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# Grain Yield and Nutrient Uptake of Rice as Influenced by the Nano Forms of Nitrogen and Zinc

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

An experiment was conducted at college farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana, in Sandy loam soils during *rabi,* 2020 to study the effect of nano nitrogen and nano zinc on the yield and nutrient uptake of rice (*Oryza sativa*. L). The experiment was carried out in randomised block design with 10 treatments and 3 replications. Results revealed that application of 50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage ($T_{10}$) significantly increased the grain yield (6810 kg $ha^{-1}$) and uptake of nitrogen (147.7 kg $ha^{-1}$), phosphorous (30.0 kg $ha^{-1}$), potassium (137.9 kg $ha^{-1}$) and zinc (367 kg $ha^{-1}$) which were on par with ($T_9$) application of 50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage.

*Keywords: Rice; foliar application; nano nitrogen; nano zinc; yield; nutrient uptake.*

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## 1. INTRODUCTION

Rice (*Oryza sativa L*) is the prominent staple food for a large part of the world, especially in Asia. India is the world's second largest producers of rice accounting for 20% of all world rice production after china. Fertilizers are indispensable in agricultural production system. Application of fertilizers started in 1960's which closely coincided with the introduction of fertilizer responsive varieties in Indian agriculture. Although fertilizer application remarkably improved the crop growth and enhanced the yields of several crops but the yields got plateaued due the low fertilizer response ratio, imbalanced fertilization and increased intensities of micronutrient deficiencies across the country. This necessitates to develop slow release fertilizers to regulate the nitrification processes thereby nitrogen availability be sustained during the crop period.

Nitrogen (N) is a primary nutrient for all the crops. The nitrogen requirement for cereal crops is higher when compared to other crops for its growth, development and grain production [1]. Most of the rice soils are deficient in N, only a fraction of N requirement can be met with biological nitrogen fixation by Cyanobacteria diaztrophic bacteria [2]. Thus, nitrogen fertilizer application is essential to meet the crop requirement. But, the efficiency of added fertilizer N in rice depends on the N sources, application method, rate of N as well as management practices [3]. Prilled urea (PU) is applied as N source for rice but the efficiency of added N from PU is very low, generally it is around 30-45%. This low N use efficiency in rice culture is attributed mainly to denitrification, ammonia volatilization and leaching losses [4]. This necessitates to develop slow release fertilizers to regulate the nitrification processes thereby N availability be sustained during the crop period.

In rice, among the micronutrients zinc deficiency is often observed and zinc (Zn) deficiency has been found responsible for reduction of yield in rice next to N, P, K. Zinc deficiency was first diagnosed in rice (*Oryza sativa .L*) on calcareous soils of Northern India [5]. It was subsequently found to be a widespread phenomenon in lowland rice areas of Asia. Zinc deficiency causes multiple symptoms that usually appear 2 to 3 weeks after transplanting rice seedlings. Compared with legumes, cereals are generally more prone to zinc deficiency leading to a substantial reduction in grain yield and nutritional quality. Nevertheless, frequency of zinc deficiency is greater in rice than other crops, with more than 50 % of the crop worldwide prone to this nutritional disorder. Zinc can be applied in many ways to crop such as soil application, foliar spray, seed treatment, fertigation *etc*. Foliar or combined soil + foliar application of fertilizers under field conditions has proved to be highly effective and can be a practical way to maximize the zinc accumulation and uptake in grains [6].

In view of the low nitrogen use efficiency and importance of zinc for rice crop, this study aims to study the effect of nano forms of nitrogen and zinc on the yield and nutrient uptake of rice

## 2. MATERIALS AND METHODS

The present experiment was conducted at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana, India during *rabi* 2020. The soil of experimental plot was sandy loamy and slightly alkaline (pH 7.85), with available nitrogen (230 kg $ha^{-1}$), phosphorous (36.5 kg $ha^{-1}$), potassium (358 kg $ha^{-1}$) and zinc content (0.3 mg $kg^{-1}$). Geographically the experimental plot was situated between 17 $^{0}$19' 16.4" North latitude and 78$^{0}$ 24' 43" East longitudes and at an altitude of 542.3 m above mean sea level. The total rainfall received during the crop growth period was 32 mm in 5 rainy days The experimental field was laid out in randomized block design with 10 treatments each replicated thrice. The treatments were *viz.,* control (no fertilizer) ($T_1$), 100% conventional N fertilizer through urea ($T_2$), $T_2$ + soil application of $ZnSO_4$ at transplanting ($T_3$), $T_2$ + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage ($T_4$), $T_2$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage ($T_5$), $T_2$ + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage ($T_6$), 75% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen before panicle initiation stage. ($T_7$), $T_7$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage ($T_8$), 50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage ($T_9$), $T_9$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage ($T_{10}$). Each plot measures 22.68 $m^{-2}$ (5.4 m X 4.2 m). Telangana Sona variety (RNR 15048) seedlings were transplanted on 21$^{st}$ December with a spacing of 15 cm X 15 cm. The recommended dose of fertilizers for the transplanted rice crop 120:60:40 kg N, P and K respectively. One third of the nitrogen, entire recommended dose of phosphorous and potassium were applied in the form urea, SSP and MOP as basal during the time of transplanting to all the plots except control. 25 kg $ha^{-1}$ of $ZnSO_4$ was applied as basal application according to the treatment specification. One third of nitrogen was applied in the form of urea or foliar spray of nano nitrogen as per the treatment specifications at tillering stage of the crop. On the third day after the application of nitrogen, foliar application of nano zinc was applied in accordance with the treatments. As per treatment stipulations another one third of nitrogen was applied at panicle initiation stage in the form of urea or foliar spray of nano nitrogen followed by the foliar spray of nano zinc on the third day after the application of nitrogen.

