International Journal of Research in Agronomy

**E-ISSN:** 2618-0618
**P-ISSN:** 2618-060X

www.agronomyjournals.com
2024; SP-7(7): 699-705
Received: 12-04-2024
Accepted: 15-05-2024

**BVSS Santoshi**
Research Scholar, Department of Agronomy, Agricultural College, Mahanandi, Andhra Pradesh, India

**A Malliswara Reddy**
Associate Professor, Department of Agronomy, Agricultural College, Mahanandi, Andhra Pradesh, India

**PV Ramesh Babu**
Scientist, Department of Agronomy, ARS, Ananthapuramu, Andhra Pradesh, India

**P Kavitha**
Professor & Head, Department of Soil Science & Agricultural Chemistry, Mahanandi, Andhra Pradesh, India

**Corresponding Author:**
**BVSS Santoshi**
Research Scholar, Department of Agronomy, Agricultural College, Mahanandi, Andhra Pradesh, India

# Effect of nitrogen management practices on growth and yield of maize (*Zea mays* L.) under scarce rainfall zone of Andhra Pradesh

**BVSS Santoshi, A Malliswara Reddy, PV Ramesh Babu and P Kavitha**

**DOI:** https://doi.org/10.33545/2618060X.2024.v7.i7Sj.1178

**Abstract**
A field experiment was conducted to study the response of maize (*Zea mays* L.) to nano urea under Scarce Rainfall Zone of Andhra Pradesh on sandy loam soils at College Farm, Agricultural College, Mahanandi campus of Acharya N. G. Ranga Agricultural University during *rabi*, 2023-2024. The experiment was laid out in randomized block design with nine nitrogen management practices and replicated thrice. The results revealed that, application of 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded highest plant height, number of leaves plant$^{-1}$, lesser number of days to attain days to 50% tasseling and silking, highest grain and stover yield of maize. The soil application of conventional urea along with foliar application of nano urea improved the growth and yield in maize under scarce rainfall zone of Andhra Pradesh.

**Keywords:** Foliar spray, maize, nitrogen, nano urea and urea

## Introduction
Maize (*Zea mays* L.), belongs to the family Poaceae, having wider adaptability under varied agro-climatic conditions and soils. Maize is also known as "Queen of Cereals", because it has highest genetic yield among the cereals. It serves as a staple food crop to people residing in rainfed areas. Every part of the maize plant has economic value (the grain, leaves, stalk, tassel and cob) and all are used to produce a large variety of food and non-food products. Besides the normal yellow (or) white grain, maize have many types like sweet corn, baby corn, popcorn, flour corn, waxy corn, quality protein maize *etc*. Normal maize kernels are composed of carbohydrates, protein, fats and some other vitamins & minerals. The crop is a major source of grain feed for humans and rich source of fodder for livestock. Maize is an important industrial raw material and provides large opportunity to value addition and also acts as a source in the manufacture of ethanol fuel, starch, syrup, dextrose, oil, gelatin, lactic acid *etc.*
Globally, maize is the third most essential cereal crop after rice and wheat. It is cultivated in nearly 205 million hectares with a production of 1210 million tonnes and productivity of 5878 kg ha$^{-1}$ all over the world (FAO STAT 2021-22). Among all the over world USA is the largest producer of maize contributing 32% of the global production. In India, maize is the third most important crop after wheat and rice mainly grown in two seasons, *kharif* and *rabi*. Among the maize growing countries, India ranks 4$^{th}$ in area and 7$^{th}$ in the production, representing around 4% of area and 2.59% of total production. It is cultivated over an area of 9.9 million hectares, with the production of 25.16 million metric tonnes and the total productivity 3571 kg ha$^{-1}$ (www.icar.gov.in).
In Andhra Pradesh, maize crop accounted for 5.71% of the total cropped area, cultivated in 3.82 lakh hectares with a production of 27.51 lakh tonnes and with the productivity of 7138 kg ha$^{-1}$. (www.des.ap.gov.in 2022-23). In terms of maize production, the major maize growing districts in Andhra Pradesh are Nandyal, Bapatla, Vizianagaram, Eluru, Sri Satyasai and Srikakulam and these districts together accounted for 61.04% of total area under the crop. Among all the districts, Nandyal district is alone accommodated for 18.44% of total area *i.e.*, 7.07 lakh hectares under maize crop with the total production of 3.27 lakh tonnes.

