Effect of Nano Fertilizers on Yield, Nutrient Uptake, Soil nutrient status and Fertilizer use efficiency of *Bt* Cotton

# ABSTRACT:

# Aims: Foliar application of nano fertilizers aims to reduce the need for conventional fertilizers. Nano fertilizers enhanced crop growth, yield and quality by improving nutrient uptake. They enable precise nutrient delivery that aligns with the crop's growth stages, while their increased surface area facilitates faster metabolic reactions. This, in turn, boosts photosynthesis, leading to greater dry matter production and higher yields. Foliar application of nano fertilizers during the flowering, boll initiation and boll development stages meets the nutrient requirements of the plant, resulting in improved productivity and quality. By combining conventional fertilizers with nano fertilizers in a balanced manner, it is possible to achieve higher crop productivity in a sustainable way.

**Place and Duration of Study:** A field experiment was conducted during *Kharif* 2023 at AICRP on Cotton, Haradanahalli farm, Chamarajanagar.

**Study Design and Methodology:** The experiment was laid out in split plot design with three replications comprising three levels of conventional fertilizers in main plot *viz.,* 50%, 75% and 100% RDNP and four dosages of nano fertilizers in subplot *viz.,* nano urea @ 2 ml L-1 and 4 ml L-1, nano DAP @ 2 ml L-1 4 ml L-1, respectively sprayed at 40, 60 and 80 DAS.

**Results:** The results revealed that among different levels of conventional fertilizers, application of 100% RDNP noticed significantly higher total number of bolls (47.3 plant-1), good opened bolls (42.2 plant-1), seed cotton yield (1453 kg ha-1) and stalk yield (2562 kg ha-1). The same treatment recorded higher nutrient uptake (120.96, 37.27, 97.48 kg NPK ha-1, respectively). And soil nutrient availability (203.14, 57.66, 153.75 kg N P2O5 K2O ha-1, respectively). Significantly higher fertilizer use efficiency was noticed with 50% RDNP (15.86 kg N kg-1, 31.53 kg P kg-1), whereas higher potassium use efficiency was recorded in 100% RDNP (19.37 kg K kg-1). Among the nano fertilizers, application of nano DAP @ 4 ml L-1 at 40, 60 and 80 DAS resulted significantly higher total number of bolls (46.7 plant-1), good opened bolls (41.9 plant-1), seed cotton yield (1420 kg ha-1), stalk yield (2497 kg ha-1) and nutrient uptake (116.91, 37.37, 96.57 kg NPK ha-1, respectively), similar trend was observed with fertilizer use efficiency also. where, foliar spray of nano urea at 2 ml L-1 recorded higher available nitrogen, phosphorous and potassium content in soil with 194.41, 54.48 and 152.48 kg ha-1, respectively.

**1. INTRODUCTION**

Cotton, often called “White Gold,” is a vital commercial crop, playing a crucial role in global agriculture and industry, India, is one of the leading cotton producers in the world. Approximately 65% of India's textile industry depends on cotton, underscoring its economic importance.

In India crop is cultivated in an area of 12.9 million hectares with production of 3.3 million bales and an average yield of 442.65 kg per hectare. In Karnataka, cotton is grown on 9.49 lakh hectares, yielding about 251 lakh bales, with a slightly higher yield of 460.02 kg per hectare average. (Anon., 2023) [1]. However, cotton productivity remains low due to some factors such as erratic rainfall, drought and Inadequate fertilizer application, as 70% of the crop is grown under rainfed conditions. In addition to these challenges, cotton cultivation is also plagued by biotic and abiotic stresses, which hinder plant growth and reduce productivity. Among the production constraints, nutrient management is very crucial, as nitrogen (N) where it is a important nutrient plays a key role in protein synthesis and chlorophyll formation. However, traditional nitrogen fertilizers are often inefficient, with only 30-50% of the nitrogen being absorbed by plants. The rest is lost through processes like leaching and volatilization, contributing to both economic losses for farmers and causes environmental pollution.

To address these issues, innovative solutions like nano fertilizers are emerging. For example, nano urea has potential in improving nitrogen use efficiency, with a 500 ml bottle replacing a traditional 45 kg bag of urea, reducing nitrogen fertilizer needs by up to 50%. Similarly, IFFCO's Nano DAP, which contains 8% nitrogen and 16% phosphorus, enhances nutrient absorption through its sub 100 nanometer particles. By integrating nano fertilizers and conventional fertilizers cotton farmers can enhance crop productivity, reduce environmental impact and improve overall sustainability in agriculture.

