Influence ~~Effect~~of plant geometry and cultivars on growth, yield attributes and yield of HDPScottonunder ~~in~~rainfed shallowsoils

Comment [IM1]:

Comment [IM2]:

Comment [IM3]: Please state the meaning of this abbreviation

ABSTRACT

A field experiment was conducted atSiddapurresearch farm, Regional Agricultural Research Station, Warangal, Telangana, India during *kharif* 2022 to investigate ~~study~~ the effect ~~impact~~ of plant geometry and cultivars on growth and yield of cotton under high plant density ~~planting~~ system. The results revealed thatplant height (102.7 cm) and drymatter production (6499 kg ha^{-1}) were significantly higher at ultra narrow spacing of 90 x 15 cm(74,074 plants ha^{-1}) than medium and wider spacings of 90 x 30 and 90 x 60 cm,respectively but, was on par with narrow spacing of 90 x 20 cm (55,555 plants ha^{-1}). Though sympodial branches $plant^{-1}$ (16.4) and number ~~no.~~ of bolls $plant^{-1}$ (24.0) were significantly greater with wider spacing(90 x 60 cm: 18,518 plants ha^{-1}), adoption of high plant density method ~~planting~~ of 90 x 15 cm spacing (74,074 plants ha^{-1}) (2707 kg ha^{-1}) and 90 x 20 cm (55,555 plants ha^{-1}) (2498 kg ha^{-1})resulted in significantly higher cotton seed ~~cotton~~ yield. The yield from 90x15 cm was26.2% and 11.7% higher than that of 90 x 30 cm (2391 kg ha^{-1})and 90 x 60 cm (1998 kg ha^{-1}), respectively.In case of cultivars, though growth and yield attributes were not significantly influenced, but, the boll weight (5.2) and seed cotton yield(2845 kg ha^{-1}) were significantly higher with NCS 2778 over other cultivars viz., *Bt*Suraj (2151 kg ha^{-1}), WGCV-79 (2310 kg ha-1) and ADB-39 (2288 kg ha^{-1})

Comment [IM4]: Review this statement appropriately

Comment [IM5]: Please recast this stat

Keywords: cotton; cultivars; high density planting system; plant geometry; Telangana

1. INTRODUCTION

Cotton (*Gossypiumhirsutum* L.) it is popularly called as "the king of fibres".It is the leading fibre crop in the world as the crop plays a vital role in Indian economy and provides basic raw material for textile industry, export and import of yarn fabrics. Thus, cotton industry provides employment in farming, processing and marketing sectors.According to United States Department of Agriculture (USDA), globally, cotton area and production are projected as 35.5 million hectares and 115.7 million balesduring 2022-23 (Anonymous, 2023). India has the largest area under cotton cultivation with 13.0million hectares with the production and productivity of 34.3 million bales and 447 kg ha^{-1},respectivelyduring 2022-23. In Telangana, the area of cotton during 2021-22was1.8million hectareswith the production and productivity of 4.8 million bales and 439 kg ha^{-1}, respectively(Indiastat)The lower productivity of cotton in India in general or Telangana in particular can be primarily attributed to the fact that a majority of the cotton-growing zones are reliant on rainfed conditions. Majority of research findings revealed that heavy soils are more suitable for cotton cultivation (Kavya *et al*. 2022). However, in the state of Telangana, most of the farmers are cultivating cotton as a rainfed crop in light textured soils characterized by shallow depth, poor fertility, susceptible to soil and water

Comment [IM6]: Provide the source of this data erosion resulting in significantly low yields. Further, monocropping, low plant population, imbalanced application of fertilizers and delayed sowings (due to late onset of rainfalls), intermittent and terminal dry spells.In cotton, wider spacing of 90-120 cm x 60 cm is being recommended and adopted. However, it results in lower plant population per unit area. In the event of heavy rainfall or high temperature with prolonged dry spell during seedling development, the optimum plant stand is affected leading to low seed cotton yield. Hence, to maintain optimum plant population, the intra-row spacing has to be reduced and short compact genotypes have be grown which can produce higher yield as reported by Basavanneppa*et al.* (2000) and Mert *et al.* (2006). The possible way for increasing the cotton productivity is through manipulation of row spacing to increase plant density and their spatial arrangement with an appropriate plant geometry, which is termed as highdensity planting system (HDPS) in cotton. HDPS leads to rapid canopy closing and reduced evaporation. Better genotypes which are suitable for HDPS is an option to increase productivity of rainfed cotton on shallow to medium soils. Conventional and late maturing hybrids often experience terminal drought resulting in low yields (Jost and Cothren, 2001). With the advent of *Bt* technology and the release of hybrids during 2002, cotton productivity gained a momentum. Further, cotton hybrids are predominantly cultivated in India but high cost of *Bt* cotton hybrid seed is also one of the reasons for farmers debts during recurrent crop failure. For improving the productivity and profitability in this region, it necessitates a system which should be alternative for these reasons to the existing *Bt* cotton hybrid cultivation (Venugopalan*et al*., 2014). Farmers were looking for genotypes that could yield better under higher planting densities with fewer bolls per plant, synchronized maturity with uniform boll bursting and minimum monopodial branches for HDPS. Spatial arrangement of compact and short statured plants by agronomic manipulation of row spacing with increased plant density can obtain higher yield. There is better light interception, greater leaf area, low weed competition and earliness in crop maturity by adoption of ultra-narrow row cotton (Wright *et al*., 2011). With this back ground, the present experiment was conducted to identify suitable cultivars and ideal crop geometry for HDPS cotton on shallow soils.

