International Journal of Plant & Soil Science

Volume 35, Issue 13, Page 33-42, 2023; Article no.IJPSS.100044
ISSN: 2320-7035

Influence of Varieties and Foliar Application of Zinc on Growth, Yield and Economics of Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i132984

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/100044

Original Research Article

Received: 08/03/2023
Accepted: 11/05/2023
Published: 15/05/2023

ABSTRACT

A field experiment was conducted during Kharif 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P) to determine the "Influence of Varieties and Foliar application of Zinc on Growth , Yield and Economics of Rice (*Oryza sativa* L.)". The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha) and K (240.7 kg/ha) and the treatments consisted of 3 different Zinc viz. (0.5%), (1.5%) and (2.5%) with combination of 3 Varieties viz. BPT5204, RNR15048, and KNM118. The experiment was laid out in RBD with 9 treatments each replicated thrice The results showed that treatment 9 [BPT5204+ Zinc(2.5%)] recorded significantly higher plant height (113.77 cm), , maximum number of tillers/hill (12.80), higher plant dry weight (54.13g),maximum number of effective tillers/hill (12.50) ,maximum number of panicles/plant (10.20),maximum number of

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grains/panicle (104.70), higher test weight (18.70 g), higher grain yield (5.81 t/ha), maximum straw yield (5.92 t/ha) and higher harvest index (50.19 %) compare to other treatment. The maximum gross returns (1,62,773.00 INR/ha), net return (1,10,546.50 INR/ha) and highest benefit cost ratio of (2.12) was recorded.

Keywords: Rice; varieties; zinc; growth; yield; economics.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most consumed cereal grain in the world, constituting the dietary staple food of more than half of the world population and referred to as “Global grain”. The theme on rice as “Rice is life” was used for international year of rice 2004, denoting its overwhelming importance as an item of food and commerce by the United Nations. “Globally, 1.4 billion ha of cultivable land is available. In rice growing countries, India has the largest area under rice in the world” [1]. “It is tropical plant ,it flourishes comfortably in hot and humid climate. It is fundamentally a kharif crop in India. It demands temperature of around 25 degree Celsius and above and rainfall of more than 100cm. It is also grown through irrigation in those areas that receives comparatively less rainfall. In India, states located in the Eastern and Southern parts cultivate the majority of rice. West Bengal is the leading rice producer in India which is followed by Uttar Pradesh, Telangana, Andhra, Punjab, Orissa, Bihar, Chhattisgarh, Tamil Nadu, Assam and Haryana” [2] . “The starch content of the rice plant is generally low during the early growth stages and increases toward flowering. Generally, before flowering, the starch accumulates in the leaf sheath and culm, but after flowering, it accumulates in the panicle. Much of the starch accumulated in the leaf sheath and culm before flowering is translocated into the grains during ripening. Carbohydrates produced by photosynthetic tissues is either transported to other organs as soluble sugars, or accumulated in leaves as soluble sugars and starch during the different growth stages. Soluble carbohydrates and starch, which accumulates under normal conditions before the stress commonly, constitute the main resources for plants to supply energy during stress condition” [3].

“Rice ranks first in area and second in terms of production after china and is grown in all most tropical and sub humid regions of different countries .Globally, rice covers an area about 878 Million hectares with production of 898 Million tonnes and the productivity of 3348 kg/ha” [4]. “In India , rice grown cover an area about 43.78 million hectares with production of 118.43 million tonnes and productivity of 2708 kg/ha under 2019-2020 , During 2019-2020 total area coverage under rice in Uttar pradesh was 5.74 lakh hectare with the production of 13.11 lakh tonnes and productivity of 2704kg/ha” [5]. “According to government third advance estimates rice production in 2020-2021 is 121.46 Million tonnes" [6].