The productivity of Nandyal district is 4622 kg $ha^{-1}$.

Conventional chemical fertilizers are widely used across the globe for achieving maximum yield in agricultural systems to meet the demand of food for ever-growing population. With an increasing world population and diminishing arable land it is becoming necessary to employ larger quantities of chemical fertilizers, especially nitrogen (N) to meet the global food demands. However, indiscriminate use of conventional fertilizers has led to environmental pollution due to loss of nutrients primarily through leaching causing ground water pollution, surface run-off and contamination of open water bodies leading to eutrophication.

One of the crucial agricultural technologies today was developed by using nanotechnology are nano fertilizers. Nano fertilizers are a novel concept in agricultural nutrient management and while it is still in its early stages, there is a big push in agriculture for long-term cop development because they are eco - friendly.

Nano fertilizers can be composed of different nano particles (NPs), *i.e.*, carbon - based, metal oxides and other nano porous materials, depending on their combination and compositional properties. They can be prepared *via* biological, chemical (bottom-up) and physical (top-down) approaches and another emerging technology that uses clean, non-hazardous and especially environmentally friendly procedures, such as crop improvement, crop protection, crop yield growth, stress tolerance and soil enhancement. These nano fertilizers are essential to reduce the use of inorganic fertilizers and also reduce their antagonistic effects on the environment, as they are highly reactive, can penetrate into epidermis and enables slow release & dispersion, thus improving nutrient use efficiency.

Under field condition, nitrogen use efficiencies of conventional fertilizers rarely exceed 30-35% and it is essential to look for some alternate novel nutrient sources. The novel nano fertilizers are believed to have the potential for a paradigm shift in agriculture. Therefore, nano fertilizers can reduce nutrient losses through leaching and gaseous emissions, ensuring a sustainable production system. The nano urea fertilizer is capable of releasing nitrogen for a much longer period than the conventional fertilizers.

So far, studies on effect of nano urea on growth parameters and yield in maize is meagre. Considering the reasons stated above, to fill the lacunae and to generate more information, the present experiment is proposed to find out the "Response of maize (*Zea mays* L.) to nano urea under Scarce Rainfall Zone of Andhra Pradesh".

## Material and Methods

A field trail was carried out at Agricultural College Farm, Mahanandi campus of Acharya N. G. Ranga Agricultural University during *rabi*, 2023-2024. The experiment laid out in a randomized block design with nine treatments (nitrogen management practices) consists of : control (no application of N) ($T_1$), Foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$), 100% RDN through urea in three splits (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$), 100% RDN through urea in three splits (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$), 33% RDN through urea as basal + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_5$), 50% RDN through urea as basal + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_6$), 75% RDN through urea in three splits (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$), 75% RDN through urea in three splits (66% basal + 17% knee high stage + 17% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_8$), 50% RDN through urea in three splits (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage) ($T_9$). The treatments are replicated thrice. The soil of the experimental field was sandy loam in texture, with neutral in reaction (pH 7.24), low in organic carbon, available nitrogen and available phosphorus and high in available potassium. Recommended dose of nitrogen (RDN) of maize crop is 250 kg $ha^{-1}$ applied to the respective treatments. Application of 100% recommended dose of P and K (80 kg $P_2O_5$ and 80 $K_2O$ $ha^{-1}$) as basal dose is uniform to all the treatments. Foliar application of nano urea @ 4 ml $L^{-1}$ is uniform to all the respective treatments.

