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Effect of Nitrogen and Zinc fertilization on Growth and Yield of Hybrid Rice (*Oryza sativa* L.)

Pragya Bharti[1]*, Umesha C.[1] and Prashant Kumar[2]

[1]Department of Agronomy, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India
[2]Krishi Vigyan Kendra, Siwan, Dr RPCAU, Pusa, Bihar, India

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ABSTRACT

In order to investigate how nitrogen and zinc affect the growth and yields of hybrid rice field trial was carried out during the *kharif* of 2022 at the CRF, Naini Agricultural Institute, SHUATS, Prayagraj (UP). A randomized block design (RBD) was used to set up the experiment, which consisted of three replications and nine different nitrogen and zinc treatment combinations. The results of the experiment showed that the hybrid rice's growth characteristics were significantly increased by the application of nitrogen (175 kg ha^{-1}) and Zinc (25 kg ha^{-1}), as compared to other nitrogen and zinc combination treatments. Similarly, the above quoted treatment yielded higher gross return (1,24,828 Rs ha^{-1}), higher net return (78,890.18 Rs ha^{-1}) and higher B:C ratio (1.72).

Key words: *Plant, Growth parameters, Hybrid Rice, Nitrogen, Yield attributes, Zinc.*

Introduction

Rice's international reputation is growing in tandem with population growth, rising levels of affluence, and dietary trends. Global production of food will need to increase more than 40 % by 2030 and 70 % by 2050, according to UNFAO projections. (FAO, 2017). In order to meet the growing population's needs, the goal is to quadruple rice production in India by 2025, as well as in a number of other distinct Asian worldwide locations. India leads in the world rice production, with an output of 112.901,000,000 tonnes, 43.79 million-hectare area, and a productivity of 2.572 t ha^{-1} (Directorate of Economic and Statistics 2017-2018). Cereals are a vital part of the global diet, due to population growth. Wheat, rice, and maize make for over half of all calories consumed globally (Gnanamanickam, 2009). Although rice ranks second in terms of planted area, It is a crucial component of the food supply for Asian countries, especially in the south-east, where it is cultivated on millions of hectares of land and is a profitable crop (Gomez, 2001).

N is an essential component for the growth and metabolic processes of rice. in terms of yields and growth, to increase the performance of each variety of rice, it is essential to assess the efficacy and optimal rate for various treatment levels before prescribing a nitrogen fertilizer dose for every crop (Noor, 2017). Several rice regions around the world use a prescribing approach based on common models that ignores site-specific crop yields when proposing Nitrogenous fertiliser to comply with the N requirements. (Vennela *et al.*, 2023; Noor, 2017). Effective use of Nitrogenous chemical fertilizers by culture and agriculture can be achieved. The most effective way to reduce the risk of soil-water contamination due to low N inputs is to breed cultivars with the highest nitrogen use efficiency (Noor, 2017; Fageria *et al*., 2008; Pandit *et al.,* 2021). By using the right amount of N, you can maintain safety while saving money.

According to Quijano-Guerta *et al*., (2002), Zinc is the 2nd greatest nutrient in rice, after N. Zn is involved in a variety of processes, including energy loss, auxin metabolism, chlorophyll production, and protein synthesis. In India, calcareous soils, where insoluble Zinc hydroxide and its carbonate are generated, account for 50% of zinc (Zn) deficient soils. It is possible to restore it by adding zinc to soil or spraying on leaves of the plant. Keeping the foregoing in mind, the experiments was design to determine the "Effect of Nitrogen and Zinc fertilization on Growth and Yield of Hybrid Rice (*Oryza sativa* L.)".