2. MATERIALS AND METHODS

The experiment was carried out at Siddapurresearch farm, Regional Agricultural Research Station, Warangal during *kharif* 2022. 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 kg ha^{-1}) and pH (7.3). The total rainfall received during the cropping season was 1222 mm. The experiment was laid out in randomised block design (with factorial concept) and replicated thrice. It consisted of 16 treatment combinations comprising of four plant spacings S1: 90 x 15 cm(ultra narrow), S2:90 x 20 cm (narrow), S3: 90 x 30 cm (medium), S4: 90 x 60 cm (wider) in factor Iand four varieties (V1: *Bt*Suraj , V2: WGCV-79 , V3:ADB-39 , V4: NCS-2778 in factor II.All the recommended agronomic practices and need based plant protection measures were followed to establish a healthy crop. The growth and yield observations were recorded as per standard procedures. The data was statistically analyzed by adopting standard analysis of variance (ANOVA) as described by Gomez and Gomez. The significancedifference was also tested ~~by~~ 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

3.1 Effect of P~~p~~lant G~~g~~eometry and C~~c~~ultivars onG~~g~~rowth Component ~~parameters~~ of C~~c~~otton

Comment [IM7]: State the proceduces use for better understanding

Comment [IM8]: State the year

The results showed that growth parameters like plant height and drymatter production were significantly influenced byplant geometry (Table.1).however,~~Significantly~~ taller plants (102.7 cm) and drymatter production (6,499 kg ha^{-1}) were observed with spacing 90 x 15 cm (74,074 plants ha^{-1}) and was at par with spacing 90 x 20 cm (55,555 plants ha^{-1})(100.3 cm and 6,085 kg ha^{-1}). While, ~~significantly~~ lower plant height of (81.8 cm) and drymatter production (3,873kg ha^{-1}) was recorded at the ~~with~~ spacing 90 x 60 cm (18,518 plants ha^{-1}).The greater number of plants per unit area resulted in more height per plant which may be due to the increased competition for sunlight and CO_2. Further, less space was available for growth of each plant and led to increase in internodal length and hence, the plant grew taller. These results are in agreement with Kumar *et al*. (2017), Ali *et al*. (2009), Munir *et al*. (2015) and Tuppad (2015). Wali and Koraddi (1989) have also reported that increase in plant population ultimately increases plant height.The possible reason for higher dry matter production with ultra narrow spacing could be the higher plant population per unit area. These are in line with Sankarnarayanan*et al*. (2018) and Devi *et al.* (2018). Darawsheh*et al.* (2009) observed that the partitioning of assimilates to reproductive parts was lower in narrow row high plant density system.The plant height drymatterproductionand monopodial branches plant^{-1}did not differ significantly due to cultivars under HDPS.

3.2 Effect of P~~p~~lant G~~g~~eometry and C~~c~~ultivars on Y~~y~~ield A~~a~~ttributing C~~c~~haracters of C~~c~~otton

A perusal of data in Table1indicated that yield parameters likesympodial branches plant^{-1}and ~~no.~~number of bolls plant^{-1}were significantlydiffered due to varied plant geometry.Both ~~these~~ characters increased with increase in intra row spacing or decrease in plant density~~.~~andSignificantly higher sympodial branches plant^{-1} (16.4) were recorded with wider spacing of 90 x 60 cm (18,518 plants ha^{-1}) and medium spacing of 90 x 30 cm (37,037 plants ha^{-1})(16.2). While, significant~~ly~~ lower sympodial branches plant^{-1} (14.3) were recorded with ultra narrow spacing of 90 x 15 cm (74,074 plants ha^{-1}). By adopting wider spacing or lower planting densities, plants have a greater opportunity for lateral branch expansion and the potential to develop additional auxiliary buds, in contrast to plants grown in closer spacing or higher densities, which lead to an increased number of branches per plant. These findings are similar with the studies conducted by Sisodia and Khamparia (2007) as well as Parlawar*et al*. (2017). Further, the number ~~no.~~ of bolls plant^{-1} followed the similar trend of sympodial branches plant^{-1}.The greater number of bolls plant^{-1} observed in wider spacings can be attributed to the ample space provided for growth, regular availability of water and nutrients, and enhanced photosynthetic efficiency, which ultimately leads to a significant increase in the number of sympodial branches plant^{-1}. This increase in bolls plant^{-1} was direct consequence from the greater presence of sympodial branches plant^{-1}. Similar results were found by Kumar and Ramachandra (2019) and Munir *et al.* (2015). Whereas, Boll weight was not significantly affected by varied plant geometry. None of the growth and yield attributes except boll weight was significantly influenced among the cultivars. While, significantly more boll weight wasregistered with NCS 2778 (5.2 g). The variation in yield potential among genotypes can be attributed to a multitude of physiological processes, which are influenced by a combination of the plant's genetic composition and the surrounding environmental conditions (Udikeri and Shashidhara,2017)

