841kg/ha) was noticed with S3-90 x 60 cm due to less plant population per unit area even though more no. of bolls per plant recorded. These results are in conformity with the work done by Singh et al. [10], Gouthami et al. [21,22,11,12,20].

SCY was significantly influenced by different fertilizer levels. Among them, significantly higher seed cotton yield (2072 kg ha^{-1}) was recorded with 125%RDF, compared to 100%RDF + Microbial consortia (1706 kg ha^{-1}) and 100%RDF (1996 kg ha^{-1}) and lower seed cotton yield was recorded in the control treatment. The crop canopy has an impact on production efficiencies and profitable yields, which can be controlled through row spacing and population modification. An adequate plant stand may help in harnessing all renewable and non-renewable resources in a more and efficient manner, leading to increased agricultural yields [23].

In cotton plants, nutrient requirements vary across different growth stages rather than being uniform. Applying fertilizers according to the specific crop growth periods enhances nutrient uptake, promotes plant growth and development, and ultimately supports higher seed cotton yields

Table 1. Yield attributes, yield and fibre quality characters of Bt cotton under varied plant densities and fertilizer levels during kharif, 2023

Spacings	**No. of bolls plant $^{-1}$**	**No. of bolls m^{-2}**	**Boll weight (g)**	**Seed cotton yield (kg/ha)**	**UHML (mm)**	**Micronaire (μg inch^{-1})**	**Tenacity (g tex^{-1})**	**Uniformity index (%)**
S1: 80 cm X 20 cm (62,500 plants ha^{-1})	19.6	108.8	4.2	2040	28.36	3.86	29.22	83.75
S2 :90 cm X 15 cm (74,074 plants ha^{-1})	16.1	112.3	4.0	2233	28.43	3.93	29.48	83.75
S3: 90 cm X 60 cm (18,518 plants ha^{-1})	22.2	40.1	4.3	1841	28.19	3.84	28.96	83.67
Sem +	0.38	2.2	0.13	4.91	0.23	0.07	0.22	0.26
CD (*P*=0.05)	1.11	6.45	NS	14.41	NS	NS	NS	NS
Fertilizer Levels								
F1: 100%RDF	18.5	84.7	4.3	1942	28.36	3.81	29.21	83.77
F2: 125% RDF	22.7	105.4	4.0	2362	28.55	3.91	29.64	83.66
F3: 100% RDF+ microbial consortia	20.5	93.5	4.3	2113	28.15	3.9	28.94	83.77
F4: Control	15.4	64.4	3.9	1737	28.22	3.87	29.06	83.66
Sem +	0.44	2.54	0.15	5.67	0.27	0.08	0.26	0.3
CD (*P*=0.05)	1.28	7.45	NS	16.64	NS	NS	NS	NS
Interaction								
Sem +	0.76	4.4	0.26	9.82	0.47	0.14	0.45	0.51
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NS- Nonsignificant

According to Dadgale et al. [22] the beneficial impact of mineral nutrient supply on the number of sink organs is not solely due to increased nitrogen (N) supply, but also due to enhanced supply of photosynthates to the sink sites. These results are in conformity with Bharathi et al. [18] and Kanchana et al. [11,24,25].

The interaction effect on yield attributes and seed cotton yield on varied plant spacings and fertilizer levels was found to be non-significant during this study.

Effect of different Plant Spacings and Fertilizer levels on Fibre quality characters: "There are a number of factors influencing fiber quality, of which cultivar is of the greatest importance while agronomic practices are secondary" [6,26]. A perusal data presented in the (Table 1) shows the fibre quality characters, viz. upper half mean length (mm), tenacity ($gtex^{-1}$), micronaire ($\mu ginch^{-1}$) and uniformity ratio (%) were not influenced significantly due to varied plant spacings, fertilizer levels and their interaction. This was due to the fact that quality parameters are primarily governed by genetic makeup of cotton genotypes. Similar results were reported by Dadgale et al. [22,4,27,28].

4. CONCLUSION

From the above discussion it was concluded that growing Bt cotton at plant density of 74,074 plants ha^{-1} under HDPS by adopting spacing of 90 cm x 15 cm was found to be effective to obtain significantly higher seed cotton yield (2233 kg ha^{-1}). With respect to fertilizer levels, (125 % RDF) recorded the highest seed cotton yield (2362 kg/ha) because more no of bolls per plant in a unit area were registered.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Agriculture market intelligence centre, PJTSAU: Available: www.pjtasu.edu.in.
2. India Stat. Area, production and productivity of cotton: 2022.
   Available: http://www. indianstat.com
3. Arun venkatesh S, Rajendran K. Evaluation of plant density and cotton genotypes (*Gossypium hirsutum* L.) on cotton yield and fibre quality. International Journal of Forestry and Crop Improvement. 2013; 40(1): 1-5.
4. Kavya D, Kumari CP, Sreenivas G, Ramprakash T, Triveni S. Influence of varied plant densities and nitrogen doses on growth and yield of *Bt* cotton (*Gossypium hirsutum* L.) under high density planting system. International Journal of Environment and Climate Change. 2022;12(11): 1498-1504.
5. Madhavi B, Rani PL, Sreenivas G, Surekha K. Effect of high-density planting and weed management practices on weed drymatter, weed indices and yield of *Bt* cotton. International journal of pure and applied bioscience. 2017;5(4): 1945-1950.
6. Basavanneppa MA, Hallikeri SS, Channabasavanna, Nagalikar VP. Response of compact and early maturing cotton genotypes to plant densities in Tunga Bhadra Project (TBP) area. Journal of Cotton Research and Development. 2000;14:155-58.
7. Mert M, Aslan E, Akişcan Y, Caliskan ME. Response of cotton (*Gossypium hirsutum* L.) to different tillage systems and intra-row spacing. Soil and Tillage Research.2006;85(1-2): 221-228.
8. Bhalerao PD, Gaikwad GS. Productivity and profitability of *Bt* cotton (*Gossypium hirsutum*) under various plant geometry and fertilizer levels. Indian Journal of Agronomy. 2010;55(1): 60-63.
9. Munir MK, Tahir M, Saleem MF, Yaseen M. Growth, yield and earliness response of