“Zinc is the most commonly deficient micronutrient in agricultural soils. Analysis of over 256,000 soil samples from all over India showed that about 50% of the soils were deficient in zinc and it causes leaf bronzing and poor tillering at the early growth stages, leading to delayed maturity and significant yield loss ,Its main cause of deficiency of plant available Zn in soil is the precipitation or adsorption of Zn with various soil components, depending on the pH and redox potential” [7]. “Zinc is one of the most essential micronutrients required for the growth and development of plant and human beings. One-third of the human population, including children and women suffer from Zn deficiency related health problems such as growth retardation, lack of appetite, lack of immune function, hair loss, diarrhoea, vision, and skin lesions, weight loss, delayed healing of wounds, and mental lethargy , The lack of micronutrients has become the major nutritional problem affecting more than two billion people in both developed and developing countries of Asia, Africa and Latin America. Micronutrient deficiencies or "hidden hunger" affects approximately 38% of pregnant women and 43% of preschool children worldwide and the most widespread among developing countries” [8].

RNR 15048 (Telangana Sona) is the widely recognized for its super fine quality (short slender) of good cooking quality with grain yield of 6.5-7.0t/ha and high milling recovery (68-70%). *Kharif* duration:110-120 days ,*Rabi* :125-130 days. It is said to be resistant to blast and tolerant to BPH nearly saving Rs. 2000 to 3000 per acre expenditure on plant protection.

KNM 118 (Kunaram sannalu) is the rice a good alternate variety to mega rice variety, MTU 1010 as it exhibits high yield potential (7-8 t/ha) with good test weight, and is less prone to grain shattering and lodging at the time of harvest when compared to MTU 1010. This variety can attain plant height of 100-106 cm with *Kharif* duration of 120-125 days, and *Rabi* :125-130 days. It is suitable for *kharif,* late *kharif* and *rabi* seasons. This variety has tolerance to leaf blast and neck blast.

BPT 5204 (Samba Masuri) is medium slender type and is semi dwarf variety suitable for rainfed shallow low lands in the country in the Crop duration is 135-140 days and is suitable for *kharif* and *Rabi* seasons. The yield potential of BPT 5204 is 5.5-6.0 t/ha. This variety is resistant to neck blast and tolerant to gall midge and is non-lodging and non-shattering type.

"Zinc is an essential micro nutrient for crop plants. Zn is essential for several biochemical processes in rice plant, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation and membrane integrity. Zn- enrichment leads to more root surface area and the ability to change chemistry and biology of rhizosphere by releasing phytosiderophores from roots which ultimately increases Zn uptake by plants" [9]. "zinc is major component and activator of several enzymes involved in metabolic activities , its deficiency continues to be one of the key factors in determining rice production in several parts of country" [10] . "Foliar application of zinc usually applied under emergencies to save the crops to symptoms of Zn appear ,single foliar application may not be adequate to severe deficiency symptoms , foliar application of 0.5% aqueous solution of $Znso_4$ twice at 20 and 30 days after transplanting" [11] . Keeping in view the above fact, the experiment was conducted to find out Influence of Varieties and Foliar spray of Zinc on Growth , Yield and Economics of Rice "(*Oryza sativa* L.)"

2. MATERIALS AND METHODS

The experiment was conducted during *Kharif* season of 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha) and K (240.7 kg/ha). The treatment consisted of 3 different Zinc *viz.* (0.5%), (1.5%) and (2.5%) with combination of 3 Varieties *viz*. BPT5204, RNR15048, and KNM118. The experiment was laid out in RBD with 9 treatments each replicated thrice. The treatment combinations were as follows: Treatment 1[RNR 15048 + zinc (0.5%)], Treatment 2 [RNR 15048 + zinc(1.5%)], Treatment 3[RNR 15048 + zinc (2.5%)], Treatment 4 [KNM 118 + zinc (0.5%)], Treatment 5 [KNM 118 + zinc (1.5%)], Treatment 6 [KNM 118 + zinc (2.5%)], Treatment 7 [BPT 5204 + zinc (0.5%)], Treatment 8 [BPT 5204 + zinc (1.5%)], T 9 [BPT 5204 + zinc (2.5%)]. Data was collected on growth parameters [Plant height (cm) , Number of tillers/hill , Plant dry weight (g), Crop Growth Rate (g/m^2/day)], yield attributes [number of effective tillers/hill, number of panicles/plant, number of grains/panicle, grain yield(t/ha) ,straw yield(t/ha),harvest index(%)] and data were subjected to statistical analysis of variance method [12].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height (cm): Plant height (113.77 cm) was significant for treatment 9 [BPT5204 + (Zinc 2.5%)] (Table 1). This could be due to variation in varietal genetic makeup and , its adaptation to the environment. Similar results were reported by Kiran et al. [1]. "Further, in higher plant height with application of zinc (2.5%) may be due to adequate supply of zinc which contributed to accelerate enzymatic activity and auxin metabolism in plants" as reported by Khan et al. [13].