Both nano nitrogen and nano zinc were applied as foliar application in the present study. The liquid formulation of nano nitrogen contained 40000 ppm of N. The recommended amount of spray fluid for nano formulations is 313 L $ha^{-1}$. The recommended dosage of nano nitrogen is 4 ml $L^{-1}$. The liquid formulation of nano zinc formulation obtained contains 10000 ppm of zinc. The recommended dosage of nano zinc is 2 ml $L^{-1}$.

Recommended plant protection measures were taken up in order to protect the crop from pests and diseases. Harvesting and threshing operations were done with the brush cutter and thresher in order to adopt mechanization in cultivation. Growth and yield components were recorded periodically. After harvest grain yield and straw yield were recorded.

For nutrient analysis the plant samples were collected dried and ground to fine powder using willey mill and were analyzed. Nitrogen content (%) in the plant were determined by the micro kjeldhal method (Jackson, 1967) using Kelplus N analyser after digesting the samples with $H_2SO_4$ and $H_2O_2$ [7]. For phosphorous the tri-acid ($HNO_3$ and $HCLO_4$) in the ratio of (3:1) respectively digested plant and weed samples were analysed for phosphorus content by Vanadomolybdo phosphoric acid. The intensity of yellow colour developed was measured by using spectrophotometer at 420 nm [7]. Potassium content in the di-acid mixture was determined with flame photometer [7]. The zinc content in the triacid digest was assessed by using Atomic absorption spectrophotometer. (FS 420 model of Varian make) [8].

The uptakes were calculated by the following formulae

N uptake = Nitrogen content (%) /100 X Dry matter (kg ha $^{-1}$)
P uptake = Phosphorous content (%)/100 X Dry matter (kg ha $^{-1}$)
K uptake = Potassium content (%)/ 100 X Dry matter (kg ha $^{-1}$)
Zn uptake = Zinc content (mg kg $^{-1}$) x Dry matter production (kg $ha^{-1}$) /1000

The data obtained from various parameters under study was analyzed by the method of analysis of variance (ANOVA) as given by Gomez and Gomez [9]. 5% level of significance was used in the “F” test.

## 3. RESULTS AND DISCUSSION

### 3.1 Seed Yield

Seed yield was significantly influenced by the foliar application of nano nitrogen and nano zinc (Table 1). The highest seed yield (6810 kg $ha^{-1}$) was recorded with the application of 50% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage ($T_{10}$), which was on par with the application of 50% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage ($T_9$) (6653 kg $ha^{-1}$). Lowest seed yield (3136 kg $ha^{-1}$) was obtained with the no fertilizer (control) ($T_1$).

Higher grain yield might be due to improved nutrient uptake by the plant leading to the ideal growth of the plant parts and metabolic processes like photosynthesis resulting in maximum accumulation and translocation of photosynthates to the economic parts of the plant, hence ensuing in higher yield that might be attributed to increased source (leaves) and sink (economic part) strength. These findings were in agreement with the findings of Taiz and Zeiger [10], Sheykhboglou et al. (2010), Harsini et al. [11], Liu and lal [12] and Benzon et al. [13].

### 3.2 Straw Yield

Straw yield was significantly influenced by the foliar spray of nano nutrients (Table 1). Higher straw yield (7891 kg $ha^{-1}$) was noticed with treatment $T_6$ (100 % conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage). It was noticed on par with $T_4$ (application of 100% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage) (7712 kg $ha^{-1}$), $T_{10}$ (50% conventional N fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage) (7702 kg $ha^{-1}$), $T_9$ (50% conventional N fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage) (7662 kg $ha^{-1}$) and statistically higher when compared to that of other treatments. The lowest straw yield (4329 kg $ha^{-1}$) was recorded with no fertilizer treatment. Increase in the straw yield with the foliar spray of nano nitrogen and nano zinc fertilizers might be due to the fact that nano fertilizers due to quick absorption by the plant and easily translocated at a faster rate that aided in higher rate of photosynthesis and more dry matter accumulation which resulted in higher straw yield. These findings were in agreement with the reports of Tarafdar et al. (2012), Aziz et al. (2018), Hafeez et al. [14], Kumar et al. [15] and Sirisena et al. [16].

