**Original research article**

**Determining the Effect of Phosphorus and Micronutrients on Yield and Economics of Rice (*Oryza sativa* L.)**

 **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 results showed that treatment 7 [Phoshorus (70 kg/ha)+ Zinc(10 kg/ha)] recorded significantly higher number of panicles/plant, number of grains/panicle, test weight, grain yield, straw yield, harvest index and maximum gross returns, net return, benefit cost ratio was recorded.

.

***Keywords:*** *Rice, Phosphorus, Micronutrients, Yield and Economics.*

**Introduction**

Rice is a major staple food of (70%) of Indian population, it provide (21%) and (15%) per capita of dietary energy and protein, respectively **(Maclean *et al.,* 2002).**And also which provides instant energy as its most important component is carbohydrate (starch). Rice flour is rich in starch and is used for making various food materials. It is also used in some instances by brewers to make alcoholic malt. Likewise, rice straw mixed with other materials is used to produce porcelain, glass and pottery. Rice is also used in manufacturing of paper pulp and livestock bedding.

In world rice growing in 165.12 million ha, the production is 509.42 million tonnes and the yield is about 4.61 metric tons/ha **(USDA, 2022).** Among the rice growing countries of the world, India has the largest rice acreage and ranked second in production after wheat in the world. In India rice is grown in 45.07 million ha, the production level is 122.27 million tones and the yield is about 2713 kg/ha **(GOI, 2021).** In Uttar Pradesh state ranks third in the country in production of rice. it grown over area about 5.68 mha which comprise of (13.5%) of total rice in India. Annual rice production is around 15.66 million metric ton, the average yield is 2759 kg/ha **(GOI, 2021).**

Phosphorus deficiency is one of the major constraints to crop production. The unique feature of P is its low availability due to slow diffusion and high fixation in soils. Phosphorus is the second major nutrient for plant growth after nitrogen as it is an integral part of different bio chemicals like nucleic acid, nucleotides, phospholipids and phosphoproteins. Sufficient P nutrition improves several plant processes such as photosynthesis, nitrogen fixation, flowering, seed formation, root development and crop maturation**.** It has been observed that P fertilizer reduced the concentration of Na+ in shoots, resulting in better survival, growth and yield of rice **(Naheed *et al.,* 2008).** Also phosphorus is majore component in ATP, the molecule that provides energy to that plant for such processes as nutrient translocation, nutrient uptake and respiration. Phosphorus is also component of other compound necessary for protein synthesis and transfer of genetic material DNA, RNA**.**

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9].

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9].

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9].

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9].

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9].

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9

Micronutrients are as important as

macronutrients in plant nutrition and the

deficiency of micronutrients is considered one of

the major causes of declining the productivity

trends in rice growing countries including

Bangladesh. Micronutrients are needed in trace

amounts but their adequate supply improves

nutrient availability and positively affects the cell

physiology that is reflected in yield as well [6].

Farmers apply N, P, K and S fertilizers widely

and application of micronutrients such as Zn, Cu,

Mn and B is not a usual practice. Soils deficient

in their supply of micronutrients are alarmingly

widespread across the globe due to intensive

cropping, loss of fertile topsoil and losses of

nutrients through leaching [7]. When

micronutrients are in short supply, the growth

and yield of crops are severely depressed [8].

The presence of micronutrient deficiency renders

it impossible for the plants to gain maximum

benefit from NPK fertilizers application.

Micronutrient deficiency in 50% of the world’s

soils and many crops greatly reduces the amount

and quality of food which adversely affects

human health, the economic status of farmers

and the environment around the world [9

Micronutrients are as important as macronutrients in plant nutrition and the deficiency of micronutrients is considered one of the major causes of declining the productivity trends in rice growing countries, micro nutrients are needed in trace amounts but their adequate supply improves nutrient availability and positively affects the cell physiology that is reflected in yield as well. When micronutrients are in short supply, the growth and yield of crops are severely depressed. The presence of micronutrient deficiency renders it impossible for the plants to gain maximum benefit from NPK fertilizers application.