Materials and Methods

The field experiment was carried out at crop Research Farm, NAI, SHUATS, Prayagraj (UP) during the *Kharif* season 2022. The soil texture of the experimental field was classified as sandy loam, with a pH of 7.8, medium levels of organic carbon (0.61%), a low level of available Nitrogen (224 kg ha^{-1}), high levels of available phosphorus (37.8kg ha^{-1}), and medium level of available Potassium (239.9kg ha^{-1}). The treatment includes three nitrogen levels: 125, 150, and 175 kg ha^{-1}, as well as zinc levels of 15, 20, and 25 kg ha^{-1} the experiment was carried out with randomized block design with nine treatments and was reproduced three times. The treatment combinations were: T_1 Nitrogen (125 kg ha^{-1})+ Zinc (15 kg ha^{-1}), T_2 Nitrogen (125 kg ha^{-1}) + Zinc (20 kg ha^{-1}), T_3 Nitrogen (125 kg ha^{-1}) + (Zinc 25 kg ha^{-1}), T_4 Nitrogen (150 kg ha^{-1}) + Zinc (20kg ha^{-1}), T_5 Nitrogen (150 kg ha^{-1}) + Zinc (15 kg ha^{-1}), T_6 Nitrogen (150 kg ha^{-1}) + Zinc (25 kg ha^{-1}), T_7 Nitrogen (175 kg ha^{-1}) + Zinc (15 kg ha^{-1}), T_8 Nitrogen (175 kg ha^{-1}) + Zinc (20 kg ha^{-1}), T_9 Nitrogen (175 kg ha^{-1}) + Zinc (25 kg ha^{-1}). The plants were selected randomly from each plot and the growth, yield, and parameters under investigations were meticulously recorded, economics of cultivation were calculated and recorded data were subjected to statistical analysis at 5% degree of freedom following statistical procedure (Gomez and Gomez, 1976).

Results and Discussion

Growth parameters

Different treatment has had a significant impact on plant height, with ranging from 92.37 to 106.73 cm. It was observed that plant height was significantly higher and statistically at par in treatments where N was used at 150 or 175 kg ha^{-1} along with Zn dose of 15, 20 or 25 kg ha^{-1} (Treatment T_4 to T_9), while lowest plant height was observed in treatment T_1 Nitrogen (125 kg ha^{-1}) plus Zinc (15 kg ha^{-1}). Among the treatments T_4 to T_9, numerically higher plant height was observed in treatment T_9 with Nitrogen (175kg ha^{-1}) plus Zinc (25 kg ha^{-1}).

The number of tillers $hills^{-1}$ also significantly affected by different treatments and ranged from lowest of 13.06 in treatment T_1 to highest of 15.45 in treatment T_9. However, number of tillers $hills^{-1}$ in treatment T_9 were statistically equivalent to treatment T_5, T_6, T_7 and T_8.

Table 1. Effects of Nitrogen and Zinc fertilization on the growth Parameter of Hybrid Rice.

S. No.	Treatments combination	Plant height (cm)	Number of tillers $hills^{-1}$	Plant dry weight (g $Plant^{-1}$)	CGR (gm^{-2} day^{-1})
1.	N (125) + Zn(15) kg ha^{-1}	92.37	13.06	37.96	17.68
2.	N (125)+ Zn(20) kg ha^{-1}	94.82	13.09	38.86	18.79
3.	N(125) + Zn (25) kg ha^{-1}	95.27	13.23	40.87	18.87
4.	N(150) + Zn (15) kg ha^{-1}	98.91	13.26	42.63	19.35
5.	N(150) + Zn (20) kg ha^{-1}	99.13	14.22	43.76	19.41
6.	N(150) + Zn (25) kg ha^{-1}	101.35	14.59	46.35	19.63
7.	N (175) + Zn(15) kg ha^{-1}	104.44	14.60	48.01	20.43
8.	N (175) + Zn(20) kg ha^{-1}	105.38	14.77	48.77	21.60
9.	N(175) + Zn(25) kg ha^{-1}	106.73	15.45	49.38	23.16
	F-test	S	S	S	S
	Sem±	3.14	0.54	1.32	0.58
	CD(P=0.05)	9.42	1.62	3.95	1.75

The plant dry weight and CGR also showed similar trend among different treatments. plant dry weight and CGR ranged from 37.96 to 49.38 g and 17.68 to 23.16 gm^{-2} day^{-1}. Both these dry weights and CGR were lowest under treatment T_1 while these parameters were increased by 30 and 35% in treatment T_9.