# 2. MATERIALS AND METHODS

# The field experiment was conducted during *Kharif* 2023 at AICRP on Cotton. The experimental site is geographically located in the Southern Dry Zone (Zone-6) of Karnataka and lies in 11.9261° N latitude and 76.9437° E longitude at an altitude of 865 m above the mean sea level. The soil is sandy loam in texture with (pH - 8.62, OC - 0.59% low available nitrogen (242.79 kg ha-1), medium available phosphorus (48.74 kg ha-1) and medium potassium (202.59 kg ha-1).

# The actual rainfall received during the crop growing period was below normal (523.6 mm), maximum rainfall was recorded in the month of May (299.0 mm) where the lowest was recorded during December (9.0 mm). The highest and lowest mean maximum temperature recorded was in the months of April (34.3 oC) and July (29 oC). While the highest and lowest mean minimum temperature were recorded in the month of September and January with 21.2 oC and 12.7 oC, respectively.) The mean maximum relative humidity ranged between 97 to 100 %. The mean minimum relative humidity ranged from 52 to 65 %, during the crop growth period from July to December 2023.

The experiment was laid out in split plot design with three replications comprising three levels of conventional fertilizers in main plot, *viz.,* 50%, 75% and 100% RDNP and four dosages of nano fertilizers in subplot *viz.,* nano urea @ 2 ml L-1 and 4 ml L-1, nano DAP @ 2 ml L-1 and 4 ml L-1, respectively sprayed at 40, 60 and 80 DAS. The land preparation was done by ploughing once with mould board plough and then harrowed twice to bring the soil into fine tilth and later ridges and furrows were formed. The treatments were imposed as per the plan conventional fertilizers were applied as per recommendation of UAS (B) Package of Practices (150:75:75 kg N: P2O5: K2O ha-1).The full dose of phosphorus and potassium were applied as basal. Whereas, nitrogen was applied in four equal splits, one as basal and second top dressing applied at grand growth stage after 50 DAS, third top dressing at 80 DAS and fourth top dressing at 110 DAS and foliar spray of nano urea at 2 ml L-1 and 4 ml L-1 and nano DAP at 2 ml L-1 and 4 ml L-1 were applied according to treatments at 40, 60 and 80 DAS.

Thinning was done at 15 days after sowing retaining one healthy seedling per hill. First irrigation was given immediately after sowing for uniform germination and subsequent protective irrigations were given as per the crop requirement, based on the soil moisture content. Hand weeding was done thrice at 20, 40 and 60 DAS, followed by hoeing to keep the experimental plot free from the weeds. The plant protection measures were taken as per the package of practices for management of boll worms and sucking pests. Yield parameters such has number of good opened bolls plant-1 , number of bad opened bolls plant-1, total number of bolls plant-1, single boll weight, seed cotton yield and stalk yield wrer recorded at harvest.

**2.1 Statistical analysis and interpretation of data**

The experimental data obtained were subjected to statistical analysis adopting Fisher’s method of analysis of variance as out lined by Gomez and Gomez (1984) [2]. Over all differences were tested by ‘F’ test at 5 per cent level of significance. In case of significant results, critical difference (CD) at 5 per cent level of probability was calculated for testing the difference between the two treatment means.

**Fig 1. Monthly metrological data for experimental year (2023) against normal years at AICRP on cotton, Chamarajanagar (Karnataka)**

**3. RESULTS AND DISCUSSION**

**3.1 Yield Attributes**

Among the different doses of RDNP, significantly higher number of total number of bolls (47.3 plant-1), good opened bolls (42.2 plant-1), lower number of bad opened bolls (5.1 plant-1), boll weight (6.18 g), seed cotton yield (1453 kg ha-1) and stalk yield (2562 kg ha-1) was noticed with application of 100% RDNP followed by 75% RDNP (42.5, 35.3, 7.2 plant-1, 5.83 g, 1315 kg ha-1 and 2363 kg ha-1, respectively).

The higher values in 100% RDNP may be due to improved nutrient availability, enhanced uptake of plant nutrients. Which supported physiological processes like photosynthate translocation, while phosphorus boosts water and metabolite absorption. These improvements lead to better yield attributes. This results are in conformity with Ghule *et al*. (2013b) [3].

Among nano fertilizers significantly higher number of total number of bolls (46.7 plant-1), good opened bolls (41.9 plant-1), lower number of bad opened bolls (4.8 plant-1), boll weight (6.16 g), seed cotton yield (1420 kg ha-1) and stalk yield (2497 kg ha-1) were recorded in spraying of nano DAP at 4 ml L-1 at 40, 60 and 80 DAS, followed by nano DAP at 2 ml L-1 (44.3, 38.2, 6.1 plant-1, 5.80 g, 1336 kg ha-1 and 2398 kg ha-1, respectively) (Table. 1).

