Archives of Current Research International

Volume 25, Issue 8, Page 549-557, 2025; Article no.ACRI.141975
ISSN: 2454-7077

Effect of Nitrogen Levels and Growth Retardants on Cotton 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.

Article Information

DOI: https://doi.org/10.9734/acri/2025/v25i81438

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/141975

Original Research Article

Received: 27/05/2025
Published: 13/08/2025

ABSTRACT

Trials were conducted during three years from 2021-22 to 2023-24 at Main Cotton Research Station, Navsari Agricultural University, Surat, Gujarat to study the effect of nitrogen levels on yield of cotton and to find out the efficacy of growth retardants on plant canopy of cotton grown under high density planting system. Nine treatment combinations comprising of three nitrogen levels *viz;* 375 kg N/ha, 300 kg N/ha and 225 kg N/ha with three treatments of growth retardants *viz;* Cycocel spray @ 50 g a.i./ha in each spray at 60 and 75 days after sowing, Mepiquat chloride spray @ 37.5 g a.i./ha in each spray at 60 and 75 days after sowing and Control (water spray at 60 and 75 days after sowing) were laid out in factorial randomized block design. Nitrogen levels significantly

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Cite as: *Sankat, K. B., M. M. Patel, P. S. Patel, and H. R. Ramani. 2025. "Effect of Nitrogen Levels and Growth Retardants on Cotton Under High Density Planting System". Archives of Current Research International 25 (8):549-57. https://doi.org/10.9734/acri/2025/v25i81438.*

influenced on growth parameters *viz;* plant height, number of sympodial branches/plant, sympodial length and days to 50 % flowering, yield attributes *viz;* number of bolls/plant and boll weight, seed cotton yield (kg/ha), lint yield (kg/ha) and stalk yield (kg/ha). Important growth and yield parameters *viz;* plant height, number of sympodial branches/plant, sympodial length, days to 50 % flowering, number of bolls/plant and boll weight, seed cotton yield (kg/ha), lint yield (kg/ha) and stalk yield (kg/ha) were significantly influenced by growth retardant treatments. Conclusion of the experiment was drawn that application of 300 kg nitrogen/ha in five equal splits at 30, 60, 75, 90 and 105 days after sowing along with 40 kg P_2O_5/ha as basal dose and spraying of mepiquat chloride 5 % AS @ 37.5 g a.i./ha at 60 and 75 days after sowing found optimum for obtaining higher seed cotton yield as well as net returns from *Bt* cotton hybrid grown with high density planting system maintaining 60 x 45 cm spacing under irrigated condition of south Gujarat.

Keywords: Bt cotton; nitrogen; mepiquat chloride; plant growth retardant.

1. INTRODUCTION

"Cotton (*Gossypium hirsutum* L.) is known as "*White gold*" and "*King of natural fibre*". Nutrient management is considering one of the most important factors that affecting cotton growth. Nitrogen is one of the primary elements limiting crop production" (Li *et al*., 2021). Therefore, "chemical nitrogen fertilizer is applied comparatively in larger quantity for cotton farming" (Watts *et al*, 2017). "Demand of crop for sufficient nitrogen is in contradiction to increasing nitrogen use efficiency, particularly in the conventional farming made by many farmers" (Rochester and Bange, 2016; Yang *et. al*, 2021). As per an estimate made by Macdonald *et. al,* (2017), about 10 and 35 % of nitrogen containing chemical fertilizers are lost to the hydrosphere and atmosphere, respectively. "The inefficient utilization of nitrogen fertilizer caused by enhanced application of nitrogen creates challenges to sustainable crop production and environmental health" (Luo *et. al*., 2018). Comparatively higher vegetative growth in cotton plants generally occurs at the expense of reproductive plant parts and a large fraction of squares and small bolls on the lower sympodial branches either shed or open badly resulting in lower yield. Plant growth regulators (PGRs) are the substances when added in a small quantity may modify the plant growth usually by stimulating or inhibiting some part of natural growth regulation in plant body. Plant growth regulators are considered as new generation of agrochemicals after chemical fertilizers, pesticides and herbicides. PGRs may enhance yield by enhancing the retention of photosynthates into developing bolls. Cotton farmers and persons engaged in research have, therefore, frequently utilized plant growth retardants as a mean to maintain the balance between reproductive and vegetative growth for obtaining higher cotton production and productivity. Synthetic chemical compounds are widely used in cotton cultivation, for decreasing plant height. Mepiquat chloride is such compound is popular to reduce inter nodal length and ultimately reducing plant height and stimulating the translocation of photosynthates towards reproductive parts like developing cotton bolls, as a consequent results in higher yields. PGRs have been widely used in developed countries for enhancing cotton yield by maintaining plant growth and to improve lint yield and fiber quality. Gwathmey and Clement (2010) reported that source sink balance can be changed by using plant growth regulator like mepiquat chloride. Use of mepiquat chloride enhances nitrogen uptake resulting into enhanced seed cotton yield (Shekar*et al*, 2015). Application of mepiquat chloride at squaring or at both squaring and flowering stages considerably improved cotton fibre quality characters *viz;* fiber length and fiber strength without significant loss of yields (Ren*et al,* 2013). Cycocel could also be used to control the vegetative growth of cotton plants as per the findings of Alfageih et al. (2001). However, research on spraying of growth retardants in conjunction with high density planting may pave way for synchronized maturity of the crop with uniform plant height that may help in harvesting of seed cotton mechanically at large scale.

