

Influence of Phosphorus and Micronutrients on Growth and Yield of Rice
(*Oryza sativa* L.)

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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 Phosphorus and Micronutrients on growth and yield of Rice (*Oryza sativa* L.)”. The experiment was laid out in Randomized Block Design comprising of 10 treatments which include of three levels three Phosphorus viz @ 50,60 and 70 kg/ha. and three levels of micronutrients viz. Zinc @ 10kg/ha, Iron @ 15kg/ha and Boron @ 4 kg/ha. The results showed that treatment 7 [Phosphorus (70 kg/ha)+ Zinc(10 kg/ha)] recorded significantly higher plant height, number of tillers/hill, plant dry weight (g), number of panicles/plant, number of grains/panicle, test weight, grain yield, straw yield and harvest index.

Keywords: *Rice, Phosphorus, Micronutrients, Growth, Yield.*

Introduction

Rice is a major staple food of (70%) of Indian population, it provides (21%) and (15%) dietary protein and energy per capita, respectively [17] if Carbohydrate (starch), which is another material that offers rapid energy, is also extremely important. Starch-rich rice flour is used to make a variety of culinary products. In some cases, brewers use it to create alcoholic malt. Likewise, proclean, glass, and pottery are made from rice straw combined with other elements. In addition, rice is used to make paper pulp and bedding for animals.

The yield of the 165.12 million ha of rice grown globally is around 4.61 metric tons/ha, and the total production is 509.42 million tonnes [31]. India has the largest rice-growing area and is the second-largest producer of rice in the world, after the wheat. Rice is grown on 45.07 million ha in India, with a yield of roughly 2713 kg/ha and a production level of 122.27 million metric tonnes [10]. The state of Uttar Pradesh is third in the country for rice production. It occupies an area of 5.68 million hectares and contributes to 13.5% of all the rice produced in India. 15.66 million metric tonnes of rice are grown annually, with a yield average of 2759 kg/ha [10].

One of the major problems to crop production is a phosphorus deficiency. Due to slow diffusion and strong soil fixation, P has a special property that makes it limited. After nitrogen, phosphorus is the second most important nutrient for plant growth since it is an essential component of several biochemicals, including nucleic acids, nucleotides, phospholipids, and phosphoproteins. The capacity of plants to carry out various functions, including the process of photosynthesis nitrogen fixation, flowering, seed formation, root development, and crop maturity, is improved by proper P nutrition. According to discoveries, P fertilizer decreased

the amount of Na^+ in shoots, which improved rice survival, growth, and yield [11]. Additionally, phosphorus has a major part in the molecule ATP, which gives that plant energy for actions like respiration, nutrient uptake, and nutrient translocation. In addition, phosphorus is a component of other compounds required for the transfer of DNA and RNA and for the synthesis of proteins.

Micronutrients are just as essential to plant nutrition as macronutrients, and their deficiency is one of the primary contributors causing declining productivity trends in countries where rice is grown. Micronutrients are only required in trace amounts, but their adequate supply increases nutrient availability and has a positive impact on cell physiology, which is reflected in yield as well. Crop growth and results suffer significantly when micronutrient levels are low. Insufficient levels of micro nutrients make it impossible for plants to benefit fully from the use of NPK fertilizers.

In India, after phosphorus, potassium, and nitrogen, respectively, zinc is considered as the fourth important nutrient that limits crop productivity. In addition to being an important micronutrient for the proper growth and metabolism of the plant, zinc is essential to ensuring the integrity of plant membranes and for the activation of enzymes like alkaline phosphatase, carbonic anhydride, super oxide dismutase, and hydrolyzes.

