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Research Article

Performance of cotton genotype TCH 1819 to high density planting system under winter irrigated condition at the Western agroclimatic zone of Tamil Nadu

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Abstract
Plant population is an important attribute in crop management practice. Increasing the plant density by decreasing the crop row spacing was an alternative strategy to optimize crop profit. Hence, the field trial was conducted at Tamil Nadu Agricultural University, Coimbatore, during the winter season of 2017 – 18 to study the effect of row spacing on the growth and yield of cotton genotype TCH 1819. The experimental design was Randomized Block Design (RBD) with seven spacing treatments *viz.,* T_1: 60 x 15 cm (1,11,111 plants ha^{-1}), T_2: 60 x 20 cm (83,333 plants ha^{-1}), T_3: 75 x 15 cm (88,888 plants ha^{-1}), T_4: 75 x 20 cm (66,666 plants ha^{-1}), T_5: 75 x 30 cm (44,444 plants ha^{-1}), T_6: 90 x 15 cm (74074 plants ha^{-1}), T_7: 90 x 20cm (55,555 plants ha^{-1}) and was replicated thrice. Plant densities showed a significant (p=0.05) difference for all the characters studied. The higher plant density of 1,11,111 plants (60 x 15 cm) observed significantly (p=0.05) maximum plant height (103.14 cm), Leaf Area Index (LAI) (4.35), Dry Matter Production (DMP) (8125 kg/ha), Crop Growth Rate (CGR) (6.58 g/m^2/day), root length (41.46 cm), root dry weight (14.94 g/plant), and chlorophyll index (48.24). The number of sympodial branches per plant (17) and bolls per plant (22 bolls) was found significant in the wider spacing of 75 x 30 cm. The narrow spacing of 60 x 15 cm noted the highest seed cotton yield (2565 kg/ha), net return (₹65706.62), and B: C (2.32) ratio, followed by the spacing of 75 x 15 cm due to more plant density per unit area (m^2). So, maximum yield in cotton can be achieved by decreasing the row spacing and increasing the plant population per unit area.

Keywords: Growth, High density Planting system, Root characteristics, Seed cotton yield

INTRODUCTION

Cotton, the clothing fiber since ancient times has played an important role in the history and civilization of mankind. It is the main cash crop grown for its fiber and seed oil in the world. The crop has occupied the largest area in India. The area under cotton is 129.57 lakh hectares, and production is 371 lakh bales and productivity is 486.76 kgs per hectare. The productivity is low compared to the world average (768 kgs per hectare) (https://cotcorp.org.in/national_cotton.aspx). Cotton is extremely sensitive to adverse environmental conditions and field management. The current day cotton varieties are of long duration, tall-growing, and with long sympodial growth. This leads to an increase in the cost of cultivation because of more manual pickings (Gunasekaran *et al.,* 2020). To improve productivity, optimize profit, and select management strategies under rising production costs, the alternative way is a high-density planting system. It is the manipulation of row spacing, plant density, and the spatial arrangement of cotton plants for obtaining higher yields. In simple terms, it is growing cotton densely than what is being practiced. This planting system produces fewer bolls than conventionally planted cotton but retains a higher percentage of total bolls in the first sympodial position

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and a lower percentage in the second position (Vories and Glover 2006). The High Density Planting System (HDPS) besides providing better light interception, efficient leaf area development, and early canopy closure which will shade out the weeds and reduce their competitiveness (Wright *et al.,* 2011) also provides synchronized flowering, uniform boll bursting and early cut-off (Gunasekaran *et al.,* 2020). Hence, HDPS is the solution to improve productivity and profitability, increase input use efficiency, and minimize the risks associated with current cotton production in India. Therefore, the trial was conducted to find optimum crop geometry and know the yield potential of cotton genotype TCH 1819.