cotton to row spacing and nitrogen management. Journal of Animal & Plant Sciences.2015; 25(3).

10. Singh J, Blaise D. Nutrient management in rainfed cotton. CICR Tech. Bulletin. 2000: 6:3.
11. Kanchana T, Sakthivel N, Thavaprakaash N, Balamurugan J. Performance of compact cotton (*Gossypium hirsutum* L.) genotypes to varied nutrient levels under high density planting system in winter irrigated condition. Journal of Pharmacognosy and Phytochemistry. 2019; 8(3): 3084-3088.
12. Kumar CS, Ramachandra C. Effect of planting geometry and varieties on yield and economics of cotton under rainfed conditions of southern dry zone of Karnataka. International Journal of Chemistry Studies. 2019; 7(3): 2564-2566.
13. Manjula U, Shashidhara GB. Performance of compact cotton genotypes under high density planting system at different fertilizer levels. Journal of Farm Sciences. 2017;30(4): 460-466.
14. Gomez KA, Gomez AA. Statistical procedures for agriculture research. John Wiley and Sons Publishers, New York. 1984;357-423.
15. Jagtap DN, Bhale VM. Effect of different plant spacing and nitrogen levels of desi cotton hybrid. International Journal of Forestry and Crop Improvement. 2010;1(2): 77-79.
16. Devi B, Bharathi S, Sree Rekha M, Jayalalitha K. Performance of cotton under high density planting with varied spacing and levels of nitrogen. The Andhra Agricultural Journal. 2018; 65(1): 49-52.
17. Gadade GD, Gokhale DN, Chavan AS. Performance of hirsutum cotton genotypes to different fertilizer levels under high density planting system. Journal of Cotton Research and Development. 2015; 29 (1): 45-47.
18. Bharathi S, Sree Lakshmi B, Ratna Kumari S. Evaluation of compact cultures under high density planting system with different nutrient levels in rainfed vertisols. International Journal of Chemical Studies. 2018;6(5): 3371-3373.
19. Bednarz BS, Krzepilko A. Effect of different fertilization on enzyme activity in rhizosphere and non-rhizosphere of amaranth. International Agrophysics. 2009;23: 409- 412.
20. Sankaranarayanan K, Jagvir S, Rajendran K. Identification of suitable high density planting system genotypes its response to different levels of fertilizers compared with *Bt* cotton. Journal of Cotton Research and Development. 2018; 32(1): 84-96.
21. Gouthami R, Nagabhushanam U, Ramanjaneyulu AV, Madhavi B, Kamalakar J, Yakadri M. Influence of plant geometry and cultivars on growth, yield attributes and yield of HDPS cotton under rainfed shallow soils. International Journal of Environment and Climate Change. 2023;13(10): 245-250.
22. Dadgale PR, Chavan DA, Gudade BA, Jadhav SG, Deshmukh VA, Pal S. Productivity and quality of *Bt* cotton (*Gossypium hirsutum*) as influenced by planting geometry and nitrogen levels under irrigated and rainfed conditions. Indian Journal of Agricultural Sciences. 2014;84 (9): 1069-72.
23. Manjunatha MJ, Halepyati AS, Koppalkar BG, Pujari BT.Yield and yield components, uptake of nutrients, quality parameters and economics of *Bt* cotton (*Gossypium hirsutum* L.) genotypes as influenced by different plant densities. Karnataka Journal of Agricultural Sciences. 2010;23(3): 423-425.
24. Basha SJ, Aruna E, Sharma AS, Reddy YR. Standardization of nutrient management for cotton (*Gossypium arboreum* L.) genotypes under high density planting system (HDPS). International Journal of Pure & Applied Biosciences. 2017;5(6): 1251-1253.
25. Jaffer sadhik A, Kavitha S, Renugadevi JD. Productivity and nutrient uptake of *Bt* cotton (*Gossypium hirsutum* L) under different spacing and nutrient levels. Journal of Cotton Research and Development. 2022;28(2): 260-262.
26. Venugopalan MV, Kranthi KR, Blaise D, Lakde S, Sankaranarayana K. High density planting system in cotton-The Brazil Experience and Indian Initiatives. Cotton Research Journal.2013; 5(2): 172-185.
27. Nalayini P, Manickam S. Agronomic manipulation of high strength cotton genotype, CCH4474 for yield maximization under irrigated agro ecosystem of Coimbatore. Journal of Cotton Research

and Development. 2018;32(2): 256-259.

28. Rao RS, Venkatramulu M, Kumar JH, Reddy PR. Inluence of high-density planting system in *Gossypium hirsutum* genotypes under rainfed light soils. International journal of chemical studies. 2020;8(3):193-196.

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