The global and regional food security is seen to be severely compromised by zinc (Zn) lack among the micronutrients [23]. Zinc lack resulted in lower yields and Zn malnutrition among people in regions with significant consumption of rice. It was later discovered to be a common problem in Asia's lowland rice regions, together with N and P shortages. At the seedling stage in a nursery and three weeks after transplanting to the main field, rice begins to show signs of zinc deficiency. Low plant-available Zn in the soil delays maturity and significantly decreases production in rice by causing leaf bronzing and poor tillering in the early stages of growth. Application of zinc sulphate (ZnSO_4) before flooding or after transplanting is usually employed to treat zinc deficiency with the goal to prevent Zn deficiency and increased grain yield [21].

For crops to develop and develop, iron (Fe) is one of the basic metals required. Fe is the micronutrient that plants need the most of the seven [15]. It helps in the production and breakdown of chlorophyll in addition to the synthesis of proteins and nucleic acids. Iron is a constituent of ferredoxins and iron porphyrins, both of which are essential elements in the light phase of photosynthesis. Iron also plays a significant part in respiration and growth of healthy, green leaves. Iron is also necessary for electron transport in photosynthesis. Catalase, which succinic dehydrogenase, and aconitase are just a few of the enzymes that it activates.

Inadequate boron delays flowering, causes flower bud abortion, and makes panicles sterility [22] affects plasma membrane integrity, structure, and cell wall biosynthesis as well. Inadequate levels of boron in rice plants result in undeveloped leaves that are white and rolled at the tips, the death of growing points, and, if affected at the time of panicle development, the inability to create panicles. For lignification, nucleotide synthesis, respiration, pollen viability,

carbohydrate metabolism, sugar transport, and other processes, boron is required. According to [3] mineral carbonate can affect photosynthesis and activate a variety of enzyme systems involved in the metabolism of nucleic acids and proteins in plants.

In considering the previously mentioned fact, an experiment has been carried out to find out the “**Influence of Phosphorus and Micronutrients on Growth and Yield of rice (*Oryza sativa* L.)**”.

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 consists of 3 different Phosphorus *viz.* (50 kg/ha), (60 kg/ha) and (70 kg/ha) with combination of 3 micronutrients *viz.* Zinc (10 kg/ha), iron (15 kg/ha), and boron (4 kg/ha). The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T1- [Phosphorus (50 kg/ha) + Zinc (10 kg/ha), T2 – Phosphorus (50 kg/ha) + Iron (15 kg), T3 – Phosphorus (50 kg/ha) + Boron (4 kg/ha), T4 – Phosphorus (60 kg/ha) + Zinc (10 kg/ha), T5- Phosphorus (60 kg/ha) + Iron (15 kg), T6 – Phosphorus (60 kg/ha) + Boron (4 kg/ha), T7 – Phosphorus (70 kg/ha) + Zinc (10 kg/ha), T8 – Phosphorus(70 kg/ha)+ Iron (15 kg), T9- Phosphorus (70 kg/ha) + Boron (4 kg/ha). T10-120:60:60 (NPK Kg/ha).

The experiment was laid out in Randomized Block Design, with 10 treatments replicated thrice. The observations were recorded for plant height, number of tillers/hill, plant dry weight (g), Crop growth rate (g/m²/day), Relative growth rate (g/g/day), number of panicles/plant, number of grains/panicle, test weight (g), grain yield (t/ha), strover yield (t/ha) and harvest index (%). The data was computed and analysed by following statistical method of **Gomez and Gomez (1984)**. [9]

RESULT AND DISSCUSSION

Growth parameters

Plant height (cm):

The data revealed that significant and higher plant height (119.5 cm) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)]. However, treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found statistically at par with treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 1).

The application of phosphorus (70 kg/ha) resulted in a significant and higher plant height, which may be attributable to the fact that phosphate stimulates root growth and development during the seedling stage, facilitating in the seedling's rapid development. **Majeed *et al.* [20]** in wheat reported similar results. In addition, the application of Zn (10 kg/ha) raised plant height. This might be attributed to Zn's role in the biosynthesis of indole acetic acid (IAA) and, in particular, to its role in the beginning of primordial for reproductive parts and the partitioning of photosynthesis towards them, which enhanced flowering and fruiting and raised plant height. These results similar to **Himanshu *et al.* [12]**.