### 3.3 Nutrient Uptake

Significant increase in the nutrient uptake was observed with the foliar application of nano nutrients (Table-2).Highest uptake of nitrogen (147.7 kg $ha^{-1}$), phosphorous (30.0 kg $ha^{-1}$) and Potassium (137.9 kg $ha^{-1}$) by crop was registered in the treatment $T_{10}$ (50% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage) which was found to be on par with $T_9$ (50% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage) 137.9 kg $ha^{-1}$, 25.6 kg $ha^{-1}$ and 137.9 kg $ha^{-1}$ N,P and K respectively. Whereas, the lowest uptake was obtained in the treatment $T_1$ (no fertilizer) 70.5 kg $ha^{-1}$, 12.1 kg $ha^{-1}$and 78.6 kg $ha^{-1}$ N, P and K respectively. The uptake of nutrients was found to be increased with the foliar application of nano nitrogen and nano zinc which might be due to the quick absorption and rapid transport of nano nutrients in the plant. These results are in consonance with Ashoka et al. [17], Ali et al. [18] and Apoorva et al. (2015).

**Table 1. Seed yield and straw yield (kg $ha^{-1}$) as influenced by the foliar application of nano nitrogen and nano zinc**

| Treatment | Yield (kg $ha^{-1}$) | |
|---|---|---|
| | **Seed** | **Straw** |
| $T_1$-No fertilizer (control) | 3136 | 4329 |
| $T_2$-100% conventional nitrogen fertilizer through urea | 6265 | 7386 |
| $T_3$-$T_2$ + soil application of 25 kg $ha^{-1}$ $ZnSO_4$ at transplanting. | 6390 | 7403 |
| $T_4$-$T_2$+ foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage | 6002 | 7712 |
| $T_5$-$T_2$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage | 6456 | 7532 |
| $T_6$-$T_2$ + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage + foliar spray of 2 ml $L^{-1}$ Nano zinc at tillering and before panicle initiation stage | 6095 | 7891 |
| $T_7$-75% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ Nano Nitrogen before panicle initiation stage. | 5890 | 7063 |
| $T_8$-$T_7$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage | 5986 | 7156 |
| $T_9$-50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage. | 6653 | 7662 |
| $T_{10}$-$T_9$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage | 6810 | 7702 |
| SE(m)± | 123 | 125 |
| CD (P = 0.05) | 352 | 357 |

**Table 2. Influence of foliar application of nano nitrogen and nano zinc on the nutrient uptake ($kg\ ha^{-1}$) at harvest stage of the crop**

| Treatment | N uptake | P uptake | K uptake | Zn uptake |
|---|---|---|---|---|
| $T_1$-No fertilizer (control) | 70.5 | 12.1 | 78.6 | 100.8 |
| $T_2$-100% conventional nitrogen fertilizer through urea | 128.5 | 23.7 | 127.1 | 289.3 |
| $T_3$-$T_2$ + soil application of 25 kg $ha^{-1}$ $ZnSO_4$ at transplanting. | 130.5 | 24.2 | 128.2 | 310.5 |
| $T_4$-$T_2$+ foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage | 123.0 | 20.9 | 123.7 | 283.5 |
| $T_5$-$T_2$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage | 131.2 | 25.2 | 133.0 | 335.8 |
| $T_6$-$T_2$ + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage + foliar spray of 2 ml $L^{-1}$ Nano zinc at tillering and before panicle initiation stage | 125.9 | 21.9 | 125.2 | 347.7 |
| $T_7$-75% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen before panicle initiation stage. | 119.9 | 17.9 | 118.5 | 291.3 |
| $T_8$-$T_7$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage | 121.5 | 19.2 | 120.5 | 341.3 |
| $T_9$-50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage. | 138.9 | 27.1 | 137.9 | 299.8 |
| $T_{10}$-$T_9$ + foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage | 147.7 | 30.1 | 145.3 | 367.0 |
| SE(m)± | 3.5 | 1.1 | 4.1 | 4.4 |
| CD (P = 0.05) | 10.5 | 3.2 | 12.2 | 13.2 |

Significantly higher zinc uptake (367 kg $ha^{-1}$) was noticed in the treatment $T_{10}$ (50% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage) which is *fb* $T_6$ (100% conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage), $T_8$ (75 % conventional N fertilizer through urea + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and P.I stage + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage) (341.3 kg $ha^{-1}$), $T_5$ (100% conventional N fertilizer through urea + foliar spray of 2 ml $L^{-1}$ nano Zn at tillering and P.I stage) (335.8 kg $ha^{-1}$), T3 (100% conventional N fertilizer through urea + soil application of $ZnSO_4$ at transplanting). Lowest zinc uptake (100.8 kg $ha^{-1}$) was recorded in the treatment where no fertilizers were applied. These results were in agreement with the findings of Apoorva et al. (2015), Benzon et al. [13] and Drostkar et al. (2015).

## 4. CONCLUSION

The seed, straw yields and nutrient uptake were significantly influenced by the foliar application of nano nutrients over the conventional nutrients. Application of 50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage+ foliar spray of 2 ml $L^{-1}$ nano zinc at tillering and before panicle initiation stage ($T_{10}$) had shown in best results in terms of seed yield, straw yield and nutrient uptake which was found to be on par with ($T_9$) 50% conventional nitrogen fertilizer + foliar spray of 4 ml $L^{-1}$ nano nitrogen at tillering and before panicle initiation stage.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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