International Journal of Plant & Soil Science

Volume 35, Issue 12, Page 98-104, 2023; Article no.IJPSS.99083
ISSN: 2320-7035

Influence of Foliar Application of Zinc on Growth and Yield in Different Varieties of Rice (*Oryza sativa L.)* and Yield Validation Using SPSS Model

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Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2023/v35i122972

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/99083

Original Research Article

Received: 25/02/2023
Accepted: 27/04/2023
Published: 12/05/2023

ABSTRACT

Agronomy Department, Farm, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj (U.P.), India. To research the effects of zinc treatment on rice (*Oryza sativa* L.) growth and yield. The medications include the verities MTU-7029, BPT -5204, and RNR15048, as well as zinc concentrations of 0.2%, 0.3%, and 0.4%. The pH of the soil in the experimental plot was 7.8, the texture was sandy loamy, and the amount of organic carbon was low (0.35%). The larger plant height (117.68 cm), greater number of tillers per hill (16.72), Application of RNR-15048

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+ ZnSo4 - 0.4% significantly increased plant dry weight (55.47 g/plant), number of panicles/hill (10.01), number of grains/panicle (141.37), 1000 seed weight (22.27 gm), grain yield (6.43 t/ha), and stove yield (12.11 t/ha), obtained Yield in Experiment (6.43t/ha), percentage Increased Over Predicted Yield (55.21%).

Keywords: Rice; varieties; zinc; growth parameters; yield attributes and economics.

1. INTRODUCTION

The most important cereal food crop in India is rice (*Oryza sativa* L.), which accounts for around 24% of the nation's total cropped land. It contributes 42% of the nation's overall production of food grains and 45% of the nation's total production of cereals. After China, India is the country with the largest rice-growing area and the second-highest rice production [1].

About 31% of India's GDP is derived from agriculture, and 25% of its exports are composed of agricultural goods. More than 65% of people rely on it as a staple meal, so the expansion and stability of its production are crucial to the safety of our country's food supply. The biggest area of rice cultivation is in India, where there are 44.6 million hectares of rice planted in four primary eco-systems: Irrigated, rain fed lowland, rain fed upland, and flood prone, which take up 21, 14, 6, and 3 million hectares, respectively, and produce about 90 million tonnes of rice annually [2].

With the introduction and cultivation of semi-dwarf, fertilizer-responsive, and non-inns moderate yielding varieties in the early 1970s, which was crucial to the "Green Revolution," rice production and productivity significantly improved [3]. The output and quality of rice, which is utilised for feed and industrial uses, were significantly improved by rice hybrids. If the management level is greater than 60%, hybrid rice growing is commercially viable. Hybrids are non-lodging, have considerable pest and disease resistance, are short-lived, respond well to stress and various climatic conditions, and have a longer shelf-life. Out of the 43 million hectares that are being grown for rice, 3 million of those are hybrids, according to Sarkar SC [4]. Because of the pressing need for high yielding rice types due to population growth, rice hybrids break yield barriers and produce 15-20% more.

Around 50% of farmed soils worldwide have low Zn concentrations during cereal-growing seasons [5]. Zn deficiency in plants is characterised by decreased membrane integrity, increased vulnerability to thermal stress, and decreased synthesis of auxin, chlorophyll, cytochromes, carbohydrates, and nucleotides.

A few of the Zn-containing enzymes that are inhibited include alkaline phosphatase, carbonic anhydrase, Cu-Zn-superoxide dismutase, phospholipase, carboxypeptidase, and RNA polymerase [6]. Zinc interacts with more than 500 different kinds of proteins. Chelated zinc (EDTA) Zinc sulphate heptahydrate, applied as a foliar fertiliser and in the soil, increased the zinc content of plant parts like hull, bran, white rice kernels, and straw [7]. Foliar fertilisation has a stronger effect on raising Zn concentration in rice than soil application, according to the rice crop's immediate response to nutrient treatment. The production of cereal and straw from different types of rice differed substantially when Zn was applied and when it wasn't. Grain yields of diverse rice kinds increased by 29% and 22% on average with soil + foliar and merely soil applications of Zn, respectively [8].

These factors were taken into consideration as the current study, "Foliar application of zinc on growth and yield in different varieties of rice (*Oryza sativa* L.) and yield validation using SPSS model", was carried out at the Kharif season of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh.