MATERIALS AND METHODS

The evaluation of cotton genotype TCH 1819 under HDPS was carried out during 2017 – 2018 in winter irrigated season at Eastern block farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore situated in the North-Western Agro-Climatic Zone of Tamil Nadu at 11°N 76°57´E longitude and at an altitude of 426.7 meters above MSL. The soil of the field was sandy clay loam in texture, low in available nitrogen (224 kg.ha^{-1}), medium in available phosphorus (13.5 kg.ha^{-1}) and available potassium (250 kg.ha^{-1}). The rainfall during the cropping period is 558 mm, which was received in 23 rainy days. The mean maximum temperature ranges from 28.5 to 32.4^{o}C and the mean minimum temperature ranges from 16.1 to 24.0^{o}C. The experiment was designed in randomized block design which was replicated thrice with seven spacing treatments [T_1: 60 x 15 cm (1,11,111 plants ha^{-1}), T_2: 60 x 20 cm (83,333 plants ha^{-1}), T_3: 75 x 15 cm (88,888 plants ha^{-1}), T_4: 75 x 20 cm (66,666 plants ha^{-1}), T_5: 75 x 30 cm (44,444 plants ha^{-1}), T_6: 90 x 15 cm (74074 plants ha^{-1}), T_7: 90 x 20cm(55,555 plants ha^{-1})].
The field was ploughed once with disc plough followed by cultivator twice. Rotavator was used to break the clods and then ridges and furrows were formed. The crop was sown on August 23, 2017, by dibbling seeds at a depth of 4 to 5 cm as per spacing in treatments. Fertilizer dose of 100:50:50 kg NPK.ha^{-1} was applied. The entire dose of phosphorus, 50 percent of N and K was applied as band placement 5 cm away and 5 cm below the seed row as basal placement. The remaining ½ N and K were top-dressed at 40 - 45 DAS. Pre-emergence herbicide pendimethalin @ 1.0 kg.ha^{-1} was sprayed to prevent the growth of weeds. Hand weeding was carried out at 40 DAS. First irrigation was given at the time of sowing to ensure uniform germination and life irrigation was given on the third day after sowing. The subsequent irrigations were scheduled at 7-10 days intervals depending upon the field moisture condition. The sucking pest incidence was noticed during the cropping season. Initially, imidacloprid @ 2 ml per litre was sprayed. At later stages, Acephate @ 4 ml per litre was sprayed against whitefly incidence as and when required. Harvesting of kapas was commenced on 135 DAS and pickings were taken at weekly intervals. The number of bolls on labelled plants from each plot was noted at each picking and expressed per plant. Harvested bolls from each treatment were weighed and expressed in kg.ha^{-1} (Crop Production Guide, 2012).
Data on different parameters *viz.,* growth and yield attributes were statistically analyzed as described by Gomez and Gomez (1984). Wherever the results are significant, critical differences were worked out at a five percent level.

RESULTS AND DISCUSSION

Data about the growth and yield attributes of the cotton genotype TCH 1819 as influenced by the various spacing treatments are presented in Table 1.

Growth attributes

Plant geometries influenced all crop traits *viz.,* plant height, Leaf Area Index (LAI), Crop Growth Rate (CGR), root length, root dry weight, Chlorophyll index, Dry Matter Production (DMP).

Plant height

Plant geometries showed no significant difference with plant height at 30 DAS and thereafter, the difference in plant height was observed for various spacing treatments. The highest plant height was observed with a narrow spacing of 60 x 15 cm. The maximum height was because of the competition for solar radiation for the photosynthetic process. This was in confirmation with the results of Ram and Giri (2006), Singh *et al.* (2007) and Munir *et al.* (2015). In that, the availability of horizontal space for the individual cotton plant in narrow rows reduced due to which intense interplant competition for nutrient and light suppressed node appearance and plants grew taller in respect of vertical space.

Leaf area index (LAI)

Leaf area is the photosynthetic surface that plays an important role in production. Leaf area index increased gradually up to 90 DAS and reached a maximum of 4.35. The leaf area was higher in the narrow spacing of 60 x 15 cm was due to increased plants per unit land area. The increased LAI was due to more plants per unit area: thereby, more leaves lead to more LAI. This agreed with the findings of Udikeri and Shashidhara (2017) that the total dry matter production of cotton and supply of required photosynthates for the developing bolls largely depends on leaf area and leaf area index.

Crop growth rate (CGR)

Crop growth rate indicates dry matter production. It is used for the estimation of the production efficiency of the crop. CGR recorded at a narrow spacing of 60 x 15 cm was significantly higher than other plant densities adopted. The Crop Growth Rate (CGR) was 8.73 at 60-90 DAS at a higher plant density of 60 x 15 cm. A similar observation of higher CGR at the initial stage at higher plant density was reported by Manjunatha *et al.* (2010a).

Root length

The length of the root per unit volume of soil is an important parameter. The root length was measured with minimal root disturbance. The genotype TCH 1819 showed significant differences in root length at all the stages of crop growth. The longest root was observed at a higher plant density (60 x 15 cm) over the rest of the treatments. This is due to congestion of plant per unit area which induced more vertical growth of the root.

Root dry weight

Plant geometries had an effect on root dry weight. Increased plant densities (60 x 15 cm) provided higher root dry weight. This is due to competition among plants for resources in higher densities, thus resulting in higher nutrient uptake and, finally greater root dry weight.

Root volume

The root volume was significantly influenced by plant densities. The wider spacing of 90 x 20 cm recorded the highest root volume, which may be due to more space and less competition in the rhizosphere region.

Chlorophyll index

The effect of spacing on the chlorophyll index was significant in all stages of the crop. The SPAD values showed higher (49.68) at a narrow spacing of 60 x 15 cm. Chlorophyll maintenance and consequently photosynthesis durability in stressful conditions are among physiological indicators of stress resistance (Zhang *et al.,* 2006).

