

Effect of nitrogen doses and its time of application on growth and yield of *Bt* cotton (*Gossypium hirsutum*)

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ABSTRACT

A field experiment was conducted during the rainy (*kharif* June–November) season of 2014 at New Delhi, to study the effect of different levels and time of nitrogen (N) application on growth and yield of *Bt* cotton (*Gossypium hirsutum* L.). The results revealed that application of increasing levels of N from 100 to 175 kg/ha showed an increase in plant height (134.1 cm to 164.4 cm), leaf-area index (LAI) (2.50 to 8.91), dry-matter production (301.7 to 362.8 g/pl), crop growth rate (CGR) in *Bt* cotton, although the highest values of these parameters were recorded with application of 175 kg N/ha. Application of N when applied basal also recorded significant influence on various growth parameters over without basal dose of N. The yield of *Bt* cotton was also increased significantly by different N levels. The highest seed cotton yield (2.65 t/ha) was recorded with the application of 175 kg N/ha, being 25.6, 14.7 and 3.5% higher than 100, 125 and 150 kg N/ha, respectively. Basal application of N @ 30 kg/ha has an edge over the treatments where basal application of N was not done with respect to yield-contributing characters (sympodial branches/plant, opened bolls, total number of bolls and boll weight) and yield of *Bt* cotton.

Key words : *Bt* Cotton, Growth, N-application, Nitrogen levels, Yield

Cotton (*Gossypium* species) is the most important fibre and cash crop, grown commercially for agricultural and industrial purposes. In India, cotton is one of the major cash crops, occupying an area of 12.5 m ha with the production of 0.34 m cotton bales. After the approval of Genetic Engineering Approval Committee (GEAC) in 2002, the area of *Bt* cotton spread rapidly. At present, *Bt* cotton (11.76 m ha) accounts for more than 90% of total cotton area in India. Nitrogen (N) management in this crop is one of the most important practices for getting high yield and quality fibre. Both N deficiency as well as excess N adversely affects plant growth and development, retention of boll, seed-cotton yield, lint yield and quality of fibre. An under-estimation and application of N can cause detrimental losses to yield proportional to the fertilizer shortfall, depletion of the soil N reserve, and depletion of soil fertility (Nichols and Green, 2003). Over-fertilization results in

excessive vegetative growth, decreased lint turn out, increased wilt-disease incidence, delay in maturity which may results in immature fibre, adversely affects lint yield and fibre quality (Main *et al.*, 2011). Application of N more than recommended dose not only increases production costs but also causes severe environmental problems, like groundwater contamination by NO₃⁻ leaching (Zhao *et al.*, 2009).

The N requirements of cotton plants are not constant throughout the crop growth. At early stage of crop only a small amount of N is required for vegetative growth which is generally less than 25% of the total quantity of N required by crop in entire season (Guthrie, 1991). A successive increase in N level from 50 to 150 kg/ha results in significant increase in the plant height. Kumbhar *et al.* (2008); Srinivasan (2006) tested 2 *Bt* hybrids under graded levels of fertilizers (80: 40: 40, 100: 50: 50 and 120: 60: 60 kg NPK/ha) and observed significant increase in seed cotton yield with the increasing level of fertilizers. Singh *et al.* (2008) reported that on an average of 2 years, the plant height, leaf-area index, dry-matter production, crop growth, yield-attributing characters and seed-cotton yield significantly increased with increase in level of N from 0 to 150 kg/ha. Considering all these factors into account, a field experiment was conducted to evaluate the effect of

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different N levels and time of N application on growth and productivity of *Bt* cotton.