The maize variety of PAC - 751 hybrid having duration of 120-140 days was sown with a spacing of 60 cm x 20 cm and gap filling was done at 9 DAS. Hand weeding and timely plant protection was taken up as and when required.Foliar application of nano urea @ 4 ml $L^{-1}$ at knee high and tasseling stages was in respective treatments. The critical difference was correlated at 5 per cent level of significance to compare different treatment means as suggested by Panse and Sukhatme (1985) [13].

## Results and Discussion

### Effect of nitrogen management practices on initial and final plant population

Nitrogen management practices did not differ significantly with respect to initial and final plant population of maize during the present investigation (Table 1). This might be due to the crop was sown at optimum soil moisture content of better crop establishment.

### Effect of nitrogen management practices on plant height of maize

Plant height of maize at different growth stages *viz.*, 30, 60, 90 DAS and at harvest was significantly influenced by different nitrogen management practices during the present study (Table 2). Plant height was increased progressively with advance in age of the crop, irrespective of the treatments imposed.

At 30 DAS, among the different nitrogen management practices evaluated, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher plant height, however which was statistically at par with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$), 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage ($T_3$), 75% RDN (66% basal + 17% knee high stage + 17% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_8$), 50% RDN as basal + two foliar sprays of nano urea at knee high stage + tasseling stage ($T_6$), 33% RDN as basal + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_5$). The lower plant height of maize was recorded with control (no application of N) ($T_1$), which was statistically comparable with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

At 60 DAS, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher plant height, which was statistically at a par with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$) and 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$). This might be due to foliar spray of nitrogen synchronized with crop demand, resulting in higher nitrogen uptake both from roots and leaves, which in turn increases cell division, cell elongation and growth. These results are in accordance with the findings of Reddy *et al.* (2023) [12]. The lower plant stature of maize was recorded significantly with control (no application of N) ($T_1$), however, which was statistically comparable with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

At 90 DAS, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher plant height, however, which was statistically comparable with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$). The lowest plant height of maize was recorded with control (no application N) ($T_1$), which was statistically at a par with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

At harvest, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher plant height, however, which was on par with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$). The increase in plant height of maize with the application of nano nitrogen might be attributed due to nano particles can move easily within the plant and facilitating for better distribution of nutrients which helped in growth of new cells there by increased plant height. The sufficient supply of nutrients *viz.*, nanoparticles to the plants without any significant loss to the environment may increase the plant height. These results are corroborative with the findings of Samui *et al.* (2022) [9], Kundu and Chhabra (2023) [5], Singh *et al.* (2023) [11]. The lower plant height of maize was recorded with control (no application of N) ($T_1$), which was statistically comparable with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

**Effect of nitrogen management practices on number of leaves plant$^{-1}$ of maize**

Number of leaves plant$^{-1}$ in maize at different growth stages *viz.*, 30, 60, 90 DAS and at harvest was significantly influenced by different nitrogen management practices during the present investigation (Table 3.) Number of leaves plant$^{-1}$ were increased progressively upto 60 DAS and marginally declines at 90 DAS and at harvest due to senescence of older leaves irrespective of treatments imposed.

The number of leaves plant$^{-1}$ of maize at 30 DAS did not exerted any significant difference. However, slightly higher numerical values in number of leaves plant$^{-1}$ were recorded with the treatments of soil application urea as basal dose. At 30 DAS, foliar application of nitrogen was not imposed in the respective treatments. The results are in accordance with the findings of Parameshnaik *et al*. (2024) [6].