2. MATERIALS AND METHODS

At the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, the experiment was carried out during the Kharif of 2022. Which is situated 98m above mean sea level (SL) at 25.24' 42" N latitude, 81.50' 56" E longitude. Ten treatments, each replicated three times, were used in the experiment's Randomised Block Design. Each treatment's plot was 3m x 3m in size. There are three levels of zinc factors[ZnSo4 -0.2% (30,60 DAS), ZnSo4 -0.3% (30,60 DAS), ZnSo4 -0.4%

(30,60 DAS)], and three different rice verities (MTU-7029, BPT-5204, RNR-150480). The different levels of zinc supplied during 30 and 60 DAS. The Rice varieties were sown on 26 June 2022 by maintaining a spacing of 22.5 cm × 10 cm. Each plot was used for 1m2 of the harvest. Five plants were then at random chosen from it to record the yield and growth parameters. The treatment details are as follows, T_1 -(MTU-7029 + ZnSo4- 0.2%), T_2 -(MTU-7029 + ZnSo4- 0.3%), T_3 – (MTU-7029 + ZnSo4- 0.4%), T_4 -(BPT -5204 + ZnSo4- 0.2%), T_5 -(BPT -5204 + ZnSo4- 0.3%), T_6 -(BPT -5204 + ZnSo4- 0.4%), T_7 -(RNR15048 + ZnSo4- 0.2%), T_8 -(RNR15048 + ZnSo4- 0.3%), T_9 -(RNR15048 + ZnSo4- 0.4%), T_{10}-(N 120 Kg/ha + P 60 kg/ha +k 60 kg/ha) Control. Plant height, dry weight, number of tillers per hill, crop growth rate, number of panicles per hill, number of grains per panicle, test weight, grain yield, and straw yield were all observed. By using the analysis of variance approach, the data were statistically analysed [9].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height: At 100 DAS, treatment-9 (RNR-15048 + ZnSo4 - 0.4%) had the noticeably taller plant height (117.68 cm). However, statistically speaking, treatment-8 (RNR- 15048 + ZnSo4 - 0.3%) was comparable to treatment-9 (RNR-15048 + ZnSo4 -0.4%). Different zinc levels over the control had a substantial impact on plant height, a key growth metric. In comparison to the other treatments, plants at 0.4% were found to be noticeably taller. In comparison to the other treatments, plants at 0.4% were found to be noticeably taller. High levels of photosynthetic and hormonal activity led to meristematic growth in the apical region, which caused the plants to elongate sufficiently as a result of the application of Zn. According to Ghatak et al. [10] and Haque et al. [11], a significant contributing aspect is the genetic makeup of the variety. The synchronised availability of all important plant nutrients, particularly nitrogen for a longer period during growth phases, may also contribute to an increase in plant height [12].

Number of tillers/hill: At 80DAS, Treatment-9 (RNR-15048 + ZnSo4 - 0.4%) had the considerably larger number of tiller/hill (16.72) than the other treatments. However, statistically speaking, treatment-8 (RNR-15048 + ZnSo4 - 0.3%) was comparable to treatment- 9 (RNR-15048 + ZnSo4 -0.4%). The application of zinc may be the cause of the much more tillers per hill. The dynamics of zinc in soil may have been improved by zinc-enriched urea and Zn-FYM incubation to extend its availability for enhanced rice growth and tillering. Superiority of Zn-EDTA. Gangloff *et al*. [13]. Additionally, the likely cause of high tillering capacity in high yielding varieties. Yadav et al. [1] similarly reported similar results. According to Wang et al. [14], the heterogeneity in individual tiller yields was caused by the uneven distribution of photo- synthetic active radiation (PAR), in which the early-emerging superior tillers took priority over the light source at the top and shaded the later-emerging tillers in low-light situations.

Dry weight/plant: Treatment 9 (RNR-15048 + ZnSo4 - 0.4%), which had the significantly greater plant dry weight (55.47 gm), was the one that was noticed. However, statistically speaking, treatment-8 (RNR-15048 + ZnSo4 -0.3%) was comparable to treatment-9 (RNR- 15048 + ZnSo4 -0.4%). Chlorosis, decreased or absent tillering, a slower rate of crop maturity, and increased spikelet sterility are all symptoms of severe zinc deficiency in rice. Zinc insufficiency is linked to calcareous soils in lowland rice-growing regions and is exacerbated by protracted flooding. Slaton et al. [15] observed a positive dry matter production response to Zn treatment. Additionally, the rate of photosynthesis and respiration determines how much dry matter accumulates at a given time, which in turn affects how quickly plants grow in terms of their height, leaf area, tillers/hills, etc. As a result, Kumar [16] also noted that the treatment that had the highest growth also gathered more dry matter.