Number of tillers/hill:

The result revealed that significant and higher number of tillers/hill (12.6) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)]. However, treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found statistically at par with treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 1).

With the application of phosphorus (70 kg/ha), a significant and higher number of tillers appeared on each hill. This might have been because the mother culm's early growth had better nutritional status, resulting to more tillers per hill. In wheat, similar results have been found by **Figeria *et al.* [6]** In addition, an increase in tillers/hill with zinc application (10 kg/ha) could be due to increased nitrogen fixation, protein synthesis, chlorophyll synthesis, and photosynthetic growth in response to zinc application. Reported similar result **Rao *et al.* [30]**.

Plant dry weight (g):

Data found that significant and higher plant dry weight (42.79 g/plant) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)]. However, treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found statistically at par with treatment 7 [Phosphorus (70 kg/ha)+ Zinc(10 kg/ha)] (Table 1).

The application of phosphorus (70 kg/ha) resulted in significantly higher plant dry weight, which may be related to increased phosphorus supply caused on by increased root proliferation and increased levels of nutrients in the soil, which speed up cell division and increasing and lead to higher plant dry weight. **Sathish *et al.* [26]** Reported the same finding in wheat. Zinc's function across several metabolic and growth processes, hormone production, protein synthesis, and the translocation of photosynthates in various plant sections could also contribute to the rise in plant dry weight after zinc application (10 kg/ha). In wheat, **Singh *et al.* [28]** and **Choudary *et al.* [2]** reported findings that were comparable.

Crop Growth Rate (g/m²/day):

The data recorded that significant and higher crop growth rate (7.70 g/m²/day) was recorded in treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] and the treatment 10 [Control] recorded lowest crop growth rate (5.77 g/m²/day) (Table 1).

The fact that phosphorus promotes root growth which contributes to the development of an expansive root system, which in turn improves the capacity of plants to gather water and nutrients, could be responsible for the significant and higher crop growth rate observed with the use of phosphorus (70 kg/ha). Phosphorus levels that are higher also promote other plant metabolic processes including photosynthetic and cellular energy transmission. Similar results was found by **Fageria *et al.* [7]** In addition, a faster rate of crop growth was observed after zinc (10 kg/ha) application. This could be explained through xylem and phloem certainly-translocation, which boost photosynthetic activity and increase the synthesis of vegetative tissue, which slows the fast growth of the plant's components and raises dry matter. The same result was reported in **Rao *et al.* [30]**.

Relative Growth Rate (g/g/day):

The data showed that during 80-100 DAT, treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] recorded significantly higher relative growth rate (0.037 g/g/day), though there was significant among the treatment (Table 1).

The significant and higher relative growth rate that occurred with the application of phosphorus (70 kg/ha) may be attributable to the crop's rapid development as a result of adequate and continues nutrient supply, which kept better root establishment and various metabolic processes that resulted in rapid cell division and cell elongation and higher plant growth. Similar results in wheat were reported by **Satish *et al.* [26]** In addition, a higher relative growth rate was found with the application of zinc (10 kg/ha). This may be because zinc, which plays a role in many metallic enzyme structures, regulatory functions, and auxin production, has aided plant growth. **Slaton *et al.* [29]** reported a similar result.

Yield parameters:**Number of panicles/plant:**

The data recorded that significant and higher number of panicles/plant (12.76) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] However, the treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found to be statistically at par to the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 2).

The application of phosphorus (70 kg/ha), which significantly increased the number of panicles per plant, may have been a result of balanced fertiliser application. Phosphorus also encouraged normal plant growth, which led to an increase in the number of panicles each plant. **Rehman *et al.* [22]** and **Memon *et al.* [19]** noticed similar findings in wheat. In addition, the application of zinc (10 kg/ha) resulted in a higher number of panicles per plant, which may be due to the adequate supply of zinc expanding the availability and uptake of other crucial nutrients that improve crop growth. **Sanzo *et al.* [25]** reported a similar result.