The field experiment was conducted during the rainy (*kharif*) (June–November) season of 2014 at research farm of ICAR-Indian Agricultural Research Institute, New Delhi (28° 38' N, 77° 10' E and 228.61 m above mean sea-level). It comes under semi-arid and sub-tropical climate with very hot dry summers and cold winters. The total rainfall recorded during the period of experimentation was recorded 547.1 mm. Soil was sandy loam, low in organic C (0.42%) and available N (178.7 kg/ha), medium in P (11.4 kg/ha) and K (180.5 kg/ha), having pH (7.6) and electrical conductivity (0.33 dS/m). The experiment was conducted using a factorial randomized block design with 4 replications during the *kharif* season of 2014. There were 2 factors for the study, viz. 4 N levels (100, 125, 150 and 175 kg/ha) and N application (30 kg N/ha as basal and without basal). There were 9 treatments including an absolute control. Recommended dose of phosphorus (60 kg/ha) through single superphosphate and potassium (60 kg/ha) through potassium chloride (murate of potash) was applied basal at the time of last preparatory tillage. 'MRC 7017' cotton was sown on 6 June 2014. Sowing was done manually on well-prepared field by dibbling method at row spacing of 75 cm and plant-to-plant spacing of 60 cm. Thinning and gap filling were done to keep a good crop stand. All other recommended package of practices were followed to raise a healthy crop.

Biometric observations were recorded as per the standard procedures, starting 40 days after sowing (DAS) at 40-days intervals up to maturity. Five plants in each plot were selected randomly and tagged. Plant height of tagged plants was measured from the base to the tip of the most expanded leaf at harvesting. Leaf area of 2 random plants was measured with the help of leaf area meter (Model LI-3100, USA) at 120 DAS. Leaf-area index was computed with the following formula:

$$\text{LAI} = \frac{\text{Total leaf area (cm}^2\text{)/plant}}{\text{Ground area covered by the plant (cm}^2\text{)}}$$

Dry-matter accumulation of the plant was measured 40, 80, 120 DAS and at harvesting based on single plant dry matter. One plant was randomly selected and chopped in small pieces. The plant material was dried in sun followed by oven drying at 65°C (36 to 48 hours) to obtain a constant dry weight. Crop-growth rate (CGR) was computed as:

$$\text{CGR} = \frac{W_2 - W_1}{T_2 - T_1} \text{ g/m}^2\text{/day}$$

where, W_1 , plant dry weight at time T_1 ; W_2 , plant dry weight at time T_2 ; T_1 , time of first sampling; T_2 , time of

second sampling

Data on yield were recorded by combining the weight of 3 pickings (manual) done at full boll burst stage. Seed cotton was cleaned and weighed from each net plot for expressing seed cotton yield in t/ha. Data on different parameters were collected and subjected to appropriate statistical analysis by utilizing the procedure described by Cochran and Cox (1967). Significant difference between the means were tested by using 'F' test and the critical difference (CD) was calculated where variance ratio was found significant for treatment effect. The treatment effects for different treatments were tested at 5% probability level for their significance.

The plant height, LAI and dry-matter production of *Bt* cotton increased with the increasing level of N from 100 kg to 175 kg N/ha at all the observational stages (Table 1). However, the highest plant height, LAI and dry-matter production were recorded with application of 175 kg N/ha at harvesting was significantly higher than rest of the N levels and the lowest plant height, LAI and dry-matter production were found with the lowest dose of N, i.e. 100 kg N/ha. Time of application of N had significant influence on plant height, LAI and dry-matter production of *Bt* cotton and it was observed that basal application (30 kg N/

