

Original Research Article

YIELD AND ECONOMICS OF RICE AS INFLUENCED BY THE NANO FORMS OF NITROGEN AND ZINC

ABSTRACT

A field 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 economics of rice (*Oryza sativa* L.). The experiment was carried out in randomised block design with 10 treatments and 3 replications. The treatments *viz.*, Control (T₁), 100% conventional N fertilizer through urea (T₂), T₂ + soil application of ZnSO₄ at transplanting (T₃), T₂ + foliar spray of 4 ml L⁻¹ nano nitrogen at tillering and before panicle initiation stage (T₄), T₂ + foliar spray of 2 ml L⁻¹ nano zinc at tillering and before panicle initiation stage (T₅), T₂ + 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 (T₆), 75% conventional nitrogen fertilizer + foliar spray of 4 ml L⁻¹ nano nitrogen before panicle initiation stage (T₇), T₇ + foliar spray of 2 ml L⁻¹ nano zinc at tillering and before panicle initiation stage (T₈), 50% conventional nitrogen fertilizer + foliar spray of 4 ml L⁻¹ nano nitrogen at tillering and before panicle initiation stage (T₉), T₉ + foliar spray of 2 ml L⁻¹ nano zinc at tillering and before panicle initiation stage (T₁₀). The results indicated that the highest grain yield (6810 kg ha⁻¹) was registered with treatment T₁₀ (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) which is on par with T₉. The highest net returns (86649 Rs ha⁻¹) and B:C ratio (2.99) were noticed by the application of T₁₀.

Keywords: Rice, Foliar application, Nano nitrogen, Nano zinc, Yield, Economics.

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 producer 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. Since nitrogen fertilization reveals universal response in crops besides low price of urea due to decontrol (subsidized rate), farmers started the use of nitrogenous fertilizers particularly urea irrationally, which has led to the current NPK ratio of 8.2: 3.2: 1 while optimal ratio is stipulated as 4:2:1 in cereals. This is very serious issue causing nitrate pollution in ground water and eutrophication in aquatic system.

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, 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 [2]. 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 due to denitrification, ammonia volatilization and leaching losses [3]. 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 and K. Zinc deficiency was first diagnosed in rice (*Oryza sativa* .L) on calcareous soils of Northern India (Nene,1966). 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 [4].In view of the above the present study was conducted to know the effect of nano forms of nitrogen and zinc on the yield and economics of rice.

2. MATERIAL AND METHODS

The experiment was conducted at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana, India during *rabi* 2020. The type of soil in 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 located between $17^{\circ}19' 16.4''$ North latitude and $78^{\circ} 24' 43''$ East longitudes and at an altitude of 542.3 m above mean sea level. The total rainfall of 32 mm in 5 rainy days was received during the crop growth period. 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 ($5.4 \text{ m} \times 4.2 \text{ m}$).Telangana Sona variety (RNR 15048) seedlings were transplanted on 21st December with a spacing of $15 \text{ cm} \times 15 \text{ cm}$. The recommended dose of fertilizers for the transplanted rice crop $120:60:40 \text{ kg N,P and K}$ respectively. One third of the nitrogen, entire recommended dose of phosphorous and potassium were applied in the form urea, SSP and MOP as basal at the time of transplanting to all the plots except control. 25 kg ha^{-1} of ZnSO_4 was applied as basal application as per the treatment specification. At tillering stage of the crop one third of nitrogen was applied in the form of urea or foliar spray of nano nitrogen according to the treatment specifications. 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.

Data obtained from various parameters under this study were analyzed by the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). The level of significance used in the "F" test was given at 5 per cent. The prices of the inputs prevailed in local market during experimentation were considered for working out the cost of cultivation. The gross returns were calculated using the yield of rice and the market price of the produce at the time of marketing. The net returns per hectare were calculated by deducting the cost of cultivation per hectare from the gross returns per hectare.

Net monetary returns = Gross monetary returns - Total cost of cultivation

Benefit cost ratio was worked out for each treatment by using the formula

Benefit cost ratio = Gross returns (Rs ha⁻¹) / Cost of cultivation (Rs ha⁻¹)

3. RESULTS AND DISCUSSION

3.1 Seed yield

Foliar application of nano nitrogen and nano zinc significantly influenced the seed yield of rice (Table-1). 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 (T₁₀) recorded the highest seed yield (6810 kg ha⁻¹) which was at 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 (T₉) (6653 kg ha⁻¹). Lowest seed yield (3136 kg ha⁻¹) was obtained with the no fertilizer (control) (T₁). There was an increase of 8% in the seed yield was observed when compared to RDF (T₂), 58.95% over the control (T₁).

