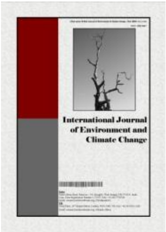

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Influence of Varied Plant Densities and Nitrogen Doses on Growth and Yield of *Bt* cotton (*Gossypium hirsutum* L.) Under High Density Planting System

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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

A field experiment was conducted at College farm, College of Agriculture, PJTSAU, Hyderabad during *kharif*, 2021-22 to study the growth and yield of *Bt* cotton as influenced by varied plant densities and nitrogen doses under high density planting system. The results revealed that among plant densities, plant height (102.8 cm) and drymatter production (7396 kg ha^{-1}) were higher with spacing of 90 x 15 cm (74,074 plants ha^{-1}) and was on par with spacing of 90 x 20 cm (55,555 plants ha-1). Whereas, sympodial branches plant^{-1} (21.0) and leaf area (4143 cm^{2} plant^{-1}) were recorded higher with spacing of 90 x 60 cm (18,518 plants ha^{-1}). Even though at spacing 90 x 60 cm (18,518 plants ha^{-1}) showed more number of picked bolls plant^{-1} (18.2), boll weight (5.10 g) but 90 x 15 cm spacing (74,074 plants ha^{-1}) showed significantly higher seed cotton yield (2176 kg ha^{-1}) which was at par with 90 x 20 cm (55,555 plants ha^{-1}) (2052 kg ha^{-1}). In case of nitrogen doses, application of 180 kg N ha^{-1} recorded higher growth parameters like plant height (103.2 cm),

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sympodial branches plant^{-1} (20.8), drymatter production (6952 kg ha^{-1}) and leaf area (3826 cm^2 plant^{-1}). Whereas, application of 150 kg N ha^{-1} recorded higher seed cotton yield (2072 kg ha^{-1}) with more number of picked bolls plant^{-1} (12.9) and higher boll weight (4.87 g) over other nitrogen doses tested.

Keywords: Telangana; high density planting system; cotton; nitrogen.

1. INTRODUCTION

Cotton is an important fibre crop, which occupies a place of special significance in Indian farming and national economy. In India during 2021-22 cotton is cultivated in an area of 120.69 lakh hectare with a production of 340.62 lakh bales and productivity of 469 kg ha^{-1}. India has the largest area under cotton cultivation followed by China and contributing about 37% and 22% of world cotton area and production, respectively. In spite of that, its productivity is still far lower against the world's average yield of about 787 kg ha^{-1} CCI [1]. While, Telangana state covering 20.51 lakh hectares and 65.87 lakh bales of production during 2021-22 Indiastat [2]. It is a fact that cotton is the back bone of textile industry and is the most important commercial crop grown under rainfed conditions of Telangana region. Though, India ranks first in the world cotton production by 2021-22, its productivity levels are very low despite the availability of *Bt* technology. Majority research findings revealed that heavy soils are suitable for cotton cultivation while, most of the farmers in Telangana state cotton cultivated cotton in light soils as a rainfed crop, hence the yields were very low. Still, various factors are responsible for low yield of cotton, the possible way for redefining the cotton productivity is through manipulation of row spacing to increase the plant density and their spatial arrangement with an appropriate plant geometry, which is termed as high density planting system (HDPS) in cotton. It is generally referred as planting at closer spacing than the recommended spacing with sole objective of maximizing the yield per unit area and it varies from genotype to genotype. The HDPS is now being conceived as an alternative production system that can improve productivity, profitability, input use efficiency and reducing input costs as well as minimizing the risks associated with the current cotton production system in India and enable mechanical picking Venugopalan et al. [3].

Nitrogen is one of the most prime element for crop production and cotton plants require larger amounts of fertilizer N than any other element because of its high concentration in the plant and low availability in the soil. Applying nitrogen fertilizer more than the recommendation is becoming a serious problem in developing countries like India Karthik et al. [4]. Optimum nitrogen fertilization is important for cotton to be grown in high density planting and to be adjusted to avoid excessive plant growth and delayed maturity and to optimize fibre quality. 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 Brodrick et al. [5]. Where, the yield potential of the crop can be achieved to maximum only when the nutrient requirements are fully met.

So, by keeping in context of various views the present experiment was undertaken to study the growth and yield of high density planting and optimum nitrogen dose for a profitable approach to realize the maximum yield potential under rainfed conditions.