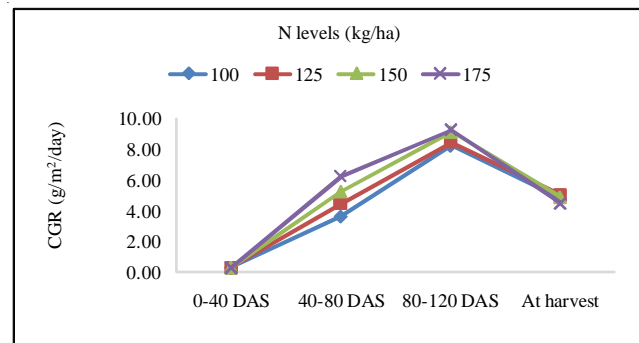


Fig. 1. Effect of nitrogen levels on crop-growth rate (CGR) of *Bt* cotton

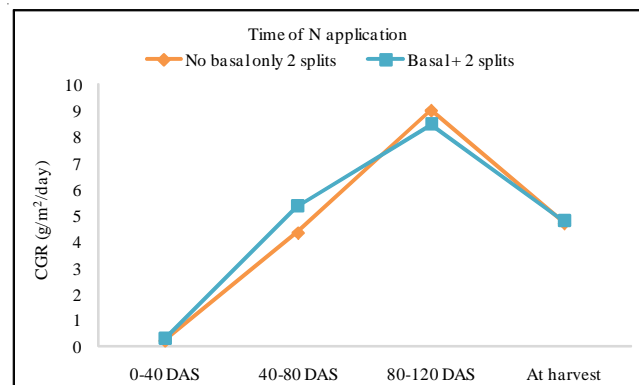


Fig. 2. Effect of time of nitrogen application on crop growth rate (CGR) of *Bt* cotton

ha) of N resulted in significantly higher plant height, LAI and dry-matter production than that without basal application. The highest plant height, LAI and dry-matter production was recorded at the time of harvesting, where 30 kg of N/ha applied as basal dose as compared to 147.1 cm, 3.14 and 329.3g respectively, with no basal application. Bhalerao *et al.* (2012) also reported an increase in plant height, LAI and dry-matter production of *Bt* cotton owing to increased N fertilization.

Crop-growth rate (CGR) values were lowest at 0–40 DAS and increased thereafter sharply with increasing crop age. The CGR value reached maximum at 80–120 DAS and declined thereafter gradually (Figs. 1, 2). The CGR values of *Bt* cotton was significantly affected by levels of N. Each successive increase of 25 kg N/ha significantly increased CGR values and this trend continues up to the highest level of N, i.e. 175 kg/ha. The data showed that the time of application significantly affected the CGR values at all stages of observations. The CGR values were higher with the treatment having basal dose of 30 kg N/ha at 0–40 days, 40–80, and 120 days to harvesting. However, the maximum CGR value at 80–120 DAS was found in treatment where no N was applied as basal. Reddy and Gopinath (2008) and Liu *et al.* (2010) also reported similar findings.

Amongst different levels of N application, 175 kg of N/ha resulted in significantly higher seed-cotton yield than rest of the treatments. The highest seed cotton yield was recorded with 175 kg N/ha being 25.6, 14.7 and 3.5%

more than 100, 125 and 150 kg N/ha respectively (Table 1). The seed-cotton yield of *Bt* cotton was also significantly affected by time of N application. Significantly higher seed-cotton yield was obtained with basal application of 30 kg/ha N compared to no basal application of N. An increase of 5.1% in seed-cotton yield was observed in the treatment where 30 kg of N/ha was applied as basal compared to no basal N. Our results support the findings of Giri *et al.* (2014).

Different levels of N tested differed significantly for monopodial and sympodial branches/plant and the highest number of monopodial branches/plant and sympodial branches/plant were recorded with 175 kg N/ha, followed by 150 kg N/ha. However, no difference was recorded between 100 and 125 kg N/ha with respect to number of monopodial branches (Table 1). The lowest number of sympodial branches/plant were recorded with application of 100 kg N/ha. Significantly higher number of sympodial branches/plant was recorded where basal application of N was done compared to no basal N. The increased LAI led to increased photosynthesis and plant height which finally increased dry-matter production (Table 1), i.e. reflected by more sympodia and monopodia production. Pettigrew *et al.* (2006) also reported similar finding in respect of N levels and sympodial and monopodial branch production.

Application of 175 kg of N/ha resulted in significantly higher number of opened bolls/plant, followed by 150 and 125 kg N/ha (Table 1). The maximum number of opened bolls/plant was observed with the highest level of N, i.e.