Keeping all the views in mind, the present investigation was designed and conducted to assess the effect of nitrogen levels on yield of cotton and to find out the effect of growth retardants on plant canopy of cotton grown under high density planting system.

2. MATERIALS AND METHODS

The study was made during *kharif* seasons of the year 2021-22 to 2023-24 at Main Cotton Research Station, Navsari Agricultural University, Surat, Gujarat to evaluate the effect of nitrogen

levels on yield of cotton and to find out the effect of growth retardants on plant canopy of cotton grown under high density planting system. Geographically, the research station is located in the South Gujarat, India. Soil of the field was *Vertisol* clayey containing 252 to 275 kg available N/ha, 29.06 to 38.73 kg available P_2O_5/ha and 496 to 542 kg available K_2O/ha. Total nine treatment combinations comprising of three nitrogen levels *viz;* 375kg N/ha (N_1), 300kg N/ha (N_2) and 225kg N/ha (N_3) with three treatments of growth retardants *viz;* cycocel spray @ 50 g a.i./ha in each spray at 60 and 75 days after sowing (G_1), mepiquat chloride spray @ 37.5 g a.i./ha in each spray at 60 and 75 days after sowing (G_2) and control *i.e.* water spray at 60 and 75 days after sowing (G_3) were carried out with factorial randomized block design. The experiment was conducted with three replications. A public sector *Bt* cotton hybrid; GTHH 49 (BG-II) was selected for the study and was sown with high dense spacing of 60 x 45 cm. Urea and single super phosphate were used as sources for N and P, respectively during the study. Common application of farm yard manures @ 5 tones/ha was done during all the three years. Seasonal conditions were moderately favourable to cotton crop during all the years of study. Necessary observations were recorded. Statistical analysis of data was carried out as per method described by Steel and Torrie (1980). Economic parameters were also computed based on current market prices of labour, inputs and produces.

3. RESULTS AND DISCUSSION

Pooled data of three years are presented in Table 1 and Table 2.

3.1 Effect on Growth Characters

3.1.1 Plant height

The differences in plant height recorded at harvest were found significant due to different levels of nitrogen and growth retardants (Table 1). Treatment N_1 recorded significantly higher plant height (139.95 cm) as compared to treatment N_3 (125.60 cm), however it was found statistically at par with treatment N_2 (135.19 cm). Higher plant height with increased level of nitrogen might be due to balancing of N which may favoured photosynthetic processes (Omran *et al.,* 2018). Similar results were also reported by Paul *et al. (*2016), Rajpoot *et al. (*2018) and Sadhana *et al.* (2021). Among growth retardants, treatment G_2 recorded significantly lower plant height (125.76 cm) and remained at par with treatment G_1 (132.68 cm) as compared to treatment G_3 (142.29 cm). Interference of mepiquat chloride as growth regulator in gibberellic acid biosynthetic pathway might be reflected in lower plant height. Decrease in plant height by spraying of mepiquat chloride was also reported in past by Brar *et al*. (2000), Wang *et al.* (2012) and Sadhana *et al.* (2021).