2. MATERIALS AND METHODS

The experiment was carried out at College farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during *kharif* 2021-22. The soil of experiment site is red sandy loam with low in available N (197 kg ha^{-1}), medium in available P (21.8 kg ha^{-1}) and organic carbon content (0.52%), high in available K (361 kg ha^{-1}) and pH (7.5). The total rainfall received during the cropping season was 504.6 mm. The experiment was laid out in randomised block design (with factorial concept) and replicated thrice. The experiment consists of 16 treatment combinations comprising four plant densities (D_1- 90 x 15 cm (74,074 plants ha^{-1}), D_2 - 90 x 20 cm (55,555 plants ha^{-1}), D_3 - 90 x 30 cm (37,037 plants ha^{-1}), D_4 - 90 x 60 cm (18,518 plants ha^{-1}) in factor I and four levels of nitrogen doses (N_1 - 90 kg ha^{-1}, N_2 -120 kg ha^{-1}, N_3 - 150 kg ha^{-1}, N_4 - 180 kg ha^{-1}) in factor II. Genotype, NCS-2778 BG-II was sown which is highly suitable to high density planting due to its compact nature. Nitrogen was applied in the form of urea as per treatments in four equal splits at 20, 40, 60, 80 days after sowing (DAS) along with recommended dose of potassium and entire quantity of phosphorus was applied basally. All recommended agronomic practices and timely need based plant protection measures were taken to establish healthy maintenance of crop. The growth and yield observations were recorded as per standard procedure. The data was statistically analyzed by adopting standard analysis of variance by Gomez and Gomez [6].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant density

Results showed that growth parameters like plant height, drymatter production, leaf area and sympodial branches plant^{-1} was significantly influenced by varied plant densities. Higher plant height (102.8 cm) was recorded with 90 x 15 cm of spacing (74,074 plants ha^{-1}) and was at par with spacing of 90 x 20 cm (55,555 plants ha^{-1}) (101.1) and 90 x 30 cm (37,037 plants ha^{-1}) (98.2 cm). While, lowest was recorded with spacing of 90 x 60 cm (18,518 plants ha^{-1}) (94.2 cm) and was on par with spacing of 90 x 30 cm. Higher plant height in closer spacing was mainly due to overcrowding and competition for nutrients, water and solar radiation which increases internodal length of individual plant. These results are in agreement with Ali et al. [7].

Where, significantly higher drymatter production (7396 kg ha^{-1}) was recorded with spacing of 90 x 15 cm (74,074 plants ha^{-1}) compared to other spacings tested but was at par with spacing of 90 x 20 cm (55,555 plants ha^{-1}) (6991 kg ha^{-1}). While, significantly lower drymatter production was noticed with spacing of 90 x 60 cm (18,518 plants ha^{-1}) Where, higher drymatter production in closer spacing was due to higher plant population accommodated per unit area.

In differ with this, significantly higher leaf area (4143 cm^2 plant^{-1}) at 100 DAS was recorded with wider spacing of 90 x 60 cm over rest of the treatments. Where, significantly lower leaf area was observed with closer spacing of 90 x 15 cm (3198 cm^2 plant^{-1}) but was found to be at par with 90 x 20 cm spacing (3343 cm^2 plant^{-1})**.** Whereas, higher number of sympodial branches plant^{-1} (21.0) was also observed with spacing of 90 x 60 cm (18,518 plants ha^{-1}) and was at par with spacing of 90 x 30 cm (37,037 plants ha^{-1}) (19.5) and in turn this was found on par with other two spacings. This is due to the fact that wider spacing provides larger ground area, maximum moisture, more nutrients and more light interception resulting in more photosynthetic activity and production of more biomass through the process of plant metabolism and produced greater leaf area and higher number of sympodial plant^{-1} when compared to closer spacing as reported by Ram and Giri [8]. These results are in close conformity with results of Alur et al. [9].

3.1.2 Nitrogen doses

Regarding to nitrogen doses, application of higher dose of nitrogen *i.e.,* 180 kg N ha^{-1} recorded higher values of all growth contributing characters like plant height (103.2 cm), sympodial branches plant^{-1} (20.8), dry matter production (6952 kg ha^{-1}) and leaf area (3826 cm^2 plant^{-1}) as compared to lower dose of nitrogen *i.e.,* 150 kg N ha^{-1} and 120 kg N ha^{-1} and 90 kg N ha^{-1} during the study. However, application of 150 kg N ha^{-1}, 120 kg N ha^{-1} were found to be equally effective in enhancing plant height, sympodial branches plant^{-1}, dry matter production and leaf area. This is due to increased availability of nutrients and uptake of nutrients from the soil, this resulted in better assimilation and growth of the plant in aspects of both shoot and root, which helped in utilization of more sunlight, water and nutrients and thus resulted in increases in growth characters and in turn increasing drymatter production and leaf area. The present results were in accordance with Zarina et al. [10] and Udikeri and Shashidhara [11].

