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"Investigating the Impact of Nitrogen, Zinc, and Iron Application on Rice Growth and Yield Characteristics"

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Abstract

A field trial was conducted to examine the "Investigating the Impact of Nitrogen, Zinc, and Iron Application on Rice Growth and Yield Characteristics" In the Agriculture Research Farm at Hardoi of Rama University, Mandhana, Kanpur, the current experiment was carried out from *Kharif* season 2022–23. The experiment followed a Randomized Block Design with nine treatment combinations and three replications. 100% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L, 100% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L, 100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L, 75% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L, 75% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L , 75% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L , 50% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L, 50% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L , 50% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L, , along with a control (120-60-60 NPK kg/ha). Among the various treatment combinations, the most significant results were observed in T_3 (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L). This treatment showed the highest values for plant height (105.26 cm), number of tillers per hill (15.31), dry weight per hill (46.89 g), number of productive tillers per square meter (307.40), number of grains per panicle (90.87), test weight (24.29 g) and Grain yield (61.56 qt/ha) in rice crop.

Keywords: RDN, Iron, Nano urea, zinc, yield.

Introduction

Rice (Oryza sativa L) serves as a fundamental staple food for a significant portion of the global population, particularly in India, where it constitutes the main source of carbohydrates for two-thirds of its populace. Belonging to the Poaceae family, rice is an edible starchy cereal grain with a chromosome number of 2n = 24. In India, rice cultivation spans an extensive area of 46.38 million hectares, yielding approximately 130.29 million metric tons, with an average productivity of around 2809 kg/ha. Uttar Pradesh stands as the second-largest rice-producing state in India, following West Bengal, with a rice production of 15.27 million metric tons from an area of 5.70 million hectares, achieving a productivity of 2679 kg/ha (Agricultural Statistics at a Glance, 2022).

Micronutrients play a pivotal role in the metabolic processes of rice, encompassing vital functions such as chlorophyll synthesis, enzyme activation, and membrane integrity, which are indispensable for major physiological activities like photosynthesis and respiration. Deficiencies in micronutrients can impede these crucial physiological processes, leading to a decline in yield (Afreen et al., 2021). Zinc (Zn) is among the 17 essential elements crucial for normal growth and development, playing a significant role in enzyme function and controlling various biochemical activities necessary for plant health. Iron also holds a critical role in chlorophyll synthesis, respiration, photosynthesis, and other essential processes. Severe chlorosis resulting from iron deficiency can lead to crop failure (Soumya et al., 2022). Nitrogen plays a pivotal role in chlorophyll production, vital for the photosynthesis process. It serves as a constituent of amino acids, nucleic acids, nucleotides, chlorophyll, enzymes, and hormones. Nitrogen promotes rapid plant growth and enhances grain yield and quality by facilitating higher tillering, grain formation and filling, and protein synthesis. Nano-urea, developed by IFFCO using Nanotechnology for agricultural purposes, provides nitrogen to crops in a targeted manner. Nano-urea molecules, sized between 20-50 nanometers, offer enhanced surface area to volume ratio, leading to more effective absorption by plants when applied as a spray on leaves (Namasharma et al., 2023). Nano-urea has demonstrated an average increase in crop yield by 8% compared to conventional urea, while also enhancing produce quality. Moreover, nano-urea reduces the requirement for urea by half or more without compromising soil productivity, thereby improving crop production and soil health (Midde et al., 2022; Bhargavi et al., 2023).

Recognizing the significance of zinc, iron, and nano-urea application, the current study aims to investigate the "Investigating the Impact of Nitrogen, Zinc, and Iron Application on Rice Growth and Yield Characteristics".

Material and Methods

The experiment was conducted at the "Investigating the Impact of Nitrogen, Zinc, and Iron Application on Rice Growth and Yield Characteristics" In the Agriculture Research Farm at Hardoi of Rama University, Mandhana, Kanpur, the current experiment was carried out from Rabi season 2022–23., during the kharif season. Seedlings of the rice variety Trimurti mani were initially raised in a nursery and later transplanted with a spacing of 30 cm × 10 cm. Each plot, measuring three meters by three meters, had two rows removed from each side. From each plot, five rice plants were selected and marked for measuring parameters such as plant height, number of tillers per hill, and yield attributes. Sampling for dry weight determination was carried out from the border row. The data collected for various factors were statistically analyzed using Gomez & Gomez's (1984) randomized block design. A significance level of 5% (p=0.05) was applied to present the results for comparing different treatments.

Results and Discussion

1. Growth parameters

Table 1. Embodies the data regarding growth attributes like plant height, number of tillers/hill and dry weight

1.1 Plant height

The data recorded at time of harvesting, significantly greater plant height (104.00 cm) was observed in treatment T_3, where nitrogen was applied at a rate of 100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L. Treatment T_2 showed comparable results. The utilization of nano encapsulated nitrogen has been noted to efficiently release nutrients, thereby modulating plant growth and meristematic activity (Midde et al., 2022). The observed increase in plant height can be attributed to the application of zinc and iron, which aid in the synthesis of growth-promoting hormones, particularly auxins, stimulating rapid cell division in meristematic tissues, consequently leading to enhanced plant height (Baishya et al., 2019).