At 60 DAS, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher number of leaves plant$^{-1}$, however, which was statistically on par with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$) and 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$), 33% RDN as basal + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_5$), 50% RDN as basal + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_6$), 75% RDN (66% basal + 17% knee high stage + 17% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_8$) and 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_9$). The lower number of leaves plant$^{-1}$ of maize at 60 DAS was recorded with control (no application of N) ($T_1$), which was statistically at a par with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

At 90 DAS, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly highest number of leaves plant$^{-1}$, however, which was statistically comparable with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$), 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage), 75% RDN (66% basal + 17% knee high stage + 17% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_8$) and 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_5$). More number of leaves plant$^{-1}$ with nitrogen management practices might be due to the combined application of soil as well as foliar spray of nitrogen. Application of foliar nutrition had significant impact of number of leaves because the plant leaves use solar energy to transform simple substances such as water and carbon dioxide into carbohydrates and other substances needed for growth. These results are corroborative with the findings of Anil *et al.* (2023) [1] and Sudha *et al.* (2023) [12]. The lower number of leaves plant$^{-1}$ of maize recorded with control (no application of N) ($T_1$) however, which was statistically at par with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

At harvest, number of leaves plant$^{-1}$ of maize were reduced due to senescence in all the treatments. Among the different nitrogen management treatments, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) and 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$) recorded higher number of leaves plant$^{-1}$ of maize, however, which was statistically comparable with 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$), 75% RDN (66% basal + 17% knee high stage + 17% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_8$) and 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_9$). The lower number of leaves plant$^{-1}$ were recorded with control (no application of N) ($T_1$) and foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

**Effect of nitrogen management practices on days to 50% tasselling of maize**

Number of days to 50% tasseling in maize under different nitrogen management practices was significantly differed during the present investigation. The data was represented in the Table 4. Among the different nitrogen management practices evaluated, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$), 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) and 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$) recorded significantly lesser number of days to attain 50% tasseling in maize compared to other tested treatments. This could be attributable due to that the application of recommended dose of fertilizers (RDF) along with nano urea might have led to earlier onset of tasseling. These results are in line with the findings of Paul *et al.* (2024) [7] and Parameshnaik *et al.* (2024) [6]. Control (no application of N) ($T_1$) and foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$) recorded significantly more number of days to attain 50% tasseling in maize.

**Effect of nitrogen management practices on days to 50% silking of maize**

Number of days to 50% silking in maize under different nitrogen management practices was significantly differed during the present investigation and the data presented in the Table 4. Among the various nitrogen management practices evaluated, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$), 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) and 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage ($T_7$) exhibited shortest duration for achieving 50% silking in maize. This might be due to soil application of RDN along with foliar application of nano urea have led to earlier onset of silking. These results are in accordance with the findings of Paul *et al.* (2024) [7]. However, control (no application of N) ($T_1$) recorded significantly more number of days to attain 50% silking in maize.

**Effect of nitrogen management practices on grain and stover yield of maize**

Grain and stover yield of maize was significantly influenced by the different nitrogen management practices during the present investigation. The data was represented in the Table 5.

**Grain yield (kg ha$^{-1}$)**

Grain yield of maize was significantly influenced by the different nitrogen management practices during the present investigation. The data was represented in the Table 5. Among the different nitrogen management practices evaluated, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher grain yield, however which was statistically comparable with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$) and 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$). Integrated nitrogen management practices recorded higher grain yield and it might be due to improvement in growth and yield attributing parameters and it is governed by the factors which have direct or indirect impact (Parameshnaik *et al.* 2024) [6]. The higher grain yield of maize with foliar feeding treatments might be due to the application of nano fertilizer were reported to stimulate the porphyrin molecules present in metabolic compounds, in turn, increasing plant biomass, yield and yield attributes of maize (Grillo *et al.* 2021) [3]. Diminutive surface property and smaller particle size of nano urea enable its penetration into the plants *via* leaves. After entry in plant systems, nano urea releases N in a controlled manner thereby it increases the nutrient content in plants and therefore improvement in nutrient uptake and use efficiency. Nano urea boosts speedy nutrients availability to growing plant parts, ensuring increased dry matter accumulation, chlorophyll production, plant growth, reproductive development and yield.. The lower grain yield of maize was recorded with control (no application N) ($T_1$), which was statistically on par with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$). These findings are similar to Sarkar *et al.* (2023) [10], Sudha *et al.* (2023) [12].