Number of tillers/hill: The results showed significant differences in maximum number of tillers/hill (12.80) which was recorded in treatment 9 [BPT5204 + Zinc (2.5%)]. However, treatment 4 [KNM118 + (Zinc 0.5%)] was found to be statistically at par with treatment 9 (Table 1). The significant and Maximum number of tillers / hill was observed with the variety (BPT5204) might be due to genetic character. The difference in growth attributes indicated that all rice varieties respond differently to the applied nutrient in uptake and use efficiency and results agree with those reported by Pratap et al. [14]. "Further, increase in tiller/hill with application of zinc (2.5%) may be due to its application attributed to its role in various enzymatic activity and auxin

metabolism which control growth of plant" as. reported by Singh et al. [15].

Plant dry weight (g): Data showed significant differences in plant dry weight (54.13 g) which was recorded in the treatment 5 [KNM 118 + (Zinc 1.5%)]. However, treatment 8 [BPT 5204+(Zinc 1.5%)] was found to be statistically at par with treatment 5 [KNM 118 +(Zinc 1.5%)] (Table 1).The Significance and might be due to their varietal genetic potential, The uptake of nutrients , competition for space, light, nutrients and differential plant height and agrees with findings by Patil et al. [16]. "Further increased in plant dry weight with the application of zinc (2.5%) may due to important role of zinc for the activation of various types of enzymes ,such as hose required for the Co_2 assimilation pathway and chlorophyll biosynthesis" as reported by Suvarna et al. [9].

Crop Growth Rate (g/m^2/day): The data recorded that significant and higher crop growth rate (7.95 g/m^2/day) was recorded in treatment 7 [BPT5204 +(Zinc 0.5%)]. However, treatment 4 [KNM 118 +(Zinc 0.5%)] was found to be statistically at par with treatment 9 [BPT5204 +(Zinc 2.5%)] (Table 1). The significant and higher crop growth rate was recorded with application of zinc (2.5%) might be due to it is function of combined effects of genetic makeup of plant, soil nutrient status, seedling vigor and environmental conditions under which it is grown, resulted increased in crop growth rate of the plant. Similar results were reported by Mustafa et al. [17].

3.2 Yield Attributes and Yield

Number of effective tillers/hill: The data showed significant differences in number of effective tillers/hill (12.50) and was recorded in the treatment 9 [BPT5204 + zinc (2.5%)] .However, treatment 4 [KNM118 + (zinc 0.5%] was found to be statistically at par with treatment 9 [BPT5204 + (zinc 2.5%)] (Table 2). The significance is attributed to varietal character and adequate availability of photosynthates under transplanted system of cultivation, good maintenance of source sink relationship due to longer reproductive phase. Similar results were also reported by Maniraj et al. [18]. "This could also be due to application of zinc (2.5%) resulted in well developed root system. The sufficient nutrition of zinc growth promoting substance like auxin in plant is produced and that may increase the overall growth of the plant" as reported by Sardar et al. [19].

Number of panicles/plant: The data showed significant differences in the maximum number of panicles/plant (10.20) and was recorded in the treatment 9 [BPT5204 + zinc (2.5%)]. However, treatment 8 [BPT5204 + (zinc 1.5%)] was found to be statistically at par with treatment 9 (Table 2). The significance could be due to increased accumulation of photosynthetic products from the source to the sink and the differences in growth characters due to genotypes differences. Similar results were reported by Dangi et al. [20]. "Zinc (2.5%) which add value in biosynthesis of indole acetic acid (IAA) and its role in initiation of primordial reproductive parts and partitioning of photosynthates towards them are responsible for increased in panicles/plant" as reported by Ram et al. [21].

