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# Growth and productivity of *Bt* cotton (*Gossypium hirsutum*) under row spacing and nitrogen doses

HASANDEEP SINGH[1], GURINDER SINGH[2]* and MOHINDER LAL[1]

*Khalsa College, Patiala, Punjab 147 001, India*

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Cotton (*Gossypium hirsutum* L.) is a shrub that is grown for its natural fiber in tropic and sub tropics regions with various climatic conditions (Nagrare *et al.* 2013). It can be grown in soil having a *p*H of 5.5 to 8.5 which is good for crop production. In India, the 11 primary cotton-producing states are categorized into 5 main geographic zones: the north zone, central zone (rainfed), central zone (irrigated), south zone (rainfed) and south zone (irrigated) (Anonymous 2022). Globally, an area under cultivation of cotton is 130.61 lakh hectares with a production of 343.47 lakh bales (one bale is equal to 170 kg) and productivity of 447 kg/ha (Anonymous 2022a). In Punjab, cotton is grown on an area of about 2.21 lakh hectares with production and productivity of 4.54 lakh bales and 320.25 kg/ha, respectively (Anonymous 2022). *Bt* cotton covered 96.14 lakh hectares (88%) of the total cultivated area (CCI 2021). Row spacing significantly affects factors such as light interception, moisture accessibility, humidity levels, nutrient absorption, weed proliferation and has direct implications on plant height, fruiting patterns, maturation, and the ultimate yield of the crop (Zaman *et al.* 2021). An optimum row spacing is required to produce a higher yield per unit area (Brodrick *et al.* 2013). Looking to the decrease in available nitrogen content in soil and to fulfill the need of the plants nitrogen is required and is supplied through fertilizer. Nitrogen is the main part of bio-chemical compounds of plant. Varied nitrogen dosages have a direct impact on both the weight of seed cotton per boll and the overall seed cotton yield per hectare (Saleem *et al.* 2010). Nitrogen application had a substantial effect on the growth, boll development, lint output and fiber quality of cotton crop (Luo *et al.* 2018).

The field experiment was conducted during the rainy (*kharif*) season of 2019 at the Campus for Research and Advanced Studies, Dhablan, Department of Agriculture at Khalsa College, Patiala (30°19′ N and 76°24′ E at an altitude of 247 meters amsl), Punjab to see the effect of row spacing and nitrogen doses on growth and productivity of *Bt* cotton. The experimental design employed was a split plot and replicated thrice. The study encompassed 3 distinct row spacing levels i.e. 40 cm, 60 cm, and 80 cm combined with 4 nitrogen application levels: 25% of the recommended nitrogen dose (RDN), 50% RDN, 100% RDN (equivalent to 90 kg/ha) and an elevated 125% RDN. With distinct row spacing, plant to plant spacing was maintained at 45 cm. The soil within the experimental field contained available N 187.26 kg/ha (Subbiah and Asija 1956), available P 16.4 kg/ha (Olsen *et al.* 1954) and available K 145.71 kg/ha (Jackson 1973). The soil's texture was identified as clayey, characterized by a *p*H of 7.3 (1:2, soil: water suspension) and organic carbon content 0.6% (Walkley and Black's 1934 rapid titration method given by Jackson 1973). It lies in the south-eastern direction of Punjab state in the north-western region of India. Throughout the year, there are variations in the mean maximum and minimum temperatures. Summer temperatures can escalate to around 45°C, accompanied by dry periods. The winter season encounters frost in December and January, with minimum temperatures falling below 4°C. Patiala receives an average annual rainfall of 547–667 mm, with 75–80% of this precipitation occurring between June and September and average humidity ranges from 90.53 to 53.6% during morning and night respectively. The varying nitrogen doses, in accordance with each treatment, were applied by the fertilizer urea and recommended dose of phosphorus (30 kg/ha) was applied in the form of single superphosphate (SSP) during the time of sowing. The crop was sown using variety RCH 773 on 24 April 2019. An analysis of variance was carried out to assess the influence of row spacing and nitrogen levels on the growth, productivity and economics of *Bt* cotton. The statistical analysis of the data was done for split-plot design by using OPSTAT software developed by CCSHAU, Hisar, Haryana (Sheoran 2010). To determine significant differences between means, the Fisher's Least Significant Difference (LSD) test was employed at a 5% probability level (P=0.05).

