Influence of plant geometry and cultivars on growth, yield attributes and yield of HDPS cottonunder rainfed shallowsoils

ABSTRACT

A field experiment was conducted atSiddapurresearch farm, Regional Agricultural Research Station, Warangal, Telangana, India during *kharif* 2022 to investigate the effect of plant geometry and cultivars on growth and yield of cotton under high plant density 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 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 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 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})

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"(Pandagaleet al, 2020). 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

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and water 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 fourvarieties (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.

Plant height Five tagged plants were used for recording plant height. Plant height (cm) was measured from the ground surface to the top most growing point in cm at harvest.

Drymatter production (kg ha^{-1})

In all the replications, five plants plot^{-1} were selected from the second border row and uprooted at at harvest. These uprooted plants were carefully placed in labelled brown paper bags. Subsequently, the plants were dried in the shade initially for 2-3 days, followed by further drying in a hot air oven maintained at a temperature of 60 - 65°C until a constant weight was achieved. The weight of the oven-dried plants was then measured using an electronic balance with a precision of 0.001 g, and the mean value was recorded as the dry matter accumulation per plant for cotton. To obtain the dry matter ha^{-1}, this value was multiplied by the plant population ha^{-1}.

No. of sympodial branches plant^{-1}

Sympodial branches are the branches that arise above the developing shoots and expand horizontally while bearing flowers at each node. At harvest, these were counted from the labeled plants, and average number of synpodial branches was calculated. The monopodia's offspring branches were also included in plant-1's total number of sympodialbranches.No. 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}.

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 yield of seed cotton yield from picking of net plots in each treatment was weighed in g plot^{-1} and yield was converted to kg ha^{-1}.

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The data was statistically analyzed by adopting standard analysis of variance (ANOVA) as described by Gomez and Gomez,1984The 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

3.1 Effect of Plant Geometry and Cultivars onGrowth Component ofCotton

The results showed that growth parameters like plant height and drymatter production were significantly influenced byplant geometry (Table.1).however, 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, lower plant height of 81.8 cm and drymatter production (3,873kg ha^{-1}) was recorded at the spacing of 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). Darawshehe*t 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 Plant Geometry and Cultivars on Yield Attributing Characters of Cotton

A perusal of data in Table1indicated that yield parameters likesympodial branches plant^{-1}andnumber of bolls plant^{-1}were significantlydiffered due to varied plant geometry.Both characters increased with increase in intra row spacing or decrease in plant densityandSignificantly 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, significantly 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 Parlaware*t al*. (2017). Further, the numberof 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

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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 Plant Geometry and Cultivars on Seed cotton Yield (kg ha^{-1})

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.

Table 1. Effect of different plant geometry and cultivars on growth, yield attributes and yield of HDPScotton

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

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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

NS- Non significant

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