Number of grains/panicle:

The data showed that significantly highest number of grains /panicle (126.5) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] among all the treatments. However, the treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found to be statistically at par to the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 2).

The application of phosphorus (70 kg/ha) resulted in a considerable and larger amount of grains per panicle, which may be because phosphorus is essential for the movement of assimilates to panicles and also functions as a component of protoplasm. **Ishizuka [13]** reported a similar result. Zinc (10 kg/ha) use additionally resulted in a higher number of grains per panicle, which may have been caused by a boost in the crop's physiological processes such as photosynthesis and the transport of plant nutrients. **Lonova [14]** reported a similar finding.

Test weight (g):

Significant and higher test weight (16.6 g) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] However, the treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found to be statistically at par to the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 2).

The significant and higher test weight that was noted with the application of phosphorus (70 kg/ha) may be due to the fact that phosphorus is essential for enzyme reactions that depend on phosphorylase as well as for cell division and the development of meristem tissue. **Juwita *et al.* [5]** reported a similar outcome. In addition, the increase in test weight noticed with zinc application (10 kg/ha) may be due to zinc's more effective participation in the various metabolic processes necessary for the production of healthy seeds. **Ali *et al.* [18]** reported a similar result.

Grain Yield (t/ha):

The data revealed that significant and higher grain yield (5.34 t/ha) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] However, the treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found to be statistically at par to the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 2).

The significant and higher grain yield that occurred with the application of phosphorus (70 kg/ha) could be due to more phosphorus being available to support the rice plant's metabolic processes, root development, and energy conversion, which in turn led to a greater translocation of photosynthesis to the productive part and increased grain yield. **Gharib *et al.* [8]** reported a similar result. In addition, a significant and higher grain yield was observed with the application of zinc (10 kg/ha). This may be as zinc participates in many metallic enzyme structures, controls auxin production, and plays a role in the control of many metallic enzyme systems, all of which help to a higher grain yield. **Ali *et al.* [18]** reported a similar finding.

Straw Yield (t/ha):

The data showed that significant and higher straw yield (7.24 t/ha) was recorded in the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] However, the treatment 9 [Phosphorus (70 kg/ha) + Boron (4 kg/ha)] was found to be statistically at par to the treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)] (Table 2).

The significant and higher straw yield that occurred with phosphorus application (70 kg/ha) may be due to increased phosphorus availability and thus, increased phosphorus uptake. This increased ATP formation, which is the main source of energy for crops, may encourage rice growth, metabolism, photosynthesis, and nucleic acid in addition to improvement in biomass production and sink formation, resulting in increases in straw yield. **Gharib *et al.* [8]** and **Yadav *et al.* [4]** also reported results that were comparable. In addition, a significant and higher yield of straw was found with the application of zinc (10 kg/ha). It may be due to zinc's beneficial impact on root proliferation, which improves the uptake of nutrients by plants from the soil and materials them to their aerial parts, ultimately promoting the vegetative growth of plants. **Khan *et al.* [16]** reported a similar result.

Harvest Index (%):

Data recorded that significant and higher harvest index (42.45 %) was recorded in treatment 7 [Phosphorus 70 kg/ha + Zinc (10 kg/ha)]. However, the treatment 9 - [Phosphorus 70 kg/ha + Boron (4kg/ha)] (41.94%) was found to be statistically at par to the treatment 7 [Phosphorus 70 kg/ha + Zinc (10 kg/ha)] (Table 2).

The significant and higher harvest index that was found with the application of phosphorus (70 kg/ha) could be due to enhanced cell activities, increased cell multiplication and enlargement, and luxuriant growth and yield attributes of the crops. This could be because more nutrients were absorbed and utilised, which improved the overall growth of the crops and the source-sink relationship, leading to an increase in yield. In wheat, **Akram *et al.* [27]** reported a similar result. In addition, a higher harvest index was found with the application of zinc (10 kg/ha). This may be related to the maximum dry matter partitioning towards grain, which increased grain yield, as well as the plant's capacity to maintain a higher supply of photosynthates in reproductive parts than in vegetative biomass. **Singh *et al.* [32]** and **Kadam *et al.* [24]** reported a similar result.