Number of grains/panicle: The data showed significant differences in number of grains /panicle (104.70) which was recorded in the treatment 9 [BPT5204 + zinc (2.5%)] (Table 2). The significance might be due to efficient utilization of growth resources, less intra species competition coupled with higher availability of nutrients among the widely spaced crop plants may be ascribed the reason for superiority in increasing of grains/panicle as reported by Rahem and Marzoka, [22]. Further increase in number of grains/panicle with application of zinc (2.5%) may be due to it is synthesizer of protein and carbohydrate resulted into bolder seeds and increased more number of grains/panicle as reported by Singh et al. [23].

Test weight (g): Significant differences in test weight (18.70 g) was recorded in the treatment 9 [BPT5204 + zinc (2.5%)]. However, treatment 7 [BPT5204+ (zinc 0.5%)] was found to be statistically at par with treatment 9 (Table 2). The significance in the test weight was recorded in variety (BPT5204) could be due to better growth and translocation of photosynthates to reproductive parts, which might have increased grain weight of the plant as reported by Singh et al. [2]. High level application of zinc (2.5%) the micronutrient involved in several physiological processes including protein synthesis, enzyme activation, carbohydrates metabolism, auxins, lipids, and nucleic acids, resulted in increased test weight. Similar results were reported by Sayed et al. [24].

Table 1. Influence of Varieties and Foliar spray of Zinc on growth parameters of rice

Sl. No.	Treatments	Plant height(cm)	Number oftillers/hill	Plant dry weight (g)	Crop growth Rate (g/m^2/day)	Relative growth rate(g/g/day)
		AT 100 DAT	**AT 100 DAT**	**AT 100 DAT**	**80 – 100 DAT**	**80 – 100 DAT**
1	RNR 15048 +Zinc 0.5%	106.07	11.50	47.95	6.05	0.0017
2	RNR 15048 +Zinc 1.5%	106.17	10.80	49.06	7.27	0.0020
3	RNR 15048 +Zinc 2.5%	106.97	11.20	48.69	7.78	0.0021
4	KNM118 +Zinc 0.5%	104.20	12.23	50.51	6.77	0.0018
5	KNM 118 +Zinc 1.5%	103.77	11.60	54.13	2.63	0.0006
6	KNM 118 +Zinc 2.5%	107.83	12.30	50.03	6.73	0.0018
7	BPT 5204 +Zinc 0.5%	108.70	12.12	49.30	7.95	0.0022
8	BPT 5204+Zinc 1.5%	110.77	12.56	53.51	6.17	0.0015
9	BPT 5204+Zinc 2.5%	113.77	12.80	53.14	5.12	0.0012
	Mean values					
	F test	**S**	**S**	**S**	**S**	**S**
	SE(m)±	0.85	0.80	0.07	0.16	0.0038
	CD (p=0.05)	2.54	1.18	0.22	0.50	0.0012

Table 2. Influence of Varieties and Foliar spray of Zinc on yield attributes and yield of rice

Sl No.	Treatments	Number of effective tillers/hill	Number of panicles/plant	Number of grains/panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1	RNR 15048 +Zinc 0.5%	11.0	8.00	96.50	13.77	4.46	5.34	45.48
2	RNR 15048 +Zinc 1.5%	10.29	8.67	97.50	13.60	4.56	5.44	45.63
3	RNR 15048 +Zinc 2.5%	10.12	8.67	96.17	13.73	5.11	5.47	48.30
4	KNM118 +Zinc 0.5%	11.54	7.67	94.73	15.30	4.85	5.49	46.94
5	KNM 118 +Zinc 1.5%	11.27	8.67	98.70	15.57	5.52	5.52	49.98
6	KNM 118 +Zinc 2.5%	10.57	8.33	98.47	15.60	5.59	5.65	49.73
7	BPT 5204 +Zinc 0.5%	11.58	8.78	99.10	18.60	5.67	5.63	49.55
8	BPT 5204+Zinc 1.5%	12.0	9.34	101.8	18.63	5.69	5.67	50.10
9	BPT 5204+Zinc 2.5%	12.50	10.20	104.70	18.70	5.81	5.92	50.19
	Mean values							
	F test	S	S	S	S	S	S	S
	SE(m)±	0.45	0.36	0.26	0.14	0.07	0.14	0.27
	CD (p=0.05)	1.08	1.06	0.78	0.40	0.24	0.13	0.79

Table 3. Influence of Varieties and Foliar spray of Zinc on the economics of rice.