3.2 Yield

Number of panicles/hill: The significant and higher number of panicles/hill (10.01) were observed in treatment-9 with (RNR-15048 + ZnSo4 - 0.4%), which was significantly superior over rest of thetreatments. However, treatment-8 (RNR-15048 + ZnSo4 - 0.3%), was found to be statistically at par with treatment-9 (RNR-15048 + ZnSo4 - 0.4%). An adequate Zn supply may have increased the delivery of other nutrients and spurred the growth of the entire plant, which could explain why there were more panicles/hills. Many earlier researchers, including Veeranagappa [17], have also reported an increase in panicles per square metre. The advantage of hybrid rice may also be that it grows long roots and broad leaves, which allow it to absorb more nutrients and yield more grains. It is appropriate for the local climate, particularly during the grain-filling stage of panicle development. Bhuiyan et al. [18] reported similar outcomes as well.

Number of seeds/pod: The significant and higher number of seeds/pod (1.94) were observed in treatment-9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (RDP 40 kg/ha+ Sulphur 20 kg/ha), was found to be statistical at par with treatment-9 (RDP 40 kg/ha+ Sulphur 30 kg/ha). The significant rise in seed/pod production could be attributed to enhanced phosphorus fertilisation, which ensures the availability of other plant nutrients, increasing carbohydrate buildup and their re-mobilization to the plant's reproductive organs, which are the closest sink. Because phosphorus is known to promote flowering and fruiting, the plants may have been stimulated to produce more pods on each plant and more seeds per pod. Shah et al. [8] reported similar results.

Number of grains/panicle: The significant and higher number of grains/panicles (141.37) were observed in treatment-9 with (RNR-15048 + ZnSo4 - 0.4%), which was significantly superior over rest of thetreatments. However, treatment-8 (RNR-15048 + ZnSo4 - 0.3%), was found to be statistically at par with treatment-9 (RNR-15048 + ZnSo4 - 0.4%). The increase in the number of grains panicle-1 may have been caused by its stimulation of physiological processes, including photosynthesis, the movement and assimilation of photosynthetic material, and the formation of more spikelets during the spikelet initiation process, all of which led to a greater number of grains/panicle. These conclusions concur with those made by Muhammad et al. [19].

Test Weight (g): Treatment 9 with (RNR-15048 + ZnSo4 - 0.4%) had the considerable and higher test weight (22.27 gm), making it significantly better than the other treatments. Nevertheless, it was discovered that treatment-8 (RNR-15048 + ZnSo4 - 0.3%) was statistically equivalent to treatment-9 (RNR-15048 + ZnSo4 - 0.4%). Higher rates of photosynthetic activity and assimilate translocation during the post-flowering phase may have contributed to an increase in the number of grains in panicle-1, improved panicle weight, and higher grain weight per panicle. These outcomes support the conclusions made by Naik and Das [20].

Grain Yield (t/ha): The significant and higher grain yield (6.43 t/ha) was observed in treatment-9 with (RNR-15048 + ZnSo4 - 0.4%), which was significantly superior over rest of thetreatments. However, treatment-8 (RNR-15048 + ZnSo4 - 0.3%), was found to be statistically at par with treatment-9 (RNR-15048 + ZnSo4 - 0.4%). The greatly increased grain output could be attributed to zinc. Zn treatments may have contributed to the enhanced grain output of rice by starting the early emergence of panicles, which may have allowed for more assimilate storage in rice grains. Khan and others [21]. Additionally, the extended yield characteristics are likely the result of an extended boom and improvement parameters, which ultimately led to an extended grain. These outcomes are in line with Yatheesh Kumar et al. [3].

Straw Yield (t/ha): The significant and higher stover yield (12.11 t/ha) was observed in treatment-9 with (RNR-15048 + ZnSo4 - 0.4%), which was significantly superior over rest of the treatments. However, treatment-8 (RNR-15048 + ZnSo4 - 0.3%), was found to be statistically at par with treatment-9 (RNR-15048 + ZnSo4 - 0.4%). Zn application increased vegetative development, which was reflected in greater accumulation of dry matter and grain yield per pot. This may have occurred as a result of Zn's involvement in metabolic, hormonal, and photosynthetic processes. Higher straw yield was obtained as a result of stimulating vegetative growth. Ghatak and others [10]. The research by Padmavathi from [22] also supports the idea that hybrid rice has the capacity to use more nitrogen through the expression of superior growth brought about by the favourable influence on nutrient uptake and physiological growth increase straw yield [23,24].

3.3 SPSS Model Validation

Predicted Yield through SPSS Model (t/ha): In comparison to all treatments had the same predicted yield.