Dry matter production

Dry matter accumulation is the index of growth put forth by crop. Higher dry matter production was observed with the narrow spacing of 60 x 15 cm. Increased dry matter production in narrow spacing may be due to more accumulation of dry matter in leaves, stem, and reproductive parts. Similar results were found by Darawsheh *et al.* (2007) that higher dry matter production of cotton at narrow spacing may be related to the better distribution of plant population

Table 1. Influence of plant geometry on growth and yield attributes of cotton at 90 DAS and seed cotton yield (Data is averaged from 5 plants/treatment).

Treatment spacing (cm)	Plant height (cm)	Leaf area index (LAI)	Crop growth rate (CGR) ($g/m^2/day$)	Root length (cm)	Root dry weight (g/plant)	Root volume (cc)	Dry matter production (DMP) ($kg.ha^{-1}$)	Chlorophyll Index	No. of bolls/m^2	Seed cotton yield ($kg.ha^{-1}$)
T_1 – 60 x 15	91.60	3.61	8.73	28.85	6.58	17.03	6150	49.68	143	2565
T_2 – 60 x 20	82.48	3.36	7.44	27.00	5.89	14.20	4827	47.86	120	2298
T_3 – 75 x 15	79.58	3.47	7.00	28.46	5.02	15.00	5005	45.84	126	2453
T_4 – 75 x 20	74.01	3.00	6.62	28.82	4.92	15.66	3973	44.67	108	2112
T_5 – 75 x 30	73.36	2.67	6.75	24.97	3.89	18.04	3162	40.36	88	1468
T_6 – 90x 15	70.80	3.19	7.18	27.49	5.68	18.19	4341	43.43	112	2184
T_7 – 90x 20	68.56	2.90	5.45	26.92	6.53	18.58	3560	41.45	95	1896
SEd	3.53	0.23	0.26	1.37	0.712	1.55	303.23	2.51	5.23	75.23
CD(p=0.05)	7.70	0.51	0.57	2.98	1.551	3.38	660.74	5.47	11.39	163.93

T_1 – 60 x 15 cm (1,11,111 $plants.ha^{-1}$); T_2 – 60 x 20 cm (83,333 $plants.ha^{-1}$); T_3 – 75 x 15 cm (88,888 $plants.ha^{-1}$); T_4 – 75 x 20 cm (66,666 $plants.ha^{-1}$); T_5 – 75 x 30 cm (44,444 $plants.ha^{-1}$); T_6 – 90 x 15 cm (74,074 $plants.ha^{-1}$); T_7 – 55,555 $plants.ha^{-1}$)

in the NR (Narrow Row) system, which may be more effective to intercept the light.

Yield attributes

The yield attributing character *viz.,* number of sympodial branches per plant, number of bolls per plant was positively influenced by the wider spacing of 75 x 30 cm while the seed cotton yield was highest (2565 kg ha^{-1}) in the narrow spacing of 60 x 15 cm followed by 75 x 15 cm (2453 $kg.ha^{-1}$).

Seed cotton yield

The ultimate seed cotton yield is the manifestation of yield contribution characters. The seed cotton yield was higher in the narrow spacing of 60 x 15 cm. Wider spacing registered more bolls and yield per plant, but a higher plant population compensated the yield per plant in narrow spacing, though there were fewer bolls and yield per plant. This is similar to the results of Kalaichelvi (2008), Krishnaveni *et al.* (2010), Manjunatha *et al.* (2010b), Brar *et al.* (2013), Kumar *et al.* (2017) and Gunasekaran *et al.* (2020) who also worked under a high-density planting system in cotton and reported an increase in yield under closer spacing than in wider spacing levels.

Economics

The gross monetary return (₹ 115425 ha^{-1}), net monetary return (₹ 65706 ha^{-1}) and B: C (2.32) ratio was highest with a narrow spacing of 60 x 15 cm followed by 75 x 15 cm (2.25). The returns were higher in the narrow spacing of 60 X 15 cm due to the higher plant population per unit area. These results are in accordance with the report of Meena *et al.* (2017) that maximum net return (₹57553 ha^{-1}) and B: C ratio (2.50) was at 90 x 45 cm closer spacing over 90 x 60 cm spacing (₹45690 ha^{-1}) and 90 x 90 cm (₹40565 ha^{-1}) wider spacing.

Conclusion

The high-density planting system showed that the narrow spacing of 60 x 15 cm produced positively high crop growth *viz.,* maximum plant height (103.14 cm), Leaf Area Index (LAI) (4.35), Dry Matter Production (DMP) (8125 kg/ha), Crop Growth Rate (CGR) (6.58 g/ m^2/day), root length (41.46 cm), root dry weight (14.94 g/plant), and chlorophyll index (48.24) and yield (2565 $kg.ha^{-1}$) with highest B: C ratio of 2.32 of the cotton genotype TCH 1819. So, by adopting HDPS, the yield per unit area can be maximized as well as profit.

Conflict of interest

The authors declare that they have no conflict of interest.

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