3.3 Effect of P~~p~~lant G~~g~~eometry and C~~c~~ultivars on Cotton S~~s~~eed ~~cotton~~Y~~y~~ield (kg ha^{-1})~~of cotton~~

The plant geometry and cultivars have exerted a significant effect on seed cotton yield.Significantly higher seed cotton yield (2707 kg ha^{-1}) was obtained withultra narrow spacing (90 x 15 cm: 74,074 plants ha^{-}

^{1}) spacing over medium spacing (90 x 30 cm: 37,037 plants ha^{-1}) (2391 kg ha^{-1}) and wider spacing (90 x 60 cm: 18,518 plants ha^{-1}) (1998 kg ha^{-1}) but was found to be at par with narrow spacing (90 x 20 cm: 55,555 plants ha^{-1}) (2498 kg ha^{-1}).Earlier, Maheshwari and Krishnasamy (2019) reported under closer spacing of 75 x 10 cm recorded significantly higher seed cotton yield (2505 and 2715 kg ha^{-1}) during 2017 and 2018, respectively as compared to that of 75 x 15 cm (2295 and 2492 kg ha^{-1}) and 75x 30 cm (1988 and 2156 kg ha^{-1}) spacings.The ultra narrow planting recorded 26.2% more seed cotton yield over wider planting or traditional planting.While,significantly higher yield (2845 kg ha^{-1}) was obtained in NCS 2778**.**The higher seed cotton yield was due to its more boll weight (5.2 g) over rest of the cultivars. Significantly less seed cotton yield (2151 kg ha^{-1}) was recorded in *Bt*suraj variety. NCS 2778 produced24.4%, 18.9 %and 19.6 % higher seed cotton yield over *Bt*Suraj, WGCV-79 and ADB-39 cultivars, respectively.

The interaction between different plant geometry and cultivars was found non-significant on growth, yield and yield contributing characters.

4. CONCLUSION

Cotton stands as the primary commercial crop in India.To enhance its productivity, the adoption of suitable cultivars in a high-density planting system has been exploredand it may offer multiple benefits like reduced weed density, improved input use efficiency, and the facilitation of mechanical picking. The results of present study clearly indicated that the adoption of ultra narrow row spacing of 90 x 15 cmhas the potential to maximize the kapas yield (2707 kg ha^{-1}). Further,NCS 2778 with significantly higher yield (2845 kg ha^{-1}) emerged as the most suitable cultivar under HDPS.

Comment [IM9]: Write the full meaning of this

ETHICAL APPROVAL

No ethical issues were reported during the research work.

Table 1. Effect of different plant geometry and cultivars on growth, yield attributes and yield of HDPS cotton in rainfed shallow soils

Formatted: Indent: Left: 0"

Treatments	Plant height (cm)	Dry matter production (kg ha^{-1})	Sympodia (No. plant^{-1})	Bolls (No. plant^{-1})	Boll weight (g)	Seed Cotton Yield (kg ha^{-1})
Spacings						
S_1:90 cm X 15 cm (74,074 plants ha^{-1})	102.7	6499	14.3	19.2	4.2	2707
S_2 :90 cm X 20 cm (55,555 plants ha^{-1})	100.3	6085	14.7	20.7	4.0	2498

S_3: 90 cm X 30 cm (37,037 plants ha^{-1})	93.1	4794	16.2	22.7	4.2	2391
S_4:90 cm X 60 cm (18,518 plants ha^{-1})	81.8	3873	16.4	24.0	4.0	1998
SEm±	1.8	213	0.5	1.0	0.2	100
CD (P=0.05)	5.4	619	1.5	3.0	NS	290
Cultivar						
V_1: *Bt*Suraj	96.1	5231	15.2	21.6	3.8	2151
V_2: WGCV-79	94.0	5211	14.3	20.0	4.0	2310
V_3: ADB-39	95.2	5343	16.1	22.8	3.4	2288
V_4: NCS 2778	92.6	5465	15.9	22.1	5.2	2845
SEm±	1.8	213	0.5	1.0	0.2	100
CD (P=0.05)	NS	NS	NS	NS	0.6	290
Interaction						
SEm±	2.0	427	1.0	2.0	0.4	200
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Comment [IM10]: Since the significance differences were separated at 5% level please indicate in the table for more understanding please