In India, zinc is considered as the fourth important yield limiting nutrient after nitrogen, phosphorus, and potassium respectively. Zinc plays an important role in the nutrition of rice, and also essential micronutrients for the normal growth and metabolism of the plant plays an important role in membrane integrity, synthesis of carbohydrates, enzyme activation such as dehydogenise, carbonic anhydride, super oxide dismutase, alkaline phosphatise etc.

Among the micronutrients, zinc (Zn) deficiency is considered as a major threat to the global and regional food security **(Rana and Kashif, 2014).** In high rice consuming areas, zinc deficiency caused yield reduction and Zn malnutrition in humans. It was subsequently found to be widespread phenomenon in lowland rice areas of Asia, next to N and P deficiencies. Zinc deficiency in rice appears right from seedling stage in nursery and three weeks after transplanting in main field. In rice, low plant available Zn in soil cause leaf bronzing and poor tillering at early growth stages, leading to delayed maturity and significant yield loss. Zinc deficiency is usually corrected by application of zinc sulfate (ZnSO4) before flooding or after transplanting to prevent Zn deficiency and increased grain yield **(Naik and Das, 2007).**

Iron (Fe) is one of the essential elements required for plant growth and reproduction. Of the 7 micronutrients, Fe has the highest plant requirement **(Jones and Benton, 2012).** It is involved in chlorophyll formation and degradation and in the synthesis of proteins and nucleic acids. Iron plays an important role in respiration and the production of healthy green leaves and also required for electron transport in photosynthesis and is a constituent of iron porphyrins and ferredoxins, both of which are essential components in the light phase of photosynthesis. It is an activator for several enzymes (e.g. catalase, succinic dehydrogenase, and aconitase), but inhibits K absorption (**Meng *et al.*, 2005)** reported that improving the iron content and bioavailability in rice is a perspective and an effective way to alleviate or even solve the widespread iron deficiency in humans..

Boron deficiency causes delay in flowering, induces flower bud abortion and causes panicle sterility **(Rehman *et al.,* 2018).** Also affect cell wall biosynthesis and affects structure and plasma membrane integrity. Boron deficient rice plants show white and rolled leaf tips of young leaves, death of growing points and unable to produce panicles if affected at panicle formation stage. Boron required for carbohydrate metabolism, sugar transport, lignification, nucleotide synthesis, respiration, and pollen viability. Boron can influence photosynthesis and activate number of enzymatic system of protein and nucleic acid metabolism in plants **(Choudary *et al.,* 2010).** Keeping in view the above fact, the experiment was conducted to find out the **“Effect of Phosphorus and Micronutrients on Yield and Economics 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 of3 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).

# RESULT AND DISSCUSSION

**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). Thesignificant and higher number of panicles/plant was recorded with the application of Phosphorus (70 kg/ha) might be due to balanced fertilizer application and also phosphorus promoted normal growth of the plant, as a result number of panicles/plant increased. Similar result was reported by **Rehman *et al.* (1996)** and **Memon *et al.* (2005)** in wheat. Further, higher number of panicles/plant was recorded with the application of Zinc (10 kg/ha) may be due to adequate supply of zinc that might have increased the availability and uptake of other essential nutrients and thereby resulting in improvement of crop growth. Similar result was reported by **Sanzo *et al*. (1989).**

# Number of grains/panicle:

The data showed that ignificantly 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 significant and higher number of grains/panicle was recorded with the application of Phosphorus (70 kg/ha) may bedue tophosphorus plays an important role in the translocation of assimilates to the panicles and also as a constituent of protoplasm, resulted higher number of grains/ panicle. Similar result was reported by **Ishizuka (1971)**. Further, higher number of grains/panicle was observed with the application of Zinc (10 kg/ha) might be due to effect on enhancing the physiological function of crop like photosynthesis and translocation of plant nutrients which ultimately increased the number of grains/panicle**.** Similar result was reported by **lonova (1977).**