Table 1. Influences of Phosphorus and micronutrients on growth parameters of rice

Sl. No.	Treatments	Plant heights (cm)	Number of tillers/hill	Plant dry weight (g)	Crop growth rate (g/m²/day)	Relative growth rate (g/g/day)
1	Phosphorus 50 kg/ha + Zinc (10kg/ha)	106.93	14.47	38.80	26.71	0.0580
2	Phosphorus 50 kg/ha + Iron (15kg/ha)	105.37	14.13	38.30	26.39	0.0587
3	Phosphorus 50 kg/ha + Boron (4 kg/ha)	106.60	14.47	38.56	26.49	0.0580
4	Phosphorus 60 kg/ha + Zinc (10kg/ha)	109.53	16.00	39.31	26.89	0.0560
5	Phosphorus 60 kg/ha + Iron (15kg/ha)	107.70	15.00	38.95	26.51	0.0573
6	Phosphorus 60 kg/ha + Boron (4 kg/ha)	108.87	15.60	39.15	26.74	0.0563
7	Phosphorus 70 kg/ha + Zinc (10kg/ha)	110.63	16.27	39.71	27.55	0.0567
8	Phosphorus 70 kg/ha + Iron (15kg/ha)	108.33	15.27	39.08	26.58	0.0567
9	Phosphorus 70 kg/ha + Boron (4 kg/ha)	109.80	16.47	39.53	27.10	0.0560
10	Control - 120:60:60 NPK (kg/ha)	103.73	13.73	38.12	26.24	0.0597
	F test	S	S	S	S	S
	SE(m)±	0.17	0.13	0.07	0.16	0.0038
	CD (p=0.05)	0.53	0.40	0.22	0.50	0.0012

Table 2. Influences of Phosphorus and micronutrients on yield and yield parameters of rice

Sl No.	Treatments	Number of panicles/plant	Number of grains/panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1	Phosphorus 50 kg/ha + Zinc (10kg/ha)	12.06	122.93	13.16	3.93	5.88	40.08
2	Phosphorus 50 kg/ha + Iron (15kg/ha)	11.48	120.80	12.99	3.54	5.62	38.67
3	Phosphorus 50 kg/ha + Boron (4 kg/ha)	11.66	121.47	13.08	3.66	5.50	39.96
4	Phosphorus 60 kg/ha + Zinc (10kg/ha)	12.99	125.40	15.09	4.86	6.86	41.47
5	Phosphorus 60 kg/ha + Iron (15kg/ha)	12.19	123.73	13.30	4.03	6.16	39.55
6	Phosphorus 60 kg/ha + Boron (4 kg/ha)	12.76	125.00	14.42	4.56	6.70	40.51
7	Phosphorus 70 kg/ha + Zinc (10kg/ha)	13.20	126.47	16.59	5.34	7.24	42.45
8	Phosphorus 70 kg/ha + Iron (15kg/ha)	12.38	124.60	13.86	4.28	6.53	39.60
9	Phosphorus 70 kg/ha + Boron (4 kg/ha)	13.09	125.73	15.94	5.10	7.06	41.94
10	Control - 120:60:60 NPK (kg/ha)	11.05	119.80	12.85	3.42	5.21	39.61
	F test	S	S	S	S	S	S
	SE(m)±	0.05	0.21	0.12	0.07	0.09	0.64
	CD (p=0.05)	0.16	0.64	0.38	0.24	0.29	1.91

CONCLUSION:

Based on above findings it can be concluded that combination of Phosphorus (70 kg/ha) along with Zinc (10 kg/ha) (Treatment 7) was observed better growth parameters and yield attributes.

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