Sl. No	Treatment combinations	Economics			
		Cost of cultivation	Gross return	Net return	B:C Ratio
1.	RNR 15048 +Zinc 0.5%	51,727.50	1,24,787	73,059	1.41
2.	RNR 15048 +Zinc 1.5%	51,727.50	1,27,773	76,046	1.47
3.	RNR 15048 +Zinc 2.5%	51,977.50	1,43,080	91,353	1.77
4.	KNM 118 +Zinc 0.5%	51,977.50	1,35,893	83,916	1.61
5.	KNM 118 +Zinc 1.5%	51,977.50	1,54,467	1,02,489	1.97
6.	KNM 118 +Zinc 2.5%	52,227.50	1,56,520	1,04,543	2.01
7.	BPT 5204 +Zinc 0.5%	52,227.50	1,58,760	1,06,533	2.04
8.	BPT 5204+Zinc 1.5%	52,227.50	1,59,320	1,07,093	2.05
9.	BPT 5204+Zinc 2.5%	51,707.50	1,62,773	1,10,546	2.12

Grain Yield (t/ha): The data revealed that significantly highest grain yield (5.81 t/ha) was recorded in the treatment 9 [BPT5204 + zinc (2.5%)] (Table 2).The significant and higher grain yield was recorded with the variety (BPT5204) might be due to greater vegetative growth and better light interception and higher dry matter portioning towards economic part, yield variability among rice cultivars also attributed to genetic characters and environmental effects .Similar results were reported by Kumar et al. [25]. Further increased in grain yield with application of zinc (2.5%) may due to fertilization is attributed to its involvement in many metallic enzyme system, regulatory functions and auxin production enhanced synthesis of carbohydrates and their transport to the site of grain production. Similar results were reported by Muthukumararaja et al. [10].

Straw Yield (t/ha): The data showed that significantly Maximum straw yield (5.92 t/ha) was recorded in the treatment 9 [BPT5204 + zinc (2.5%)] (Table 2). The significant and Maximum straw yield was recorded with the variety (BPT5204) might be due to higher photosynthetic rate as a result of enhanced LAI, which in turn boosted dry matter formation ,resulting in higher grain yield and straw yields. Similar results were reported by Maurya et al. [26]. Further increased in straw yield with application of zinc (2.5%) may due to it is attributed to adequate supply of zinc that might have increased the availability and uptake of other essential nutrients resulting in improvement in metabolic activities and also due to the effect of zinc on the proliferation of roots. Similar results were reported by Zinzala et al. [7].

Harvest Index (%): Data showed significant differences in harvest index (50.19 %) recorded in treatment 9 [BPT5204 + zinc (2.5)]. Treatment 6 [KNM118 + (zinc 2.5%)] recorded (50.1%) was found to be statistically at par with treatment 9 (Table 2). The significance in harvest index might be due to adequate and available water at reproductive stages during experimentation and this agrees to the findings of Soriano et al. [27]. Who reported that where irrigation system is flooded until ripening stage, results in increased harvest index. Similarly the application of zinc at (2.5%) contributed to the greater translocation of photosynthates from source to sink and better portioning towards reproductive growth as reported by Saikh et al. [28].

3.3 Economic Analysis

Economics: The result showed maximum gross returns (1,63,120.00 INR/ha), maximum net return (1,10,893.50 INR/ha) and highest benefit cost ratio (2.12) against treatment 9 [BPT5204 + zinc (2.5%)] as compared to other treatments (Table 3). A maximum gross return, net returns and benefit cost ratio was recorded with the application of zinc (2.5%). Similar results were reported by Bareddy et al. [29] essential plant nutrient and its involvement in the physiological process when well pronounced result in an increase in both grain and straw yield and ultimately increased benefit cost ratio [30,31].

4. CONCLUSION

Based on above findings it can be concluded that combination of BPT5204 along with Zinc (2.5%) has performed better in growth parameters and yield attributes of rice and also proven profitable.

ACKNOWLWDGEMENT

The authors are thankful to Department of Agronomy, Naini Agricultural Institute, Prayagraj, Sam Higginbottom University of Agriculture Technology And Sciences, (U.P) India for providing necessary facilities to undertaken the studies .

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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