Foliar application of nano fertilizers leads to faster nutrient uptake and higher nutrient use efficiency. These results improved the yield parameters such as, total number of bolls plant-1, number of good opened bolls plant-1 and single boll weight. Consequently, which enhanced the seed cotton yield. These findings are consistent with the results of Ullasa *et al*. (2016) [4] and Reddy *et al*. (2018) [5].

**Table 1. Yield attributes, seed cotton yield and stalk yield of *Bt* cotton as influenced by different levels of conventional and nano fertilizers**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | | **Number of good opened bolls**  **(plant-1)** | **Number of bad opened bolls**  **(plant-1)** | **Total Number of bolls (plant-1)** | **Single boll weight (g)** | **Seed cotton yield**  **(kg ha-1)** | **Stalk yield**  **(kg ha-1)** |
| **Main plot: Conventional fertilizer (M): 03** | | | | | | | |
| **M1** | 50% of recommended N and P kg ha-1 | 33.1 | 7.7 | 40.8 | 5.50 | 1194 | 2186 |
| **M2** | 75% of recommended N and P kg ha-1 | 35.3 | 7.2 | 42.5 | 5.83 | 1315 | 2363 |
| **M3** | 100% of recommended N and P kg ha-1 | 42.2 | 5.1 | 47.3 | 6.18 | 1453 | 2562 |
| **S.Em ±** | | 0.96 | 0.19 | 0.81 | 0.08 | 30.92 | 29.76 |
| **CD (p=0.05)** | | 3.77 | 0.76 | 3.18 | 0.33 | 121.41 | 116.83 |
| **Sub plot: Spraying of Nano fertilizers (S): 04** | | | | | | | |
| **S1** | Nano urea at 2 ml L-1 at 40, 60 and 80 DAS | 31.7 | 9.7 | 41.4 | 5.65 | 1231 | 2255 |
| **S2** | Nano urea at 4 ml L-1 at 40, 60 and 80 DAS | 35.1 | 7.2 | 42.3 | 5.73 | 1295 | 2331 |
| **S3** | Nano DAP at 2 ml L-1 at 40, 60 and 80 DAS | 38.2 | 6.1 | 44.3 | 5.80 | 1336 | 2398 |
| **S4** | Nano DAP at 4 ml L-1 at 40, 60 and 80 DAS | 41.9 | 4.8 | 46.7 | 6.16 | 1420 | 2497 |
| **S.Em ±** | | 1.28 | 0.33 | 1.17 | 0.12 | 32.81 | 56.47 |
| **CD (p=0.05)** | | 3.80 | 0.99 | 3.47 | 0.37 | 97.49 | 167.77 |
| **Interaction (MxS)** | | | | | | | |
| **S.Em ±** | | 2.22 | 0.57 | 2.02 | 0.21 | 56.83 | 97.80 |
| **CD (p=0.05)** | | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

# Nutrient uptake and soil nutrient status after harvest of *Bt*-cotton

Among the conventional fertilizers, application of 100% RDNP indicated significantly higher N (120.96 kg ha-1), P (37.27 kg ha-1) and K (97.48 kg ha-1) uptake followed by 75% RDNP (102.25, 32.12 and 88.44 kg NPK ha-1, respectively). This may be due to the application of nitrogen in combination with phosphorus has resulted in increased availability of both nitrogen and phosphorus in the soil, as well as an enhanced cation exchange capacity of plant roots. This was led to improved absorption of nitrogen and phosphorus by the plants, consequently increasing the concentration of these nutrients in plant, as reported by Pandey and Aggarwal (1991) [6]. Similarly, foliar spray of nano DAP at 4 ml L-1 at 40, 60 and 80 DAS registered higher N (116.91 kg ha-1), P (37.37 kg ha-1) and K (96.57 kg ha-1) uptake followed by nano DAP 2 ml L-1 (106.15, 33.68 and 90.52 kg NPK ha-1, respectively) (Table. 2 and 3). The large surface area and small particle size of nano fertilizers, enhanced their ability to penetrate the plant from the applied surface and improves nutrient uptake. The reduction in particle size increases the specific surface area and the number of particles per unit area of the fertilizer. These results were in conformity with Liscano *et al*. (2000) [7].

