Effect of nano nitrogen on growth, yield and nutrient uptake of *Bt* cotton

ABSTRACT

Aims: Foliar application of nano nitrogen is aimed to reduce the soil application of conventional nitrogen. Nano fertilizers enhance crop growth, yield and quality while enhancing the faster nutrient uptake and reducing costs. They provide precise nutrient management, matching crop growth stage and offer increased surface area for metabolic reactions. This boosts photosynthesis, leading to higher dry matter production and crop yield. Foliar application of nano urea (liquid) at flowering, boll initiation and boll development stages in cotton fulfills the nitrogen requirement and reflects higher crop productivity and quality. Higher productivity of crops in sustainable manner could be achieved applying appropriate combination of conventional fertilizer and nano fertilizers.

Study design: The experiment was laid out in split design with three replications.

Place and Duration of Study: A field experiment was conducted in shallow black soils at Main Agricultural Research Station, Raichur, during *kharif* 2022.

Methodology: There were fifteen treatment combinations, consisting of different doses of RDN (50 % N, 75 % N and 100 % N) with different concentrations of nano urea sprayed at 90, 100 DAS and 135 DAS for US-7067 BG- II hybrid of *Bt* cotton.

Results: Application of 100% RDN has recorded significantly higher plant height, sympodial branches plant^{-1} and total dry matter accumulation (176.9 cm, 27.1 and 430.31g plant^{-1}, respectively) followed by 75 % RDN (168 cm, 26.7 and 426.91 g plant^{-1}, respectively) which found *on par* with each other. It also produced higher number of bolls plant^{-1} (50.3), boll weight (5.81 g) and seed cotton yield (3388 kg ha^{-1}) followed by 75 % RDN (50.2, 5.36 g and 3376 kg ha^{-1}, respectively) which found comparable with each other. Foliar application of nano urea @ 0.6 per cent each at 90, 100 and 135 DAS has recorded significantly higher plant height (180.8 cm), sympodial branches plant^{-1} (28.5), total dry matter accumulation (429.42 g plant^{-1}), number of bolls plant^{-1} (52.2), boll weight (5.93 g) and seed cotton yield (3485 kg ha^{-1}) followed by foliar spray of nano urea @ 0.4 per cent each at 90, 100 and 135 DAS (173.3 cm, 28, 428.52 g plant^{-1}, 51.8, 5.67 g and 3465 kg ha^{-1}, respectively) which found *on par* with each other. Similar trend was recorded with regard to nutrient uptake by cotton.

Conclusion: Foliar application of nano urea reduced the dosage of conventional nitrogen by 25 per cent. There was linear increase in seed cotton yield (kg ha^{-1}) with increasing levels of nitrogen levels.

Keywords: Cotton, Foliar application, nano urea and seed cotton yield

1. Introduction

Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. India plays a vital role in the global cotton landscape, accounting for around 21 per cent of the total cotton production, cultivated across 130.49 lakh hectares, which is estimated around 40 per cent of the world cotton area. At global level, athough India occupies 40 per cent of the area, but able to produce just 21 per cent of the global cotton production. Although it possesses the largest cotton area, India's productivity, at 439 kg ha^{-1}, lags significantly behind when compared with leading cotton-producing countries like Australia (2002 kg ha^{-1}), China (1971 kg ha^{-1}), Turkey (1828 kg ha^{-1}), Brazil (1771 kg ha^{-1}), Mexico (1599 kg ha^{-1}) and USA (1061 kg ha^{-1}) (Anon, 2022).

. In Karnataka, the cotton is grown over an area of 8.97 lakh hectares with production of 21.48 lakh bales and average productivity of about 407 kg ha^{-1} (Anon, 2022). Among various production constraints, imbalanced and inadequate nutrition to cotton crop is considered to be one of the important factors.