[1]Khalsa College, Patiala, Punjab; [2]Punjab Agricultural University, Ludhiana, Punjab. *Corresponding author email: gurinderv6@gmail.com

Table 1 Effect of different row spacing and nitrogen levels on growth parameters of *Bt* cotton

| Treatment | Plant height (cm) | Leaf area per plant (120 DAS) | Number of monopodial branches per plant | Number of sympodial branches per plant |
|---|---|---|---|---|
| *Row spacing* | | | | |
| 40 cm | 209.93 | 39.97 | 4.89 | 19.65 |
| 60 cm | 200.83 | 40.93 | 5.26 | 20.63 |
| 80 cm | 195.00 | 43.90 | 5.90 | 21.61 |
| SEm± | 1.85 | 0.35 | 0.14 | 0.21 |
| CD (P=0.05) | 5.14 | 0.97 | 0.40 | 0.59 |
| *Nitrogen levels (kg/ha)* | | | | |
| 25% RDN | 192.96 | 34.06 | 4.79 | 15.91 |
| 50% RDN | 201.54 | 38.84 | 5.08 | 18.51 |
| 100% RDN | 203.77 | 45.85 | 5.50 | 23.89 |
| 125% RDN | 209.41 | 47.65 | 6.03 | 24.21 |
| SEm± | 2.14 | 0.72 | 0.22 | 0.39 |
| CD (P=0.05) | 6.18 | 2.07 | 0.63 | 1.14 |

Plant height differs significantly with respect to row spacing (Table 1). Close row spacing of 40 cm and 60 cm recorded significant increase in plant height by 7.65 and 2.98%, respectively as compared to row spacing 80 cm at maturity. Similar results were observed by Ghule *et al.* (2013). Alternatively, row spacing 80 cm significantly increases leaf area per plant by 9.83 and 7.25% (at 120 DAS), number of monopodial branches by 20.65 and 12.16% and number of sympodial branches per plant by 9.97 and 4.75% as compared to row spacing 40 cm and 60 cm, respectively (Table 1). Moreover, row spacing 80 cm significantly increases yield attributes like single boll weight by 16.45 and 6.56% (at 90 DAS), no. of picked bolls per plant by 8.79 and 4.92%, seed cotton weight per boll by 13.34 and 5.47% and seed cotton weight per plant by 3.05 and 1.78% followed by row spacing 40 cm and 60 cm, respectively (Table 2). This might be due to the lesser competition of water, nutrients, space and sunlight for plants to produce healthy leaves and more number of flowers were bearing. Similar results were observed by Kumar *et al.* (2011). Row spacing 60 cm significantly increases seed cotton yield by 7.65 and 12.81% and biological yield by 2.28 and 8.18% as compared to row spacing 40 cm and 80 cm, respectively and ginning percentage and harvest index by 5.6 and 6.77%, respectively as compared to 40 cm but biological yield at row spacing 60 cm was at par with row spacing 40 cm (Table 2) . Row spacing 60 cm produced significantly highest gross return (₹122787.50/ha), net return (₹96627.04/ha) and B:C (3.69) due to the more seed cotton yield with 60 cm as compared to 40 cm and 80 cm (Table 3). Similar results were also observed by Dhillon *et al.* (2006).

A higher level of nitrogen 125% RDN kg/ha significantly increases plant height by 8.52 and 3.90%, leaf area per plant by 39.90 and 22.68% (at 120 DAS), number of monopodial branches per plant by 25.88 and 18.70% and sympodial branches per plant by 52.16 and 30.79% at maturity as compared to 25 and 50% RDN kg/ha, respectively but on par with 100% RDN kg/ha. Similar results were also reported by Kumar *et al.* (2011). Application of 125% RDN kg/ha produced highest yield attributes and yield as compared to 25%, 50%, and 100% RDN kg/ha (Table 2). The higher nitrogen level of 125% RDN kg/ha significantly increases single boll weight (at 90 DAS) by 17.25 and 14.07%, no. of picked bolls per plant by 12.85 and 5.16%, seed cotton weight per boll by 26.54 and 20.27% and seed cotton weight per plant by 11.65 and 5.02% followed by 25 and 50% RDN kg/ha, respectively but on par with 100% RDN kg/ha. Nitrogen level 125% RDN kg/ha significantly increases

Table 2 Effect of different row spacing and nitrogen levels on yield attributing characters and yield of *Bt* cotton

| Treatment | Single boll weight (90 DAS) (g) | Number of picked bolls/ plant | Seed cotton weight per boll (g) | Seed cotton weight per plant (g) | Seed cotton yield (q/ha) | Ginning (%) | Biological yield (q/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|
| *Row spacing (cm)* | | | | | | | | |
| 40 cm | 16.17 | 29.00 | 4.42 | 147.08 | 21.83 | 32.14 | 36.83 | 0.59 |
| 60 cm | 17.67 | 30.07 | 4.75 | 148.92 | 23.50 | 33.94 | 37.67 | 0.63 |
| 80 cm | 18.83 | 31.55 | 5.01 | 151.58 | 20.83 | 32.44 | 34.82 | 0.60 |
| SEm± | 0.29 | 0.35 | 0.8 | 0.80 | 0.21 | 0.52 | 0.46 | 0.01 |
| CD (P=0.05) | 0.82 | 0.98 | 0.21 | 2.22 | 0.59 | 1.44 | 1.27 | 0.02 |
| *Nitrogen levels (kg/ha)* | | | | | | | | |
| 25% RDN | 16.11 | 28.16 | 4.22 | 139.22 | 18.44 | 29.98 | 31.65 | 0.58 |
| 50% RDN | 16.56 | 30.22 | 4.44 | 148.00 | 21.44 | 32.54 | 36.11 | 0.59 |
| 100% RDN | 18.67 | 31.67 | 4.89 | 154.11 | 24.11 | 33.95 | 38.78 | 0.62 |
| 125% RDN | 18.89 | 31.78 | 5.34 | 155.44 | 24.22 | 32.90 | 39.22 | 0.62 |
| SEm± | 0.71 | 0.45 | 0.71 | 1.62 | 0.34 | 0.42 | 0.48 | 0.01 |
| CD (P=0.05) | 2.0t5 | 1.30 | 2.05 | 4.67 | 0.99 | 1.20 | 1.38 | 0.03 |