**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 was recorded with the application of Phosphorus (70 kg/ha) may be due to phosphorus plays an important role in enzyme reactions that depend on phosphorylase and also phosphorus is part of the cell nucleus, so it was important in cell division and also for the development of meristem tissue. Similar result was reported by **Juwita *et al.* (2021).** Further, increase in test weight with the application of Zinc (10 kg/ha) might be due to more efficient participation of zinc in various metabolic processes involved in the production of healthy seeds. Similar result was reported by **Ali *et al.*(2019).**

**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 was recorded with the application of Phosphorus (70 kg/ha) might be due to more availability of phosphorus on root development, energy transformation and metabolic processes of the rice plant, which in turn resulted in greater translocation of photosynthates towards the productive part, resulted increased in grain yield. Similar result was reported by **Gharib *et al*. (2011).** Further, significant and higher grain yield was recorded with the application Zinc (10 kg/ha) may be dueto involvement in many metallic enzyme system, regulatory functions and auxin production enhanced synthesis of carbohydrates and their transport which increases grain yield. Similar result was reported by **Ali *et al.* (2019).**

**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). Thesignificant and higher straw yield was recorded with the application of Phosphorus (70 kg/ha) may be due to increasing phosphorus availability and subsequently increased its uptake, leading to more ATP formation that is the main stare for energy in plant and might encourage rice growth, metabolism, photosynthesis and nucleic acid and also improvement in biomass production and sink formation, resulted increases straw yield. Similar result was reported by **Gharib *et al.* (2011) and Yadav *et al.* (2015).** Further, significant and higher straw yield was recorded with the application of Zinc (10 kg/ha) might be due to favorable effect of zinc on the proliferation of roots and thereby increasing the uptake of plant nutrients from the soil, and supplying it to the aerial parts of the plant, ultimately enhancing the vegetative growth of plants. Similar result was reported by **Khan et al. (2007).**

# 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 was recorded with the application of Phosphorus (70 kg/ha) might be due to improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth and yield attribute of the crops probably due to more absorption and utilization of available nutrients leading to overall improvement of crop growth reflected to source-sink relationship, which in turn enhanced the yield attributes that ultimately more yield. Similar result was reported by **Akram *et al.* (2022)** in wheat**.** Further, higher harvest index was recorded with the application of Zinc (10 kg/ha) may be due to maximum dry matter partitioning towards grain hence grain yield was more and also plant maintain a higher supply of photosynthates to reproductive parts as compare to vegetative biomass. Similar result was reported by **Kadam *et al.* (2018) and Singh *et al*. (2018).**

**Economics:**

The result showed that maximum gross returns (1,70,880.00 INR/ha), higher net return (1,18,075.50 INR/ha) and highest benefit cost ratio (2.23) was recorded in treatment 7 [Phosphorus (70 kg/ha) + Zinc (10 kg/ha)].As compared to other treatments (Table 3).Higher gross return, higher net return, and highest benefit cost ratio was recorded with the application of Phosphorus (70 kg/ha) might be due to higher productivity as well as efficient use of fertilizer. Similar result was reported by **Devi *et al.* (2018).** Further, higher gross return, higher net return, highest benefit cost ratio was recorded with the application of Zinc (10 kg/ha) might be due to zinc is an essential plant nutrient and its involvement in the physiological process is well pronounced, therefore increased in both grain and straw yield. Similar result was reported by **Reddy *et al.* (2020)**