3.1.2 No of sympodial branches per plant

Number of sympodial branches per plant was found to be significant due to different levels of nitrogen (Table 1). Treatment N_1 recorded higher no. of sympodial branches per plant (19.07) as compared to treatment N_3 (17.22), however, treatment N_1 remained at par with treatment N_2 (18.16). Higher nitrogen application increased photosynthetic rate, which might have resulted in higher accumulation of metabolites, which might be increased number of sympodia/plant. Similar response of cotton crop to nitrogen application was also observed by Chandrashekar *et al.* (2016) and Nagender *et al.* (2017). In growth retardants, number of sympodial branches per plant was found to be significant. Treatment G_2 (18.33) and G_1 (18.63) found statistically similar to each other and recorded significantly higher number of sympodial branches per plant as compared to treatment G_3 (17.49).

3.1.3 Sympodial length

The result pertaining to sympodial length of cotton was found to be significant due to different levels of nitrogen and growth retardant treatments (Table1). Treatment N_1 recorded more sympodial length (30.08 cm) as compared to treatment N_3 (27.04 cm), however nitrogen level N_1 remained at par with treatment N_2 (28.77 cm). Growth retardant treatment G_2 recorded significantly lower sympodial length (27.51 cm) as compared to treatment G_3 (30.16 cm), but remained at par with treatment G_1 (28.22 cm).

3.1.4 Days to 50% flowering

No of days to 50% flowering was found to be significant due to different levels of nitrogen and growth retardant treatments (Table 1). Treatment N_1 produced significantly more number of days to 50 % flowering (67.81 days) and N_2 (66.67 days) as compared to treatment N_3 (65.30 days). Higher application of nitrogen results in excessive vegetative growth may leads to delay

in flowering and ultimately prevents boll formation and boll holding (Cisneros and Godfrey (2001) and Howard *et al*. (2001). No. of days to 50 % flowering were not affected by different growth retardants treatments.

3.2 Effect on Yield Parameters

3.2.1 Number of bolls per plant

Significant differences in number of bolls per plant were observed in different levels of nitrogen and growth retardants (Table 1). Treatment N_1 recorded significantly higher number of bolls per plant (22.10) and N_2 (21.49) as compared to treatment N_3 (19.22). Superior nitrogen dose may express a positive consequence on photosynthesis and translocation of food materials towards squares, consequential in higher boll retention and higher bolls per plant. In past, Zakaria *et al.* (2006), Hosamani *et al.* (2013) and Gundlur *et al.* (2013) also reported similar results. Among the treatments of growth retardants, treatment G_2 produced considerably higher number of bolls per plant (22.01) and was found at par with treatment G_1 (21.19) over treatment G_3 (19.62). Increased number of bolls per plant with mepiquat chloride spray might be due to reduction in abscission of flower buds and bolls. Moreover, mepiquat chloride might have counteracted the effect of abscisic acid and thus reduced the shedding of reproductive plant parts compared to control. The results are in conformity with the findings of Uma *et al*. (2019) and Priyanka *et al.*(2021).

3.2.2 Boll weight

Boll weight was significantly influenced with nitrogen levels and growth retardant treatments (Table 1). Treatment N_1 reported considerably enhanced boll weight (3.51 g) than treatment N_3 (3.38 g), however N_1 found at par with treatment N_2 (3.45 g). Among the growth retardants, treatment s G_1 (3.49 g) and G_2 (3.48 g) remained at par with each other and recorded considerably higher boll weight over treatment G_3 (3.37 g).

3.3 Effect on Yields

3.3.1 Seed cotton yield

Seed cotton yield (kg/ha) was considerably differed with different levels of nitrogen and growth retardant treatments (Table 2). Nitrogen levels N_1 and N_2 proved statistically similar to each other in recording seed cotton yield of 2719 and 2628 kg/ha, respectively and both were considerably higher than level N_3 (2331 kg/ha). The increase in seed cotton yield from applying higher nitrogen doses in N_1 and N_2 treatments might have been caused by beneficial effects of nitrogen on growth characteristics *viz;* higher plant height, increase in number of bolls/plant, accumulation of dry matter/plant, and the plant's subsequent translocation towards the sink. These findings also in a line with the results obtained by Dadgale *et al.* (2014), Zakaria *et al.* (2006), Meena *et al.* (2007) and Basavanneppa (2015) also reported favorable impact of nitrogen on seed cotton yield.