3.2 Yield Attributing Characters

3.2.1 Plant density

Significantly higher number of picked bolls plant^{-1} (18.2) were recorded with spacing of 90 x 60 cm. Whereas, significantly lower number of picked bolls plant^{-1} (7.3) were recorded with spacing of 90 x 15 cm and this was found to be at par with spacing of 90 x 20 cm (8.9). Ahmed et al. [12] reported that number of bolls plant^{-1} increased with increase in plant spacing.

Whereas, significantly higher boll weight (5.10 g) was recorded with spacing 90 x 60 cm whereas, lower boll weight was recorded with spacing 90 x 15 cm (4.41 g) and was at par with spacing 90 x 20 cm (4.56 g). The results found in this study are in line with results of Paslawar et al. [13] and Sanket et al. [14]. When cotton plants grown under wider spacing or lower plant population, bolls tend to be larger and produce more number of bolls plant^{-1} is due to availability of more nutrients and ample space to grow.

Fig. 1. View of the experimental plot at flowering stage

3.2.2 Nitrogen doses

Regarding nitrogen, higher number of picked bolls $plant^{-1}$ (12.9) and boll weight (4.87 g) were recorded with application of 150 kg N ha^{-1} which is on par with application of 180 kg N ha^{-1} (12.0, 4.83 g; number of picked bolls $plant^{-1}$ and boll weight (g), respectively) and 120 kg N ha^{-1} (11.5, 4.74 g; number of picked bolls $plant^{-1}$ and boll weight (g), respectively). Increase in the availability of nitrogen resulted in increased drymatter production of plants, which attributed to higher number of sympodial branches $plant^{-1}$ and there by induced more number of $bolls^{-1}$ plant. Whereas, drymatter production acted as a source to supply nutrients to reproductive parts (squares and bolls). So, heavier boll weight could be due to a better source-sink relationship established at adequate nitrogen dose. These results are in line with Dadgale et al. [15].

3.3 Seed Cotton Yield (kg ha^{-1})

3.3.1 Plant density

Significantly higher seed cotton yield (2176 kg ha^{-1}) was obtained with spacing of 90 x 15 cm (74,074 plants ha^{-1}) over 90 x 30 cm (37,037 plants ha^{-1}) (1857 kg ha^{-1}) and 90 x 60 cm spacing (18,518 plants ha^{-1}) (1623 kg ha^{-1}) but was found to be at par with 90 x 20 cm spacing (55,555 plants ha^{-1}) (2052 kg ha^{-1}). Higher plant densities (74,074 plants ha^{-1}, 55,555 plants ha^{-1} and 37,037 plants ha^{-1}) recorded 34.07, 26.41 and 14.43% yield increase over lower plant density (18,518 plants ha^{-1}), respectively. Yielding ability of a crop is the reflections of yield attributing characters. Even though the decrease in yield attributing character *i.e.,* sympodial branches, number of boll $plants^{-1}$, boll weight in closer spacing which was compensated by increase in plant population per unit area. Similar results were documented by Bharathi et al. [16] and Pandagale et al. [17].

3.2.2 Nitrogen doses

Regarding nitrogen, significantly higher seed cotton yield (2072 kg ha^{-1}) was recorded with application of 150 kg N ha^{-1} compared to 90 kg N ha^{-1} (1706 kg ha^{-1}) and was on par with application of 180 kg N ha^{-1} (1996 kg ha^{-1}) and 120 kg N ha^{-1} (1935 kg ha^{-1}). There was linear increase in seed cotton yield from 90 to 150 kg N ha^{-1} and on further increase *i.e.,* 180 kg N ha^{-1} did not show any positive response on seed cotton yield. This might be due to over use of nitrogen causes excessive vegetative growth, delayed maturity, produces more immature bolls, increased boll rot and invited more sucking pests which further leads to reduction in yields as reported by Kanchana et al. [18] and this was in agreement with Jagtap and Bhale [19] who reported on application of 80 kg N ha^{-1} significantly gave more seed cotton yield (2834 kg ha^{-1}) over 60 kg N ha^{-1} (2410 kg ha^{-1}) and was at par with 100 kg N ha^{-1} (2617 kg ha^{-1}). While increased seed cotton yield with increased N levels was observed by Zarina et al. [10] and Munir et al. [20].