Similarly, after the harvest of crop, the soil nutrients showed a significant difference among the treatments. Among different levels of conventional fertilizers, application of 100% RDNP resulted in higher available nitrogen (203.14 kg ha-1), phosphorus (57.66 kg ha-1) and potassium (153.75 kg ha-1). Whereas, significantly higher available nitrogen (194.41kg ha-1), phosphorous (54.48 kg ha-1) and potassium (152.48 kg ha-1) was registered with foliar spray of nano urea at 2 ml L-1 at 40, 60 and 80 DAS. This might be due to increased nutrient availability as fertilization levels raised from 50% to 100%. Similar results were obtained by Thimmareddy *et al*. (2013) [8]. decreasing trend with corresponding increase in yield and higher biomass led to greater NPK uptake, led to the depletion of the native pool of available N, P₂O₅ and K₂O in the soil. These results are in conformity with the findings of Mala *et al*. (2017) [9].

**Table 2. Nutrient uptake by *Bt* cotton at harvest as influenced by different levels of conventional and nano fertilizers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | | **Nutrient uptake (kg ha-1)** | | |
| **Nitrogen** | **Phosphorus** | **Potassium** |
| **Main plot: Conventional fertilizer (M): 03** | | | | |
| **M1** | 50% of recommended N and P kg ha-1 | 82.08 | 27.79 | 80.92 |
| **M2** | 75% of recommended N and P kg ha-1 | 102.25 | 32.12 | 88.44 |
| **M3** | 100% of recommended N and P kg ha-1 | 120.96 | 37.27 | 97.48 |
| **S.Em ±** | | 1.78 | 0.98 | 1.24 |
| **CD (p=0.05)** | | 7.00 | 3.83 | 4.86 |
| **Sub plot: Spraying of Nano fertilizers (S): 04** | | | | |
| **S1** | Nano urea at 2 ml L-1 at 40, 60 and 80 DAS | 86.55 | 28.15 | 82.46 |
| **S2** | Nano urea at 4 ml L-1 at 40, 60 and 80 DAS | 97.44 | 30.37 | 86.24 |
| **S3** | Nano DAP at 2 ml L-1 at 40, 60 and 80 DAS | 106.15 | 33.68 | 90.52 |
| **S4** | Nano DAP at 4 ml L-1 at 40, 60 and 80 DAS | 116.91 | 37.37 | 96.57 |
| **S.Em ±** | | 5.07 | 1.86 | 2.48 |
| **CD (p=0.05)** | | 15.07 | 5.53 | 7.36 |
| **Interaction (MxS)** | | | | |
| **S.Em ±** | | 8.79 | 3.23 | 4.29 |
| **CD (p=0.05)** | | **NS** | **NS** | **NS** |

**Table 3. Available soil nutrient status after harvest of *Bt* cotton as influenced by different levels of conventional and nano fertilizers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | | **Available soil nutrients (kg ha-1)** | | |
| **Nitrogen** | **Phosphorus** | **Potassium** |
| **Main plot: Conventional fertilizer (M): 03** | | | | |
| **M1** | 50% of recommended N and P kg ha-1 | 178.99 | 40.04 | 135.94 |
| **M2** | 75% of recommended N and P kg ha-1 | 182.56 | 50.16 | 138.13 |
| **M3** | 100% of recommended N and P kg ha-1 | 203.14 | 57.66 | 153.75 |
| **S.Em ±** | | 3.67 | 1.61 | 1.74 |
| **CD (p=0.05)** | | 14.42 | 6.31 | 6.84 |
| **Sub plot: Spraying of Nano fertilizers (S): 04** | | | | |
| **S1** | Nano urea at 2 ml L-1 at 40, 60 and 80 DAS | 194.41 | 54.48 | 152.48 |
| **S2** | Nano urea at 4 ml L-1 at 40, 60 and 80 DAS | 181.85 | 50.48 | 144.50 |
| **S3** | Nano DAP at 2 ml L-1 at 40, 60 and 80 DAS | 172.95 | 47.47 | 140.34 |
| **S4** | Nano DAP at 4 ml L-1 at 40, 60 and 80 DAS | 161.04 | 44.72 | 135.79 |
| **S.Em ±** | | 3.42 | 2.32 | 3.74 |
| **CD (p=0.05)** | | 10.16 | 6.90 | 11.10 |
| **Interaction (MxS)** | | | | |
| **S.Em ±** | | 5.92 | 4.02 | 6.47 |
| **CD (p=0.05)** | | **NS** | **NS** | **NS** |