Table 1. Effect of variable rates of nitrogen application on plant height, leaf-area index (LAI), dry-matter accumulation, yield attributes and yield of *Bt* cotton

Treatment	Plant height at harvest (cm)	LAI (120 DAS)	Dry-matter at harvesting (g/plant)	Sympodial branches/Plant	Mono-podial branches/plant	Opened bolls/plant	Unopened bolls/plant	Total bolls/plant	Boll weight (g)	Seed-cotton yield (t/ha)
<i>Nitrogen (kg/ha)</i>										
100	134.1	2.50	301.7	26.6	2.4	26.2	4.4	30.6	3.63	2.11
125	140.3	3.06	326.3	28.7	2.4	27.9	4.3	32.1	3.73	2.31
150	158.1	3.69	350.5	30.6	2.5	30.1	4.1	34.2	3.83	2.56
175	164.4	3.91	362.8	32.0	2.6	30.8	4.2	34.9	3.88	2.65
SEm±	0.74	0.021	1.46	0.13	0.05	0.17	0.08	0.14	0.005	0.014
CD (P=0.05)	2.15	0.061	4.25	0.37	0.15	0.50	NS	0.42	0.015	0.040
<i>Time of application</i>										
No basal, only 2 splits	147.1	3.14	329.3	28.7	2.5	28.2	4.2	32.5	3.74	2.35
Basal + 2 splits	151.3	3.44	341.3	30.3	2.4	29.2	4.2	33.5	3.79	2.47
SEm±	0.52	0.015	1.03	0.09	0.04	0.12	0.05	0.10	0.004	0.010
CD (P=0.05)	1.52	0.043	3.00	0.26	0.11	0.35	NS	0.29	0.011	0.028
<i>Control vs rest</i>										
Control	116.7	1.50	225.8	21.8	2.0	19.4	5.0	24.4	3.24	1.39
Rest	149.2	3.29	335.3	29.5	2.4	28.7	4.2	33.0	3.77	2.41
SEm±	1.10	0.032	2.18	0.19	0.08	0.25	0.11	0.21	0.01	0.021
CD (P=0.05)	2.28	0.065	4.51	0.39	0.16	0.53	0.23	0.44	0.02	0.043

175 kg N/ha, being 17.6, 10.4 and 2.3% more than 100, 125 and 150 kg N/ha respectively. Basal application of N (30 kg/ha) revealed significantly higher number of opened bolls/plant than no basal N. Application of 100 kg of N/ha recorded higher number of unopened bolls/plant, followed by 125 and 175 kg N/ha. Time of N application recorded non-significant differences between different treatments for number of unopened bolls/plant. Among the different N levels, an application of 175 kg of N/ha showed significantly higher and maximum total number of bolls/plant than 150 and 125 kg N/ha and the maximum total number of bolls/plant were 14.1, 8.7 and 2.0% higher than 100, 125 and 150 kg N/ha, respectively (Table 1). Basal application of N (30 kg/ha) exhibited significantly higher total number of bolls/plant compared to no basal N. Nitrogen led to enhancement of leaf area culminating in more sympodial branches and thus more number of total boll productions supports the present result.

Of the different N levels, the highest boll weight was recorded with 175 kg N/ha, being 6.8, 4.0 and 1.3% more over 100, 125 and 150 kg N/ha respectively. Basal application of N (30 kg/ha) recorded significantly higher boll weight than no basal application of N. An increase in boll weight with N fertilization in the present study is in close agreement with the findings of Nehra and Kumawat (2003). Number of bolls/plant, boll weight (Table 1) increased with the increasing rate of N application. Nitrogen by way of increasing LAI enabled the plant to produce more sympodial branches and thus more number of bolls. The increase in the boll weight with increased N levels was ascribed to increased seed-cotton yield (Table 1). Higher number of bolls with heavier weight under increased N fertilization together led to more seed-cotton yield realization. Nitrogen led to enhancement of leaf area and culminating in more sympodial branches and more number of total bolls production enhanced cotton yields. Bhalerao *et al.* (2012); Srinivasulu *et al.* (2006) also reported that nitrogen enhanced cotton yields.

From the above study, it can be concluded that the highest seed-cotton yield may be obtained with the application of 175 kg N/ha and basal application of N at the rate of 30 kg/ha has an edge over the treatments where basal application of N was not applied with respect to yield-contributing characters and yield of *Bt* cotton.

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