Obtained Yield in Experiment (t/ha): Obtained yield in Experiment (6.43 t/ha) was found to be highest in treatment -9 (RNR-15048+ZnSo4-0.4) as compared to other treatments.

Percentage Increased Over Predicted Yield (%): Percentage Increased Over Predicted Yield (55.21%) was found to be highest in treatment -9(RNR-15048+ZnSo4-0.4) as compared to other treatments.

Table 1. Influence of foliar application of zinc on growth parameters of different rice varieties

S. No.	Treatment combinations	Plant height	Number of tillers/hill	Plant Dry weight
1.	MTU-7029 + ZnSo4- 0.2%	108.88	14.25	47.58
2.	MTU-7029 + ZnSo4- 0.3%	109.37	14.51	48.48
3.	MTU-7029 + ZnSo4- 0.4%	111.73	15.17	49.55
4.	BPT -5204 + ZnSo4- 0.2%	111.23	15.54	51.30
5.	BPT -5204 + ZnSo4 - 0.3%	113.27	15.55	52.13
6.	BPT -5204 + Znso4 - 0.4%	116.41	16.27	53.88
7.	RNR15048 + ZnSo4- 0.2%	115.99	14.60	54.21
8.	RNR-15048 + ZnSo4- 0.3%	116.91	15.48	54.97
9.	RNR-15048 + ZnSo4 - 0.4%	117.68	16.72	55.47
	F test	S	S	S
	S Em.(±)	0.29	0.25	0.33
	CD (P=0.05)	0.88	0.76	0.99

Table 2. Influence of foliar application of zinc on yield and yield attributes of different rice varieties

S. No.	Treatment combinations	No. of Panicles/hill	No. of Grains/panicle	Test weight	Grain yield (t/ha)	Straw yield (t/ha)
1.	MTU-7029 + ZnSo4- 0.2%	7.55	120.56	19.08	5.06	9.67
2.	MTU-7029 + ZnSo4- 0.3%	8.36	126.20	19.67	5.31	9.90
3.	MTU-7029 + ZnSo4- 0.4%	8.57	131.78	20.02	5.56	10.09
4.	BPT -5204 + ZnSo4- 0.2%	7.72	127.65	19.66	5.30	9.83
5.	BPT -5204 + ZnSo4 - 0.3%	8.67	132.04	20.29	5.76	10.29
6.	BPT -5204 + Znso4 - 0.4%	9.08	135.72	21.06	6.16	11.06
7.	RNR15048 + ZnSo4- 0.2%	7.89	132.00	21.42	5.84	10.19
8.	RNR-15048 + ZnSo4- 0.3%	9.37	136.32	22.03	6.19	11.57
9.	RNR-15048 + ZnSo4 - 0.4%	10.01	141.37	22.27	6.43	12.11
	F test	S	S	S	S	S
	S Em (±)	0.23	1.98	0.21	0.07	0.22
	CD (P=0.05)	0.68	5.92	0.62	0.24	0.67

Fig. 1. Photograph showing field investigation at the crop research farm

Table 3. Yield validation using SPSS model

S. No.	Treatments	Predicted yield through SPSS Model(t/ha)	Obtained yieldin Experiment(t/ha)	Percentage increase overpredicted yield (%)
1.	MTU-7029 + ZnSo4- 0.2%	2.88	5.06	43.08
2.	MTU-7029 + ZnSo4- 0.3%	2.88	5.31	45.76
3.	MTU-7029 + ZnSo4- 0.4%	2.88	5.56	48.20
4.	BPT -5204 + ZnSo4- 0.2%	2.88	5.30	45.20
5.	BPT -5204 + ZnSo4 - 0.3%	2.88	5.79	50.26
6.	BPT -5204 + Znso4 - 0.4%	2.88	6.16	53.25
7.	RNR15048 + ZnSo4- 0.2%	2.88	5.84	50.68
8.	RNR-15048 + ZnSo4- 0.3%	2.88	6.19	53.47
9.	RNR-15048 + ZnSo4 - 0.4%	2.88	6.43	55.21

4. CONCLUSION

It was determined that the variety RNR-15048 (Treatment-9) performed well after receiving Zinc 0.4% application, which enhanced growth and yield characteristics. With the application of Zinc 0.4% on the variety of RNR-15048 (Treatment-9), maximum predicted yield through SPSS Model, Obtained yield in Experiment, percentage Increased Over Predicted Yield were also noted. Further studies may be necessary to confirm these results since they are based on only one season.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/99083