Among treatments of growth retardants, treatment G_2 recorded significant higher seed cotton yield (2717 kg/ha) as compared to treatment G_3 (2400 kg/ha), but treatment G_2 remained at par with treatment G_1 with producing 2562 kg/ha seed cotton yield. The increase in yield with mepiquat chloride spray might be due to increase in accumulation of photosynthates towards the reproductive plant parts. This might have resulted in higher number of bolls/plant and ultimately increased in seed cotton yield. Similar results were also recorded earlier by Oosterhuis and Robertson (2000). Increasing boll number/plant is proved as primary factor in enhancing seed cotton yield (Ballester *et al*., 2021). Khetre *et al*. (2018) and Priyanka *et al.* (2021) also obtained higher seed cotton yields with mepiquat chloride spray.

3.4 Stalk Yield

Stalk yield was significantly differed due to nitrogen levels and growth retardant treatments (Table 2). Treatment N_1 recorded comparatively higher stalk yield (8486 kg/ha) as compared to treatment N_3 (7114 kg/ha), however, level N_1 found statistically similar to treatment N_2 by recording stalk yield of 8120 kg/ha. Higher stalk yield with a sufficient nitrogen supply is similar to the conclusions drawn by Dadgale *et al.* (2014) and Sunitha *et al.* (2010). Among growth retardants, treatment G_3 produced higher stalk yield (8390 kg/ha) than treatment G_1 (7854 kg/ha) and G_2 (7479 kg/ha). The lowest stalk yield obtained in treatment of mepiquat chloride spray might be a result of reduced plant height and lower dry matter accumulation. Similar findings were also reported by Priyanka *et al.*(2021).

Table 1. Effect of different treatments on growth and yield attributing characters (Pooled result)

Treatments	Plantheight(cm)	No ofsympodia/plant	Symodial length(cm)	Days to50 % flowering	No of bolls/ squaremeter	Bollweight(g)
Nitrogen Levels						
N_1: 375 kgN/ha	139.95	19.07	30.08	67.81	22.10	3.51
N_2: 300 kgN/ha	135.19	18.16	28.77	66.67	21.49	3.45
N_3: 225 kgN/ha	125.60	17.22	27.04	65.30	19.22	3.38
S.Em.±	1.83	0.33	0.51	0.65	0.39	0.03
C.D. at 5 %	5.21	0.94	1.45	1.86	1.10	0.10
Growth retardants						
G_1: Cycocel@ 50 g a.i./ha in each spray at 60 and 75 DAS	132.68	18.33	28.22	66.85	21.19	3.49
G_2: Mepiquat chloride @ 37.5 g a.i./ha in each spray at 60 and 75 DAS	125.76	18.63	27.51	67.37	22.01	3.48
G_3: Water spray at 60 and 75 DAS	142.29	17.49	30.16	65.56	19.62	3.37
S.Em.±	1.83	0.33	0.51	0.65	0.39	0.03
C.D. at 5 %	5.21	0.94	1.45	NS	1.10	0.10
CV %	7.12	9.45	9.22	5.11	9.62	5.03

Table 2. Effect of different treatments on seed cotton yield, Stalk yield, Lint yield, Ginning percentage and Harvest index (Pooled result)

Treatments	Seedcotton yield(kg/ha)	Stalk yield(kg/ha)	Ginning percentage (%)	Harvestindex(%)
Nitrogen Levels				
N_1: 375 kgN/ha	2719	8486	34.36	24.35
N_2: 300 kgN/ha	2628	8120	34.46	24.52
N_3: 225 kgN/ha	2331	7117	33.92	24.74
S.Em.±	51	174	0.32	0.46
C.D. at 5 %	144	496	NS	NS
Growth retardants				
G_1: Cycocel@ 50 g a.i./ha in each spray at 60 and 75 DAS	2562	7854	34.18	24.63
G_2: Mepiquat chloride @ 37.5 g a.i./ha in each spray at 60 and 75 DAS	2717	7479	34.60	26.68
G_3: Water spray at 60 and 75 DAS	2400	8390	33.96	22.30
S.Em.±	51	174	0.61	0.46
C.D. at 5 %	144	496	NS	1.30
Interaction (N x G)			4.86	9.67
S.Em.±	55	176	--	--
C.D. at 5 %	NS	NS		
CV %	10.26	11.46		