The application of N and Zn in 9 treatments, which may have contributed to the growth parameters increase, has been found to enhance plant cell division and cell elongation (Hossain *et al.,* 2008). Additionally, by increasing amount of Nitrogenous that was available in the soil through the addition of Nitrogenous fertilisers, the soil's capacity for photosynthesis and leaf area increased, leading to a buildup of dry matter. The research of Rupp and Hubner, (1995) and Pramanik and Bera, (2012) is in agreement with these outcomes. High levels of hormonal and photosynthetic activity, along with meristematic growth in the apical region, may have been caused by Zn treatment to cause the plants to elongate sufficiently (Ghatak *et al*., 2005). The most important factor influencing yields is the number of tillers per square metre. The yield will increase with the quantity of tillers, particularly effective tillers. The increased availability of N, which was crucial for cell division, may have contributed to the more tillers there are per square metrein the current study. These findings are consistent with (Yoshida *et al*., 1972). The absorbed amount of nitrogen followed an increasing trend which can be corroborated with the increasing number of tillers (m^2) which was noticed. The amount of nitrogen absorbed during experimental trail (Gangloff *et al*., 2002). Balasubramaniyan and Palaniappan, (2005) findings also supported similar findings. A severe zinc shortage in rice results in spikelet sterility being increased, tillering being reduced or absent, and chlorosis. Zinc insufficiency is linked to calcareous soils in lowland rice-growing regions and is exacerbated by protracted flooding. Slaton *et al*., (2005) observed a positive dry matter production response to Zn treatment. The rise in all growth characteristics of hybrid rice due to application of Nitrogen and its crucial function in many metabolic events, including protein, nucleic acid, and chlorophyll production, as well as the involvement of zinc in the plant's N-metabolism, may have accelerated crop growth. (Puteh and Mondal, 2014) also revealed similar results.

Yield parameters

Except for the test weight of rice, other yield attributing parameters such as the number of panicles hills^{-1} and number of grains panicles^{-1} treatments had a significantly impact on grain yield, straw yield and harvest index. Number of panicle hills^{-1} ranged from 10.83 to 14.55 with lowest panicles hill^{-1} recorded under treatment T_1, while other treatments had significantly higher number of panicles hills^{-1}. The Number of panicles hills^{-1} were noticeably higher by around 35% in T_9 treatment compared to treatment T_1. Similarly, number of grains panicles^{-1} also showed similar trend among the different treatments and it was lowest (118.63) in treatment T_1 and increased by around 12% in treatment T_9.

The effect of N in cell division stimulation may have resulted in greater panicle production during the stage of rice production. the same results were

Table 2. Effects of Nitrogen and Zinc fertilization on the yield attributes of Hybrid Rice.

Sr. No.	Treatments	Number of panicles hill^{-1}	Number of Grains panicle^{-1}	Grain yield (t ha^{-1})	Test weight (g)	Straw yield (t ha^{-1})	Harvest index (%)
1.	N (125) + Zn(15) kg ha^{-1}	10.83	118.63	5.63	23.14	8.68	46.09
2.	N (125)+ Zn(20) kg ha^{-1}	10.86	119.17	5.92	23.24	9.23	46.24
3.	N (125) + Zn (25) kg ha^{-1}	11.20	120.20	6.09	23.60	9.34	46.27
4.	N (150) + Zn (15) kg ha^{-1}	11.30	120.73	6.34	23.65	9.51	46.33
5.	N (150) + Zn (20) kg ha^{-1}	11.31	121.11	6.36	24.03	9.51	46.50
6.	N (150) + Zn (25) kg ha^{-1}	11.76	121.60	6.46	24.30	9.53	47.40
7.	N (175) + Zn(15) kg ha^{-1}	11.83	122.99	6.63	24.81	9.98	48.96
8.	N (175) + Zn(20) kg ha^{-1}	13.20	127.36	6.73	25.06	10.01	50.82
9.	N (175) + Zn(25) kg ha^{-1}	14.55	132.83	6.92	25.19	10.16	51.09
	F-test	S	S	S	NS	S	S
	Sem±	0.61	1.83	0.19	-	0.21	1.2
	CD(P=0.05)	1.82	5.48	0.57	-	0.62	3.7

reported by Sorour *et al*., (2016). Further more, the increased number of panicles hills^{-1} this could be due to a sufficient supply of Zn, to boost the delivery of other nutrients, which in turn would have increased plant growth. Veeranagappa, (2010). Previous studies showed that the role of N in crop development, blooming and fruiting as well as seed formation could have led to an increased number of panicles m^{2}.

The various treatments did not significantly affect the test weight of hybrid rice grains, but treatment T_9test weight was numerically higher. As a result of the high sinking capacity in comparison to the limited corresponding source, because there was more grain filling, there was also more grain weight. Metwally *et al*. (2010) and Ghanbari-Malidareh, (2011) reported on the encouraging effects of N on (1000 grains-weight).