Increment in the grain yield might be due to enhanced nutrient uptake by the plant resulting in the superlative growth of the plant parts and improved metabolic processes like photosynthesis resulting in maximum accumulation and translocation of photosynthates to the economic parts of the plant, hence ensuing in high yield that might be attributed to increased source (leaves) and sink (economic part) strength. These findings were in accordance with the findings of Liu and Lal [5], Harsini et al [12] [13,14] and Benzon et al [6].

3.2 Straw yield

Straw yield was significantly influenced by the foliar spray of nano nutrients (Table-1). Treatment T₆ (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) resulted in higher straw yield (7891 kg ha⁻¹) which was found to be at par with T₄ (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), T₁₀ (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), T₉ (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. Enhancement in the straw yield with the foliar application of nano nitrogen and nano zinc fertilizers might be due to the quick absorption of nutrients in the

nano form by the plant and translocated at a faster rate influenced the root and shoot growth that aided in higher rate of photosynthesis and increased dry matter accumulation which resulted in higher straw yield. These findings were in corroboration with the reports of Hafeez et al [7], Kumar et al [8] and Abdel et al [9].

3.3 Economics

Returns from the rice crop was influenced by the foliar application of nano nitrogen and nano zinc (Table-2). 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 (T₁₀) fetched highest gross returns (130281 Rs. ha⁻¹) The next best treatment was T₉ (50% conventional N fertilizer through urea + foliar spray of 4 ml L⁻¹ nano nitrogen at tillering and P.I stage) which resulted in gross returns of 127416 Rs. ha⁻¹. The lowest gross returns were recorded with control (no fertilizer) (60777 Rs. ha⁻¹).

Higher net returns were registered with T₁₀ (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) / T₉ (50% conventional N fertilizer through urea + foliar spray of 4 ml L⁻¹ nano nitrogen at tillering and P.I stage) which gained a net returns of 86649 and 84385 Rs. ha⁻¹, respectively. The lowest net returns were noticed in the treatment where no fertilizers were applied T₁ (24397 Rs. ha⁻¹). The highest B:C ratio 2.99 was recorded with the treatment T₁₀ (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) / T₉ (50% conventional N fertilizer through urea + foliar spray of 4 ml L⁻¹ nano nitrogen at tillering and P.I stage) which fetched B: C ratio of 2.96. Lowest B: C ratio of 1.67 was registered in the treatment T₁ (no fertilizer).

Higher gross returns, net returns and B:C ratio were obtained as a result of lesser cost of cultivation due to the reduced level of urea application and effective utilization of foliar nano fertilizers which resulted in higher grain and straw yields which in turn led to higher returns. These findings were in accordance with the findings of Kumar et al [8] and Apoorva et al [10].

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: Economics of rice as influenced by foliar application of nano nitrogen and nano zinc

Treatments	Cost of cultivation (Rs/ ha)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	B-C Ratio
T ₁	36380	60777	24397	1.67
T ₂	44058	120152	75894	2.71
T ₃	44733	122423	77690	2.74
T ₄	44658	115748	71090	2.59
T ₅	43458	123740	80282	2.85
T ₆	45120	117601	72481	2.60
T ₇	43756	113082	69326	2.58
T ₈	43541	114904	71363	2.64
T ₉	43031	127416	84385	2.96
T ₁₀	43631	130281	86649	2.99

Market rates of paddy seed @ Rs. 18/-per kg; paddy straw @ Rs. 1/- per kg

4. CONCLUSION

The seed and straw yield were significantly influenced by the foliar application of nano nitrogen and nano zinc. 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 had shown in best results in terms of seed yield and straw yield which was found to be on par with 50% conventional nitrogen fertilizer + foliar spray of 4 ml L⁻¹ nano nitrogen at tillering and before panicle initiation stage. As a result of yield increment with application of nano nutrients which fetched the higher gross returns, net returns and higher B:C ratio.

COMPETING INTERESTS

Declaration of competing interest should be placed here. All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. If no such declaration has been made by the authors, SDI reserves to assume and write this sentence: "Authors have declared that no competing interests exist."

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