**Table 1. Effect 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 |

**Table 2. Effect of Phosphorus and micronutrients on the economics of rice.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl No.** | **Treatments** | **Cost of cultivation (INR/ha)** | **Gross returns (INR/ha)** | **Net returns (INR/ha)** | **B:C ratio** |
| **1** | Phosphorus 50 kg/ha + Zinc (10kg/ha) | 50,304.49 | 1,25,760.00 | 75,455.51 | 1.49 |
| **2** | Phosphorus 50 kg/ha + Iron (15kg/ha) | 50,284.49 | 1,13,280.00 | 62,995.51 | 1.25 |
| **3** | Phosphorus 50 kg/ha + Boron (4 kg/ha) | 49,979.49 | 1,17,120.00 | 67,140.51 | 1.34 |
| **4** | Phosphorus 60 kg/ha + Zinc (10kg/ha) | 51,554.49 | 1,55,520.00 | 1,03,965.50 | 2.01 |
| **5** | Phosphorus 60 kg/ha + Iron (15kg/ha) | 51,534.49 | 1,28,960.00 | 77,425.51 | 1.50 |
| **6** | Phosphorus 60 kg/ha + Boron (4 kg/ha) | 51,229.49 | 1,45,920.00 | 94,690.51 | 1.84 |
| **7** | Phosphorus 70 kg/ha + Zinc (10kg/ha) | 52,804.49 | 1,70,880.00 | 1,18,075.50 | 2.23 |
| **8** | Phosphorus 70 kg/ha + Iron (15kg/ha) | 52,784.49 | 1,36,960.00 | 84,175.51 | 1.59 |
| **9** | Phosphorus 70 kg/ha + Boron (4 kg/ha) | 52,479.49 | 1,63,200.00 | 1,10,720.50 | 2.10 |
| **10** | Control -120:60:60 NPK (kg/ha) | 44,554.49 | 1,09,440.00 | 64,885.51 | 1.45 |

**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 highest grain yield and benefit cost ratio.

## REFERENCES:

## 1. Atique-ur-Rehman & Muhammad Farooq & Abdul Rashid & Faisal Nadeem & Sabine Stuerz4& Folkard Asch & Richard W. Bell & Kadambot H. M. Siddique. (2018). Boron nutrition of rice in different production systems. A review. Agronomy for Sustainable Development 38: 25.

## 2. Choudhary, S., A. Zehra, M. Naeem, M. Khan and T. Aftab. (2020). Effects of boron toxicity on growth, oxidative damage, antioxidant enzymes and essential oil fingerprinting in Mentha arvensis and Cymbopogon flexuosus. Chem. & Biol. Technol. in Agri., 7(1): 1-11.

## 3. Devideen yadav1, Y.V. singh , Dinesh kumar, Sunita gaind and Anil kumar.(2015). Influence of sources and rates of phosphorus on plant growth, productivity and economics of aerobic rice (*Oryza sativa* L.).Indian Journal of Agronomy 60 (1): 157-159.

**4. Gulshan naheed, Muahmmad shahbazand Nudrat aisha akram. (2008).** Interactive effect of rooting medium application of phosphorus and nacl on plant biomass and mineral nutrients of rice (oryza sativa l.). Pak. J. Bot., **40**(4): 1601-1608.

 **5. Jones, J. R. & Benton. J. (2012).** Fifth. Iron Chelation in Plants and Soil Microorganisms, 447.

**6. Maclean, J.C., Dawe, D.C., Hardy, B. and Hettel, G.P. (2002).** Rice almanac (3rd edition) CABI publishing willing ford, p. 253.

**7. Naik SK, Das DK (2007)**. Effect of split application of zinc on yield of rice (Oryza sativa L.) in an inceptisol. Arch Agron. Soil Sci **53**(3):305–313.

**8. Rana, W.H. and S.R. Kashif (2014).** Effect of different zinc sources and methods of application on rice yield and nutrients concentration in rice grain and straw. Journal of Environmental and Agricultural Sciences, 1–9.

**9. S.R. Kadam, V.M. Bhale, A.B. Chorey and M.R. Deshmukh. (2018).** Influence of Zinc and Iron Fortification on Yield and Post-Harvest Studies of Different Rice Cultivars (Oryza sativa L.). Int.J.Curr.Microbiol.App.Sci **7(**1): 1878-1888.