Interaction effect of varied plant densities and nitrogen doses was not found significant on growth, yield and yield contributing characters.

Table 1. Growth parameters, yield attributes and yield as influenced by varied plant densities and nitrogen doses under high density planting system

Treatments	Plant height (cm)	Number of sympodial branches plant^{-1}	Drymatter production (kg ha^{-1})	Leaf area (cm^2 plant^{-1}) at 100 DAS	Total no. of picked bolls plant^{-1}	Single boll weight (g)	Seed cotton yield (kg ha^{-1})
Planting densities (D)							
D_1 - 90 x 15 cm (74,074 plants ha^{-1})	102.8	18.0	7396	3198	7.3	4.41	2176
D_2 - 90 x 20 cm (55,555 plants ha^{-1})	101.1	18.6	6991	3343	8.9	4.56	2052
D_3 - 90 x 30 cm (37,037 plants ha^{-1})	98.2	19.5	6292	3631	11.3	4.82	1857
D_4 - 90 x 60 cm (18,518 plants ha^{-1})	94.2	21.0	5381	4143	18.2	5.10	1623
SEm ±	1.8	0.6	190	102	0.6	0.09	65
CD (P=0.05)	5.1	1.8	549	293	1.6	0.25	189
Nitrogen doses (N)							
N_1 - 90 kg ha^{-1}	93.8	17.0	5773	3185	9.3	4.45	1706
N_2 - 120 kg ha^{-1}	98.4	19.0	6458	3535	11.5	4.74	1935
N_3 - 150 kg ha^{-1}	101.6	20.3	6876	3779	12.9	4.87	2072
N_4 - 180 kg ha^{-1}	103.2	20.8	6952	3826	12.0	4.83	1996
SEm ±	1.8	0.6	190	102	0.6	0.09	65
CD (P=0.05)	5.1	1.8	549	293	1.6	0.25	189
Interaction (DxN)							
SEm ±	3.5	1.3	380	203	1.11	0.17	131
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

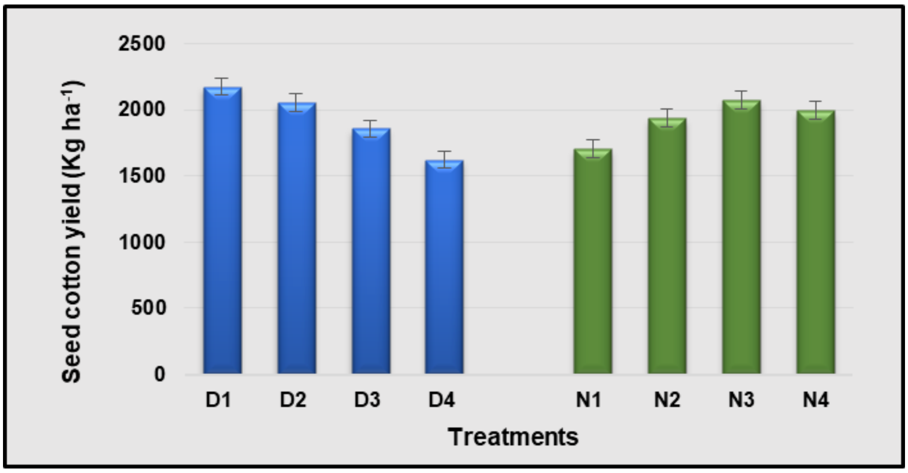

Fig. 2. Seed cotton yield (kg ha^{-1}) as influenced by varied plant densities and nitrogen doses under high density planting system during *kharif* 2021-22

4. CONCLUSION

Cotton is the major commercial crop being grown in our country. Productivity of the cotton is not up to the mark despite the major efforts made by farmer as well as scientists. Productivity could be improved with the optimization of nitrogen fertilization and high density spacing which is having multiple benefits like lesser weed density, high input use efficiency and also enable mechanical picking. The present field experiment inferred that this compact genotype, NCS-2778 gave highest growth parameters, yield attributes and seed cotton yield with closer spacing of 90 x 15 cm (74,074 plant ha^{-1}) and application of 150 kg N ha^{-1} can be cultivated for realizing higher seed cotton yield under rainfed conditions in red soils of Telangana region.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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