Nano urea as foliar spray in small quantities helps in easy absorption of nitrogen through stomata, improves crop growth, yield and reduce production costs. The foliar application of nano nitrogen at critical growth stages like flower initiation, boll initiation and boll development will enhance the crop growth and yield. Higher productivity of crops in sustainable manner could be achieved applying appropriate combination of conventional fertilizer and nano fertilizers. By foliar application of nano nitrogen fertilizer, we reduce the application of conventional fertilizers by 25 per cent. Combined application of conventional and foliar application of nano nitrogen helps in obtaining higher seed cotton yield, net returns and found economically feasible.

2. Materials and methods

A field experiment was conducted during *kharif* 2022 at Main Agricultural Research Station, UAS, Raichur on *Vertisol* having pH 8.32 and EC 0.63 dS m^{-1}. The soil was low in nitrogen (243.7 kg ha^{-1}) and medium in available P_2O_5 (29.8 kg ha^{-1}) and medium in available K_2O (202.4 kg ha^{-1}). Geographically, the experimental site was situated in North-Eastern Dry Zone (Zone 2) of Karnataka on latitude 16^o 12' North, longitude of 77^o 20' East and at an altitude of 407 m above the mean sea level. During the crop period, the higher monthly rainfall of 184.4 mm and 206.6 mm was received during the months of July and September, respectively. During the cropping period of 2022, total of 738 mm rainfall was received. The average maximum temperature during the crop growth period was 31.0^{o}C in the months of July, August and September. Average monthly minimum temperature of 17^{o}C was noticed in the month of December. The highest relative humidity of 88.0 per cent was recorded in the month of August, September, October followed by July and December (87 % and 81 %, respectively) as depicted in Fig. 1.

The experiment was laid out in split plot design, with fifteen treatment combinations consisting of three main and five sub plots. The main plot consists of different doses of nitrogen (M_1: 50% RDN, M_2:75% RDN and M_3:100% RDN and sub plot consists of different concentrations of nano nitrogen (S_1: Spraying of 0.4% nano nitrogen at flowering & boll initiation stages, S_2: Spraying of 0.4% nano nitrogen at flowering, boll initiation & boll development stages, S_3: Spraying of 0.6% nano nitrogen at flowering & boll initiation stages, S_4: Spraying of 0.6% nano nitrogen at flowering, boll initiation & boll development stages and S_5: Control without spraying, respectively).