Comment [IM11]: And show a foot note for the above table

REFERENCES

1. Agriculture market intelligence, PJTASU: www.pjtasu.edu.in
2. Ali H, Afzal M N, Muhammad D. Effect of sowing dates and plant spacing on growth and dry matter partitioning in cotton (*Gossypiumhirsutum* L.). *Pakistan Journal of Botany*. 2009; 41(5): 2145-2155
3. Basavanneppa M A, Hallikeri S S, Channabasavanna, Nagalikar V P. 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.
4. Darawsheh M K, Khah E M, Aivalakis G, Chachalis D, Sallaku F. Cotton row spacing and plant density cropping systems I. Effects on accumulation and partitioning of dry mass and LAI. *Journal of Food, Agriculture & Environment.* 2009; 7(3/4): 258-261.
5. Devi B, BharathiS, SreeRekha M, JayalalithaK. Performance of cotton under high density planting with varied spacing and levels of nitrogen. *The Andhra Agricultural Journal*. 2018; 65 (1): 49-52.
6. Gomez KA, Gomez AA. Statistical procedures for agricultural for agricultural research (2 ed.). John Wiley and Sons, New York. 1984;680.
7. Indiastat. Area, production and productivity of cotton; 2022. Available: https://www.indiastat.com
8. Jost P H, Cothren J T. Phenotypic alterations and crop maturity differences in ultra-narrow row and conventionally spaced cotton. *Crop Science*. 2001; 41 (4): 1150-1159
9. Kavya D, Kumari C P, Sreenivas G, Ramprakash T, Triveni S. Influence of varied plant densities and nitrogen doses on growth and yield of *Bt* cotton (*Gossypiumhirsutum* L.) under high density planting system. *International Journal of Environment and Climate Change*. 2022; 12(11): 1498-1504.

Comment [IM12]: Please review this reference

10. Kumar C S, 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.

11. Kumar P, Karle A.S, SinghD,VermaL. Effect of high density planting system (HDPS) and varieties on yield, economics and quality of desi cotton. *International Journal of Current Microbiology and Applied Sciences*. 2017; 6(3): 233-238.

12. Maheswari M U, Krishnasamy S M. Effect of crop geometries and plant growth retardants on physiological growth parameters in machine sown cotton. *Journal of Pharmacognosy and Phytochemistry*. 2019; 8 (2): 541-545.

13. Mert M, Aslan E, Akiscan Y, Caliskan, Y M. Response of cotton (*Gossypiumhirsutum* L) to different tillage systems and intra-row spacing. *Soil and Tillage Research.* 2006; 85: 221-28.

14. Munir M K, Tahir M, Saleem M F, Yaseen M. Growth, yield and earliness response of cotton to row spacing and nitrogen management. *Journal of Animal & Plant Sciences*. 2015; 25 (3).

15. Parlawar N D, Jiotode D J, Khawle V S, Kubde K J, Puri P D. Effect of Planting Geometry and Varieties on Morpho-Physiological Parameters and Yield of Cotton. *International Journal of Researches in Biosciences, Agriculture & Technology*. 2017; 5(2): 429-436.

16. 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.

17. Sisodia R I, Khamparia S K. American cotton varieties as influenced by plant densities and fertility levels under rainfed conditions. *Journal of Cotton Research and Development*. 2007; 21(1): 35-40.

18. Tuppad G B. Response of compact cotton genotypes to graded levels of fertilizer under varied planting density and defoliator (*Doctoral dissertation, Ph.D. (Agri.) Thesis*, University of Agricultural Science, Dharwad, India. 2015.

19. Udikeri M, Shashidhara G B. Performance of compact cotton genotypes under high density planting system at different fertilizer levels. *Journal of Farm Sciences*. 2017; 30(4): 460-466.

20. Venugopalan M V, Kranthi K R, Blaise D, Lakde S, Narayana K S. High density Planting System in Cotton-The Brazil Experience and Indian Initiatives. *Cotton Research Journal*. 2014; 5(2): 172-185.

21. Wali B M, Koraddi V R. Biometrical studies in rainfed cotton. Mysore. *Journal of Agricultural Science*. 1989; 23: 441-446.

~~**22.**~~ Wright D L, Marois J J, Sprenkel R K, Rich J R. Production of ultra narrow row cotton. University of Florida (UF), IFAS Extension. SSAGR-83. 2011.