1.2Number of tillers/hill

The data recorded at time of harvesting, a significantly greater number of tillers per hill (15.31) was observed in treatment T_3, characterized by the application of nitrogen at 100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L. Treatments T3, T2, and T1, comprising various combinations of nitrogen, zinc, iron, and nano urea, showed statistically similar results. The application of zinc and iron has been associated with increased photosynthetic activity, chlorophyll and protein synthesis, and nitrogen fixation (Rao et al., 2019). Enhanced growth performance was achieved through foliar application of nano-urea along with inorganic nitrogen fertilizer (urea), possibly due to the higher nitrogen use efficiency (NUE) of nano-urea (Namasharma et al., 2023).

1.3Plant dry weight

The data recorded at time of harvesting, a significantly higher dry weight (46.89 g) was observed in T_3, characterized by the application of nitrogen at 100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and Nano Urea 3 ml/L the time of flowering at fallowed by Treatments T2 and T1, comprising nitrogen, respectively, demonstrated statistically similar results. The larger surface area and particle size of nano urea facilitate its easy penetration into the plant, enhancing nutrient use efficiency and resulting in higher dry matter production (Midde et al., 2022). Application of nano urea during critical growth stages, such as tillering and panicle initiation, may ensure adequate nitrogen availability, promoting cell elongation, meristematic cell activity, and subsequent dry matter production (Bhargavi et al., 2023).

2. Yield attributes and Yield

Table 2 presents the data pertaining to yield attributes, including:

2.1 Number of productive tillers per square meter:

Significantly higher numbers of productive tillers per square meter (307.40) were recorded in T3, (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and Nano Urea 3 ml/L the time of flowering). Treatments T2 and T1, showed statistically comparable results.

2.2 Number of grains per panicle:

A significantly greater number of grains per panicle (90.87) were recorded in T3, (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and Nano Urea 3 ml/L the time of flowering). Treatments T2 and T1 exhibited statistically similar results.

2.3 Test weight:

Higher test weights (24.29 g) were recorded in treatment were recorded in T3, (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and Nano Urea 3 ml/L the time of flowering). Treatments T2, T1 and T9, comprising various combinations of nitrogen, zinc, iron, and nano urea, showed statistically similar results.

2.4 Grain yield

This process ultimately contributes to increase Number of grains per panicle, Number of productive tillers per square meter, and Test weight, ultimately higher grain yield in the crop. A Significantly highest grain yield (61.56) was recorded with T3, (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and Nano Urea 3 ml/L the time of flowering) which was superior over all other treatments. However, treatment T2 (100% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L) was found to be statistically at par with T3, (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and Nano Urea 3 ml/L the time of flowering) and T1 which was superior over all other treatments. The significant increase in yield attributes and overall yield may be attributed to the favorable influence of applied zinc, which exerts a catalytic or stimulatory effect on various physiological and metabolic processes of the plant. Zinc and iron play pivotal roles in the biosynthesis of Indole-3-acetic acid (IAA), promoting higher yields (Rao et al., 2019). The enhanced growth of plant parts and metabolic processes such as photosynthesis, facilitated by nano urea application, contribute to increased accumulation and translocation of photosynthates to economically important plant parts, consequently boosting yield (Namasharma et al., 2023).

Conclusion

In conclusion, based on the findings of this study, it is recommended that for rice cultivation in Central Uttar Pradesh Agro-Climatic conditions, the application of nitrogen at (100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha and along with Nano Urea 3 ml/L the time of flowering is optimal for achieving enhanced growth and yield of rice crops.

Table 1: Effect of Nitrogen and Zinc, Iron application on Plant height (cm), Plant dry weight (g/hill) and Number of tillers/hill of Rice.

Treatments		Plant height (cm)	Plant dry weight (g/hill)	Number of tillers/hill
T1	100% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L	100.88	46.01	14.74
T2	100% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L	103.23	46.61	14.86
T3	100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L	105.26	46.89	15.31
T4	75% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L	96.15	44.83	13.72
T5	75% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L	97.50	45.05	14.17
T6	75% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L	98.85	45.72	14.42
T7	50% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L	92.78	42.65	12.25
T8	50% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L	94.13	43.58	12.70

T9	50% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L	95.64	44.38	13.21
T10	120-60-60 kg NPK/ha	98.08	45.02	13.32
S.Em (±)		0.75	0.42	0.18
CD (p=0.05)		2.25	1.23	0.52
F-test		S	S	S

Table 2: Effect of Nitrogen and Zinc, Iron application on yield attributes and yield of Rice.

Treatments		**Number of productive tillers/m^2**	**Number of grains/panicle**	**Test weight (g)**	**Yield qt/ha**
T1	100% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L	300.52	88.07	24.10	58.76
T2	100% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L	302.81	89.25	24.23	59.42
T3	100% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L	307.40	90.87	24.29	61.56
T4	75% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L	286.98	85.16	23.75	57.47
T5	75% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L	289.05	86.50	23.82	57.71
T6	75% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L	291.34	87.27	24.01	58.45
T7	50% RDN + $ZnSO_4$ 15 kg/ha + 5 kg/ha + Nano Urea 3 ml/L	278.95	80.18	23.53	55.09
T8	50% RDN + $ZnSO_4$ 20 kg/ha + 10 kg/ha + Nano Urea 3 ml/L	283.09	80.51	23.62	54.10
T9	50% RDN + $ZnSO_4$ 25 kg/ha + 15 kg/ha + Nano Urea 3 ml/L	285.61	83.12	23.72	52.69
T10	120-60-60 kg NPK/ha	290.32	85.99	24.01	57.75
S.Em (±)		4.19	0.76	0.16	1.07
CD (p=0.05)		12.56	1.23	0.52	3.21
F-test		S	S	S	S

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