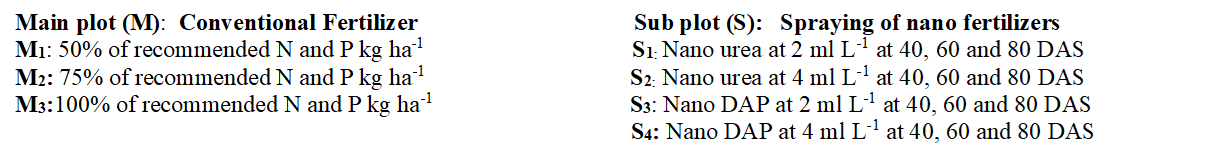
# 3.3 Fertilizer use efficiency

# Significant difference was observed with respect to fertilizer use efficiency due to varied levels of nitrogen and phosphorus through conventional fertilizers and foliar spray of nano urea and nano DAP. Among the conventional fertilizers, application of 50% RDNP recorded significantly higher nitrogen use efficiency (15.86 kg kg-1) and phosphorus use efficiency (31.53 kg kg-1) (Table. 4). This might be attributed to less loss of nutrients through leaching, volatilization and also higher yield was obtained for fertilizer applied. Similar results were also reported by Gundlur *et al*. (2013) [10] and Ambati and Thakare (2012) [11]. But in potassium higher potassium use efficiency was observed with application of 100% RDNP (19.37 kg kg-1). This might be due to the level of application of potassium is same for all the treatments and also all growth parameters and higher yield were obtained per unit of fertilizer applied was more in the same treatment. These results were in line with Devkota-Wasti (2011) [12].

# Among the nano fertilizers, significantly higher nitrogen use efficiency (13.31 kg kg-1), phosphorus use efficiency (26.24 kg kg-1) and potassium use efficiency (18.93 kg kg-1) was noticed with foliar spray of nano DAP at 4 ml L-1 at 40, 60 and 80 DAS. This might be due to application of nano fertilizers helped release of nutrients in response to crop needs. This approach enhances nutrient use efficiency by reducing nitrogen loss through leaching and emissions. Similar results were reported by Naderi and Daneshshahraki (2013) [13] and Suman *et al*. (2010) [14].

# Table 4.Nitrogen, phosphorus and potassium use efficiency (kg kg-1) as influenced by different levels of conventional and nano fertilizers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | | **Fertilizer use efficiency (kg kg-1)** | | |
| **Nitrogen** | **Phosphorus** | **Potassium** |
| **Main plot: Conventional fertilizer (M): 03** | | | | |
| **M1** | 50% of recommended N and P kg ha-1 | 15.86 | 31.53 | 15.92 |
| **M2** | 75% of recommended N and P kg ha-1 | 11.66 | 23.23 | 17.54 |
| **M3** | 100% of recommended N and P kg ha-1 | 9.67 | 19.27 | 19.37 |
| **S.Em ±** | | 0.26 | 0.52 | 0.41 |
| **CD (p=0.05)** | | 1.02 | 2.04 | 1.62 |
| **Sub plot: Spraying of Nano fertilizers (S): 04** | | | | |
| **S1** | Nano urea at 2 ml L-1 at 40, 60 and 80 DAS | 11.58 | 23.20 | 16.42 |
| **S2** | Nano urea at 4 ml L-1 at 40, 60 and 80 DAS | 12.18 | 24.41 | 17.27 |
| **S3** | Nano DAP at 2 ml L-1 at 40, 60 and 80 DAS | 12.52 | 24.85 | 17.82 |
| **S4** | Nano DAP at 4 ml L-1 at 40, 60 and 80 DAS | 13.31 | 26.24 | 18.93 |
| **S.Em ±** | | 0.32 | 0.64 | 0.44 |
| **CD (p=0.05)** | | 0.96 | 1.90 | 1.30 |
| **Interaction (MxS)** | | | | |
| **S.Em ±** | | 0.56 | 1.11 | 0.76 |
| **CD (p=0.05)** | | **NS** | **NS** | **NS** |

**Fig. 2. Nitrogen, phosphorus and potassium use efficiency (kg kg-1) as influenced by different levels of conventional and nano fertilizers**

# 4. CONCLUSION

# The findings of the current study indicate that application of 100% recommended dose of nitrogen and phosphorous, combined with foliar application of nano DAP at 4 ml L-1 at 40, 60 and 80 DAS, resulted in improved growth characteristics, higher yield parameters, and greater nutrient uptake by the plants. Additionally, a consistent increase in seed cotton yield (kg ha-1) was observed as the fertilizer levels were raised.

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