Table 3 Effect of different row spacing and nitrogen levels on economic parameters of *Bt* cotton

| Treatment | Gross return (₹/ha) | Net return (₹/ha) | B:C |
|---|---|---|---|
| *Row spacing (cm)* | | | |
| 40 cm | 114079.17 | 87918.70 | 3.35 |
| 60 cm | 122787.50 | 96627.04 | 3.69 |
| 80 cm | 108854.17 | 82693.70 | 3.15 |
| SEm± | 1105.34 | 1105.34 | 0.04 |
| CD (P=0.05) | 3068.93 | 3068.93 | 0.12 |
| *Nitrogen levels (kg/ha)* | | | |
| 25% RDN | 96372.22 | 70901.97 | 2.78 |
| 50% RDN | 112047.22 | 86231.92 | 3.34 |
| 100% RDN | 125980.56 | 99474.96 | 3.75 |
| 125% RDN | 126561.11 | 99710.41 | 3.71 |
| SEm± | 1783.50 | 1783.50 | 0.07 |
| CD (P=0.05) | 5151.11 | 5151.11 | 0.20 |

seed cotton yield by 31.34 and 12.96%, biological yield by 23.91 and 8.61% and harvest index by 6.89 and 5.08% as compared to 25% and 50% RDN kg/ha, respectively but at par with 100% RDN kg/ha (Table 2). Therefore, 100% RDN kg/ha produced a significantly maximum ginning percentage of 33.95% which was at par with 125% RDN kg/ha. This might be due to high level of nitrogen produced taller and healthy plant and more number of bolls per plant that may bring out high seed cotton yield. The higher nitrogen level 125% RDN kg/ha recorded a significantly highest gross return ₹126561.11/ha and net return ₹99710.41/ha (Table 3). The rise in economic parameters could be attributed to the elevated nitrogen level, which likely enhanced the dry matter production. Thus, in turn, could have facilitated a greater synthesis of photosynthesis, thereby leading to a boost in the seed cotton weight per plant and ultimately led to highest seed cotton yield which directly produced significantly highest economic parameters with higher nitrogen level. Similar results were revealed by Dhillon *et al.* (2006). Highest B:C (3.75) was recorded with 100% RDN kg/ha but it was on par with 125% RDN kg/ha (3.71) due to less cost of input in 100% RDN as compared to 125% RDN kg/ha .

## SUMMARY

A study was carried out at the Campus for Research and Advanced Studies, Dhablan, within the Department of Agriculture at Khalsa College, Patiala, Punjab during the rainy (*kharif*) season of 2019. The study encompassed 3 distinct row spacing levels i.e. 40 cm, 60 cm, and 80 cm combined with 4 nitrogen application levels, viz. 25% of the recommended nitrogen dose (RDN), 50% RDN, 100% RDN (equivalent to 90 kg/ha) and an elevated 125% RDN. Results indicate that both row spacing and nitrogen levels play a noteworthy role in influencing the growth traits, yield related attributes and overall yield of *Bt* cotton. Specifically, a row spacing of 80 cm exhibited superior performance in terms of growth characteristics such as leaf area per plant, no. of monopodial branches per plant, and no. of sympodial branches per plant. This choice of row spacing subsequently contributed to the enhancement of yield attributing characters, including single boll weight, the number of picked bolls per plant, seed weight per boll and seed weight per plant. But row spacing of 60 cm is required to produce a higher seed cotton yield, ginning percentage, biological yield, harvest index and economic parameters. Among nitrogen levels, 125% RDN kg/ha recorded significantly higher growth, yield attributing parameters, yield, and economic parameters followed by 25% and 50% RDN kg/ha but on par with 100% RDN kg/ha. Therefore, drawing from the findings of this study, it can be deduced that the row spacing of 60 cm with 100% RDN kg/ha is required for getting higher growth and productivity of *Bt* cotton. These findings contributes to enhance the resource efficient practices, maximizes yield and promotes sustainability. Optimized nitrogen levels benefit both crop and soil health, reducing the impact of excess usage and insufficient nitrogen on crop while boosting productivity for long-term farm viability, all while considering the crucial aspect of row spacing.

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