**Stover Yield (kg ha$^{-1}$)**

Stover yield of maize was significantly influenced by the different nitrogen management practices during this present study. The data was given in the Table 5. Among the various nitrogen management practices studied, 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded significantly higher stover yield, however which was at par with 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_7$) and 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) ($T_3$). This might be due to the large surface area and small particle size of nano urea resulted in its greater efficiency and assimilation inside the plant system, which leads to greater biomass production and in turn dry fodder of maize. The nano size of urea facilitates its penetrance into the plant from the leaf surface on which it is applied, as well as the uptake and nutrient use efficiency (Ding *et al.* 2020) [2]. Also, nitrogen has a direct relationship with the amount of chlorophyll in a plant's tissue. Consequently, it leads to an increase in the number of photosynthates and protoplasmic components, along with an acceleration of cell division and elongation, which in turn leads to luxuriant vegetative growth of maize and increased dry matter accumulation, led to higher stover yield (Kashyap *et al.* 2023) [4]. These results are inline with findings of Sarkar *et al.* (2023) [10], Sudha *et al.* (2023) [12], Singh *et al.* (2023) [11]. However, lower stover yield was produced with control (no application of N) ($T_1$), which was statistically comparable with foliar application of nano urea alone twice at knee high stage and tasseling stage ($T_2$).

**Table 1:** Initial and final plant population (No. $m^{-2}$) of maize as influenced by nitrogen management practices during *rabi*, 2023-24

| Treatment | Initial plant population (No. $m^{-2}$) | Final plant population (No. $m^{-2}$) |
|---|---|---|
| $T_1$ : Control (no application of N) | 11 | 11 |
| $T_2$ : Foliar application of nano urea @ 4 ml $L^{-1}$ alone twice at knee high and tasseling stages | 11 | 11 |
| $T_3$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) | 12 | 12 |
| $T_4$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 11 | 11 |
| $T_5$ : 33% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 11 | 11 |
| $T_6$ : 50% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 12 | 11 |
| $T_7$ : 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 12 | 12 |
| $T_8$ : 75% RDN (66% basal +17% knee high stage + 17% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 12 | 11 |
| $T_9$ : 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 12 | 12 |
| SEm± | 0.4 | 0.29 |
| CD (P=0.05) | NS | NS |

**Table 2:** Plant height (cm) at 30, 60, 90 DAS and at harvest of maize as influenced by different nitrogen management practices in maize during *rabi*, 2023 – 24

| Treatments | 30 DAS | 60 DAS | 90 DAS | Harvest |
|---|---|---|---|---|
| $T_1$ : Control (no application of N) | 77.1 | 111.6 | 138.3 | 139.7 |
| $T_2$ : Foliar application of nano urea @ 4 ml $L^{-1}$ alone twice at knee high and tasseling stages | 81.4 | 120.1 | 148.6 | 149.9 |
| $T_3$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) | 100.5 | 166.3 | 173.9 | 175.6 |
| $T_4$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 103.6 | 176.2 | 198.8 | 200.5 |
| $T_5$ : 33% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 96.8 | 141.4 | 152.1 | 153.2 |
| $T_6$ : 50% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 100.2 | 148.2 | 157.2 | 157.5 |
| $T_7$ : 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 101.1 | 175.7 | 196.5 | 198.6 |
| $T_8$ : 75% RDN (66% basal +17% knee high stage + 17% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 100.4 | 153.7 | 172.9 | 173.7 |
| $T_9$ : 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 92.9 | 152.9 | 164.0 | 166.7 |
| SEm± | 2.77 | 4.70 | 4.99 | 5.05 |
| CD (P=0.05) | 8.3 | 14.1 | 15.0 | 15.1 |