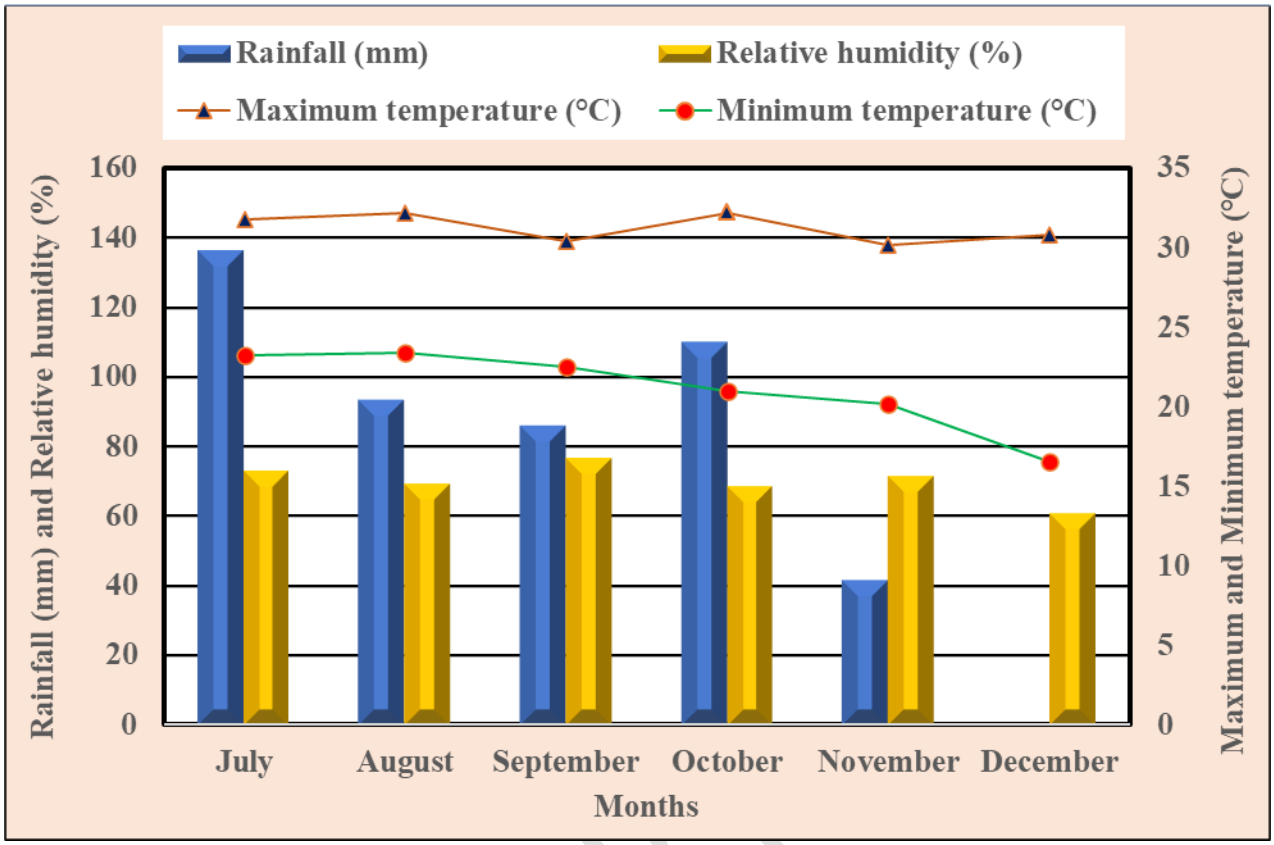

Fig. 1: Monthly meteorological data for experimental year (2022) against normal for 25years at MARS, Raichur (Karnataka)

Earlier the land was left fallow after that ground was ploughed once again, followed by two harrowings to bring the soil into fine tilth and later ridges and furrow were formed. Stubbles and weeds were removed from the experimental site and the experiment was laid out as per the plan and small bunds were raised around each plot. Lines were marked both ways as per the treatments. US 7067 BG-II certified seeds were used for sowing. The crop was sown on 2nd July, 2022. Two seeds per hill were dibbled by maintaining 60 cm space between two plants in row and 90 cm between rows. Fertilizer was applied in one basal form and four top dressings. The basal application of fertilizers in the form of urea, DAP and MOP were applied as per treatments with recommended dose of 180:90:90 N: P_2O_5: K_2O kg ha^{-1}. Among sub plots, for the preparation of 0.4% nano urea, 4ml of nano urea was mixed in one litre of water and for the preparation of 0.6% nano urea, 6 ml of nano urea was mixed in one litre of water and sprayed as per treatment doses.

The crop was irrigated next day for uniform germination. Intercultivation was done to remove all weeds from the field in order to check crop weed competition. Growth parameters such as plant height, sympodial branches and dry matter accumulation were recorded at

interval of 45 DAS, 90 DAS, 135 DAS and at harvest. Harvesting was done in two pickings. At every picking, seed cotton in each net plot was harvested separately, weighed and recorded. After complete harvesting, weight of seed cotton obtained at each picking was added with previous picking.

All the recommended agronomic practices and need based plant protection measures were followed to establish a healthy crop. The growth and yield observations were recorded as per standard procedures.

2.1 Statistical analysis and interpretation of data

The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Panse and Sukhatme (1978). The level of significance used in 'F' was P = 0.05. Critical difference (CD) values were calculated wherever the 'F' test was found significant.