The grain and straw yield of hybrid rice ranged from 5.63 to 6.92 t ha^{-1} and 8.68 to 10.16 t ha^{-1}, respectively. and recorded lowest under treatment T_1 while all other treatments have significantly higher yields. On average, grain yield and straw yields of hybrid rice was increased by 23 and 18% in treatment T_9 as compared to treatment T_1. In addition, although the grain and straw yield was significantly higher under Treatment T_9, it was statistically equivalent to treatments T_4, T_5, T_6, T_7 and T_8. Because of such variations in grain and straw yield, harvest index also showed similar trend which ranged from 46.09% in treatment T_1 to 51.09% in treatment T_9.

At the Primary stage, there was a higher concentration of N and Zn, which encouraged more development and growth, a noticeably higher grain yield (6.92 t ha^{-1}) was seen. This may be due to a favourable interaction between zinc and nitrogen as well as the completion of the N and Zn need. These findings also support the conclusion reached by (Meena *et al*., 2017). It's possible that the early emergence of panicles, which would enable a more significant storage of assimilates in rice grains, stimulated the increase in rice grain production brought

Fig. 1. Overview of the Experimental Field

Fig. 2. Transplanting of rice crop in experimental field

Table 3. Effects of Nitrogen and Zinc fertilization on economic (INR) of Hybrid

S. No.	Treatments	Cost of Cultivation (Rs.ha^{-1})	Gross Return (Rs.ha^{-1})	Net Return (Rs.ha^{-1})	B:C ratio
1	N (125) + Zn(15) kg ha^{-1}	36857.45	91648	54790.55	1.49
2	N (125)+ Zn(20) kg ha^{-1}	38679.21	93856.42	55177.21	1.43
3	N (125) + Zn (25) kg ha^{-1}	41248.45	96923.88	55675.43	1.35
4	N (150) + Zn (15) kg ha^{-1}	41868.65	108936	67067.35	1.60
5	N (150) + Zn (20) kg ha^{-1}	42666.57	110920	68253.43	1.60
6	N (150) + Zn (25) kg ha^{-1}	42983.23	112584.02	69600.79	1.62
7	N (175) + Zn(15) kg ha^{-1}	44082.79	116602.34	72519.55	1.65
8	N (175) + Zn(20) kg ha^{-1}	44864.57	120965.34	76100.77	1.70
9	N (175) + Zn(25) kg ha^{-1}	45937.82	124828	78890.18	1.72

on by the Zn treatment (Khan *et al*., 2012). The addition of N directly affects the production of straw. Nitrogen is a crucial element for plant growth during the vegetative stage, which increases plant height, number of tillers per plant., Increase straw yield results from longer plants and more tillers. Joseph *et al*., (2005) produced similar work. Zn application increased vegetative growth, resulting in an accumulation of dry matter and a higher grain yield for each plot. This may have occurred as a result of Zn's involvement in metabolic, hormonal, and photosynthetic processes. Additionally, encouraging vegetative growth led to a higher production of straw (Ghatak *et al*., 2005).

Economic Analysis

Highest gross return (1,24,828.00 Rs ha^{-1}), net return (78,890.18 Rs ha^{-1}) and benefit cost ratio (1.72) was obtained in treatment-9 i.e., Nitrogen 175 kg ha^{-1} plus Zinc 25 kg ha^{-1} as compared to others treatments.

Conclusion

It can be inferred that the simultaneous application of nitrogen and zinc promotes hybrid rice growth and production. When applying nitrogen 175 kg ha^{-1} together with zinc 25 kg ha^{-1} resulted in highest gross return, net returned and B:C ratio indicating that this treatment combination can be suggested in soils where crop yields are limited by nitrogen and zinc deficit.

Future Scope

The results of the present research were only obtained after one year of experiments in the agro-ecological environments of Allahabad; therefore, additional years of experimentation may be required before they can be regarded as recommendations.

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Study Area /Sample Collection: CRF, Department of Agronomy, NAI, SHUATS, Prayagraj (UP).
Conflict of Interest: We declare that the work presented in this study has not been influenced by any known conflicts of interest.
Ethical Approval: In this Research article, no studies are conducted with human or animal subjects by any author.

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