**Table 3:** Number of leaves $plant^{-1}$ at 30, 60, 90 DAS and at harvest of maize as influenced by different nitrogen management practices during *rabi*, 2023 - 24

| Treatments | 30 DAS | 60 DAS | 90 DAS | Harvest |
|---|---|---|---|---|
| $T_1$ : Control (no application of N) | 8 | 11 | 10 | 9 |
| $T_2$ : Foliar application of nano urea @ 4 ml $L^{-1}$ alone twice at knee high and tasseling stages | 8 | 11 | 10 | 9 |
| $T_3$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) | 9 | 13 | 13 | 12 |
| $T_4$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 9 | 14 | 14 | 13 |
| $T_5$ : 33% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 9 | 13 | 12 | 11 |
| $T_6$ : 50% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 8 | 13 | 12 | 11 |
| $T_7$ : 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 9 | 14 | 13 | 13 |
| $T_8$ : 75% RDN (66% basal +17% knee high stage + 17% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 9 | 13 | 13 | 12 |
| $T_9$ : 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 9 | 13 | 13 | 12 |
| SEm± | 0.27 | 0.33 | 0.47 | 0.44 |
| CD (P=0.05) | NS | 1.0 | 1.4 | 1.3 |

**Table 4:** Days to 50% tasseling and 50% silking of maize as influenced by different nitrogen management practices during *rabi,* 2023 - 24

| Treatments | Days to 50% tasseling | Days to 50% silking |
|---|---|---|
| $T_1$ : Control (no application of N) | 60 | 64 |
| $T_2$ : Foliar spray of nano urea @ 4 ml $L^{-1}$ alone twice at knee high and tasseling stages | 60 | 63 |
| $T_3$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) | 55 | 57 |
| $T_4$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 55 | 57 |
| $T_5$ : 33% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 58 | 61 |
| $T_6$ : 50% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 57 | 60 |
| $T_7$ : 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 55 | 57 |
| $T_8$ : 75% RDN (66% basal +17% knee high stage + 17% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 58 | 61 |
| $T_9$ : 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 59 | 60 |
| SEm± | 0.32 | 0.30 |
| CD (P=0.05) | 0.9 | 0.9 |

**Table 5:** Kernel yield (kg $ha^{-1}$) and Stover yield (kg $ha^{-1}$) of maize as influenced by the different nitrogen management practices during *rabi,* 2023 - 24

| Treatments | Kernel yield (kg $ha^{-1}$) | Stover yield (kg $ha^{-1}$) |
|---|---|---|
| $T_1$ : Control (no application of N) | 4023 | 5707 |
| $T_2$ : Foliar spray of nano urea @ 4 ml $L^{-1}$ alone twice at knee high and tasseling stages | 4184 | 6440 |
| $T_3$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) | 8030 | 9819 |
| $T_4$ : 100% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 8671 | 10474 |
| $T_5$ : 33% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 5261 | 7166 |
| $T_6$ : 50% RDN as basal + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 6459 | 7984 |
| $T_7$ : 75% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 8437 | 10291 |
| $T_8$ : 75% RDN (66% basal +17% knee high stage + 17% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 7022 | 8785 |
| $T_9$ : 50% RDN (33% basal + 33% knee high stage + 33% tasseling stage) + foliar spray of nano urea @ 4 ml $L^{-1}$ at knee high stage and tasseling stage | 6638 | 8374 |
| SEm± | 215.9 | 326.6 |
| CD (P=0.05) | 647 | 979 |

## Conclusion

The present study revealed that, among different nitrogen management practices in maize, application of 100% RDN through urea in three splits (33% basal + 33% knee high stage + 33% tasseling stage) + two foliar sprays of nano urea at knee high stage and tasseling stage ($T_4$) recorded higher growth parameters and yield in maize under scarce rainfall zone of Andhra Pradesh.

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