Table 3. Economics of different treatments

Treatments	Seed Cotton Yield (kg/ha)	Cost of Cultivation (Rs./ha)	Gross Return (Rs./ha)	Net Return (Rs./ha)	BCR
Nitrogen Levels					
N_1: 375 kgN/ha	2719	85580	190353	104773	2.22
N_2: 300 kgN/ha	2628	83717	183960	100243	2.20
N_3: 225 kgN/ha	2331	79800	163193	83393	2.04
Growth retardants					
G_1: Cycocel@ 50 g a.i./ha in each spray at 60 and 75 DAS	2563	83125	179387	96262	2.16
G_2: Mepiquat chloride @ 37.5 g a.i./ha in each spray at 60 and 75 DAS	2717	86373	190167	103794	2.20
G_3: Water spray at 60 and 75 DAS	2399	79599	167953	88354	2.11

Table 4. Prices and Cost of inputs and produce

1	Cotton seed	Rs. 1891.00 per kg	**4**	Cycocel	Rs. 1960.00 per kg
2	Urea	Rs. 5.91 per kg	**5**	Mepiquat chloride	Rs. 1400.00 per kg
3	Single Super Phosphate	Rs. 8.80 per kg	**6**	Selling price of seed cotton	Rs. 70.00 per kg

3.5 Lint Yield

Differences in lint yield were found significant due to different levels of nitrogen and growth retardant treatments (Table 2). Nitrogen doses N_1 and N_2 found statistically similar in recording lint yield of 933 and 905 kg/ha, respectively and both the treatments were found statistically higher than level N_3 (793 kg/ha). Higher lint yield with enhanced dose of nitrogen was also reported earlier by Zakaria *et al* (2006). Treatment G_2 recorded significant higher lint yield (940 kg/ha) when compared with treatment G_3 (814 kg/ha), but treatment G_2 remained similar to treatment G_1 (878 kg/ha). Asnon significant influence on ginning out turn with nitrogen levels and growth retardant treatments might be resulted in similar trend for lint yield like seed cotton yield.

3.6 Quality Characters

3.6.1 Harvest index

Harvest index was observed non-significant in different levels of nitrogen (Table 2). Mahadevappa *et, al.* (2023) also reported similar results. In case of growth retardant treatments, treatment G_2 recorded higher harvest index (26.68) over treatment G_3 (22.30), but was remained at par with treatment G_1 (24.63).

3.6.2 Ginning percentage

Ginning percentage was found to be non-significant among different levels of nitrogen and growth retardant treatments (Table 2). Non significant effect of nitrogen levels on ginning percentage was also observed by Mahadevappa *et al.* (2023).

4. ECONOMICS

Economics was worked out on individual treatment basis and presented in Table 3. Treatment N_1 (application of 375 kg N/ha in five equal splits at 30, 60, 75, 90 and 105 days after sowing) secured highest gross return (Rs.190353/ha), net return (Rs.104773/ha) and benefit cost ratio (2.22) as compared to other nitrogen levels. Among growth retardants, treatment G_2 (Mepiquat chloride @ 37.5 g ai/ha in each spray at 60 and 75 days after sowing) recorded highest gross return (Rs.190167/ha), net return (Rs.103793/ha) and benefit cost ratio (2.20).

5. CONCLUSION

Growth and yield attributing characters as well as seed cotton yield were improved with application of higher doses of N (375 kg and 300 kg N/ha) in five equal splits at 30, 60, 75, 90 and 105 days after sowing. Application of 375 kg and 300 kg nitrogen/ha secured highest gross and net returns over level N_3 (225 kg N/ha). Two sprays of mepiquat chloride @ 37.5 g a.i./ha in each spray at 60 and 75 days after sowing improved growth and yield attributing characters resulted in higher seed cotton yield. Spraying of mepiquat chloride also recorded highest gross and net returns from cotton.

Based on the results of present study it was concluded that application of 300 kg N/ha in five equal splits at 30, 60, 75, 90 and 105 days after sowing along with 40 kg P_2O_5 /ha as basal dose and spraying of mepiquat chloride 5 % AS @ 37.5 g a. i./ha at 60 and 75 days after sowing found suitable for achieving higher seed cotton yield as well as net returns from *Bt* cotton hybrid grown in high density planting system with 60 x 45 cm spacing under irrigated condition of south Gujarat.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/141975