3. RESULTS AND DISCUSSION

3.1 Growth attributes

Among main plots, significantly higher plant height (176.9 cm), sympodial branches plant^{-1} (27.1) and dry matter production (430.31g plant $^{-1}$) was recorded by treatment with 100 per cent nitrogen and it was followed by 75 per cent nitrogen (168 cm, 26.7 and 426.91 g plant $^{-1}$, respectively) which found *on par* with 100 per cent nitrogen. Among sub plots, significantly higher plant height (180.8 cm), sympodial branches plant^{-1} (28.5) and dry matter accumulation (429.42 g plant^{-1}) was recorded by treatment with 0.6% nano nitrogen sprayed at three stages followed by 0.4% nano nitrogen sprayed at three stages (173.3 cm, 28 and 428.52 g plant^{-1}, respectively) which found *on par* with each other (Table. 1). Foliar application of nutrients, specially supply of nitrogen as and when the crop demands and enhanced normal metabolic and physiological activities of plant *viz*., cell division, cell elongation and chlorophyll content which increased the plant height, number of branches, and dry matter accumulation. These results were found in conformity with the work of Beeresha *et al*. (2018) and Malik *et al*. (2021).

Table 1: Effect of different doses of nitrogen and foliar sprays of nano nitrogen on growth, yield attributes and yield of *Bt* cotton

Treatments	Plant height (cm)	No. of sympodial branches	Dry matter production (g plant^{-1})	Bolls (No. plant^{-1})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Main plot: Different dosages of nitrogen						
M_1	162.5	23.3	376.41	48.2	5.26	3080
M_2	168.0	26.7	426.91	50.2	5.36	3376
M_3	176.9	27.1	430.31	50.3	5.81	3388
S. Em.±	**3.1**	**0.6**	**2.68**	**0.6**	**0.13**	**59**
C.D. at 5 %	**12.3**	**2.4**	**10.52**	**2.2**	**0.49**	**230**
Sub plot: Different dosages of nano nitrogen						
S_1	166.2	23.8	402.55	50.1	5.26	3148
S_2	173.3	28.0	428.52	51.8	5.67	3465
S_3	169.9	26.4	411.37	51.2	5.47	3284
S_4	180.8	28.5	429.42	52.2	5.93	3485
S_5	155.5	21.9	384.18	42.7	5.04	3024
S. Em.±	**3.5**	**0.9**	**4.09**	**1.0**	**0.13**	**96**
C.D. at 5 %	**10.1**	**2.5**	**11.93**	**3.1**	**0.38**	**281**

3.2 Yield attributes

Among main plots, significantly higher number of bolls plant^{-1} (50.3), boll weight (5.81) and seed cotton yield (3388 kg ha^{-1}) were recorded by treatment received with 100 per cent nitrogen followed by 75 % RDN (50.2, 5.36 g and 3376 kg ha^{-1}, respectively) which found *on par* with 100 per cent nitrogen (Table 1).

Among sub plots, significantly higher number of bolls plant^{-1} (52.2), boll weight (5.93 g) and seed cotton yield (3485 kg ha^{-1}) were recorded by treatment with 0.6% nano nitrogen sprayed at three stages followed by nano urea @ 0.4 per cent each at three stages (51.8, 5.67 g and 3465 kg ha^{-1}, respectively) which found *on par* with each other (Table 1).

This was mainly attributed due to increasing nutrient levels as nano form of nitrogen is more easily absorbed by the plants. The foliar application of nano nitrogen also helps to

increase the photosynthetic rate of the plants, which can lead to increased plant dry matter accumulation, which may have served as a source of photosynthates for reproductive bolls, leading to increased weight of bolls, boll production which inturn have lead to higher seed cotton yield. Similar results were also attained by Choudhary *et al*. (2018) and Dhaliwal *et al*. (2021).

3.3 Nutrient uptake and available nutrients in soil at harvest

Significantly higher uptake of nitrogen (110.06 kg ha^{-1}), phosphorous (34.56 kg ha^{-1}) and potassium (120.36 kg ha^{-1}) was recorded by 100 per cent nitrogen followed by 75 per cent nitrogen (107.69 kg ha^{-1}, 31.53 kg ha^{-1} and 114.85 kg ha^{-1}, respectively) which found *on par* with 100 per cent nitrogen among main plots. Among sub plot treatments, significantly higher nitrogen (114.07 kg ha^{-1}), phosphorous (35.52 kg ha^{-1}) and potassium uptake (123.65 kg ha^{-1}) was recorded by treatment with foliar spray of 0.6% nano nitrogen sprayed at three stages followed by 0.4% nano nitrogen sprayed at three stages (107.66 kg ha^{-1}, 33.69 kg ha^{-1} and 118.24 kg ha^{-1}, respectively) which found *on par* with each other (Table 2). The nutrient uptake of plant was significantly increased owing to the combined application of nitrogen fertilizer and nano fertilizers. Similar results were found by Fan *et al.* (2012), Manikandan and Subramanian (2016).

Similarly, significantly higher available nitrogen (204.56 kg ha^{-1}), phosphorous (33.36 kg ha^{-1}) and potassium (221.63 kg ha^{-1}) was recorded in recommended dose of 100 per cent nitrogen followed by 75 per cent nitrogen (194.33 kg ha^{-1}, 32.33 kg ha^{-1} and 216.03 kg ha^{-1}, respectively) which found *on par* with 100 per cent nitrogen among main plots. Among sub plot treatments, significantly higher available nitrogen (208.05 kg ha^{-1}), phosphorous (34.50 kg ha^{-1}) and potassium (224.63 kg ha^{-1}) was recorded by treatment with 0.6% nano nitrogen sprayed at three stages followed by 0.4% nano nitrogen sprayed at three stages (201.89 kg ha^{-1}, 33.69 kg ha^{-1} and 218.59 kg ha^{-1}, respectively) which found *on par* with each other (Table 2). Higher available soil nitrogen, phosphorus and potassium were noticed in recommended dose of 100 per cent nitrogen treatment as compared to others.

Nutrient availability increases as fertilization levels are raises *i.e.,* 75 per cent to 100 per cent. Similar results were obtained by Thimmareddy *et al*. (2013), who observed elevated NPK availability (kg ha^{-1}) in soil during harvest with increasing NPK levels.

Table 2: Effect of different doses of nitrogen and foliar sprays of nano nitrogen on uptake of nutrients by cotton and available nutrients in soil

Treatments	Uptake of nutrients (kg ha^{-1})			Available nutrients (kg ha^{-1})		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Main plot: Different dosages of nitrogen						
M_1	98.74	30.69	112.28	187.15	30.69	204.90
M_2	107.69	31.53	114.85	194.33	32.33	216.03
M_3	110.06	34.56	120.36	204.56	33.36	221.63
S. Em.±	**1.47**	**0.89**	**2.00**	**3.50**	**0.56**	**3.37**
C.D. at 5 %	**5.75**	**3.49**	**7.84**	**13.76**	**2.19**	**13.22**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Sub plot: Different dosages of nano nitrogen						
S_1	102.39	30.88	112.00	191.50	30.67	212.21
S_2	107.66	33.69	118.24	201.89	33.69	218.59
S_3	104.80	32.12	116.43	195.12	31.83	214.72
S_4	114.07	35.52	123.65	208.05	34.50	224.63
S_5	98.57	29.10	108.84	180.17	29.93	200.79
S. Em.±	**3.00**	**0.93**	**3.04**	**4.03**	**0.91**	**3.12**
C.D. at 5 %	**8.76**	**2.72**	**8.89**	**11.76**	**2.66**	**9.09**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Main plots (M) - M_1: 50% of recommended N kg ha^{-1} ; M_2: 75 % of recommended N kg ha^{1};M_3:100 % of recommended N kg ha^{-1}.
Sub plots (S) - S_1: Spraying of 0.4% nano nitrogen at flowering & boll initiation stages; S_2: Sprayingof 0.4% nano nitrogen at flowering, boll initiation & bolldevelopment stages; S_3: Spraying of 0.6% nano nitrogen at flowering & boll initiation stages; S_4: Spraying of 0.6% nano nitrogen at flowering, boll initiation & boll development stages; S_5: Control (without spraying).

4. CONCLUSION

From the results of the present study, it is concluded that there was significant response of 75 per cent of recommended dose of nitrogen along with foliar application of 0.4 per cent nano nitrogen at three stages recorded higher growth attributes, yield parameters and nutrient uptake by the plants. There was linear increase in seed cotton yield (kg ha^{-1}) with increasing levels of nitrogen levels**.**

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