***Original Research Article***

**Studies on the effect of bio-fertilizer, organic manure and micro-nutrients in uptake of zinc and iron on scented rice (*Oryza sativa* L.) in central plain zone of Uttar Pradesh**

**ABSTRACT**

Nutrient management through organics plays a major role in maintaining soil health due to build-up of soil organic matter, beneficial microbes and enzymes, besides improving soil physical and chemical properties. Therefore, combined use of organic manure and inorganic fertilizers in an integrated manner will give better performance in cereals by sustaining higher yield and maintaining soil health as well. Field experiments were conducted during Kharif seasons of 2021 and 2022 at Crop Research Farm, Nawabganj, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The experiment consisted three varieties (PB-1509, PB-1121 and PB-1), three bio-fertilizer and organic manure levels (BGA @ 10 kg ha-1, FYM @10 t ha-1 and BGA @ 10 kg ha-1 + FYM @10 t ha-1) and three nutrient management treatments (NPK- 120:60:60 kg ha-1 only, NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 1% sprayed at tillering stage and NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 1% sprayed at panicle initiation stage). The treatments were accommodated in split-split plot design with three replications. The soil of experimental field was sandy loam in texture having low organic carbon (0.39 %), medium in available nitrogen (179 kg ha-1), low in available phosphorus (13.0 kg ha-1), medium in available potassium (156 kg ha-1), low in available zinc (0.58 mg ha-1) and normal in available iron (7.83 mg ha-1) with normal pH (7.95). Pooled results of two years experimentation indicated that highest value of zinc concentration (35.17, 34.67 and 33.73 ppm) and iron concentration (37.78, 37.51 and 36.57 ppm) was recorded under the variety PB-1121, BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 and NPK (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 1% sprayed at tillering stage respectively.

Keywords: Scented rice (*Oryza sativa* L.), zinc, iron uptake and concentration.

**INTRODUCTION**

Rice (*Oryza sativa* L.) is a most important staple food of about more than 60% of total world population. Rice is cultivated world-wide over an area of about 163.20 million hectares with an annual production of about 758.90 million tonnes. (503.80 million tonnes, milled basis) and productivity 4.60 tons per hectare (Anonymous, 2022a). About 90% of all rice grown in the world is produced and consumed in Asian region. It accounts 43% of total food grain production and 55% of cereal production in the country. It is a high caloric food, which contains 75% starch, 6-7% protein, 2-2.5% fat, 0.8% cellulose and 5-9% ash%.

 India is the world’s 2nd largest producer with approximately 43.0 million hectare area, accounting for 22% of the world’s rice production. At the end of fiscal year 2019, India had approximately 44 million hectares of area for cultivation of rice. This area had been relatively consistent over during the past three years. Total production of rice during 2019-20 was recorded 117.47 million tonnes. It is higher by 9.67 million tonnes than the five years average production of 107.80 million tonnes but production of rice is 110 million tonnes with an average productivity of 2590 kg ha-1. In UP, it is grown in an area of about 5.86 million ha with production of 12.90 million tonnes and productivity of 2132 kg ha-1 (Anonymous,2022b).

Worldwide, there is a growing interest in the role of micronutrients in optimizing health and in the prevention of overall diseases of the human being. Micronutrient play a crucial role for human nutrition, including the prevention and treatment of various diseases and conditions, as well as the optimization of physical and mental functioning has also been fully recognized globally in Asia, Africa and Latin America countries, the deficiency of micronutrients such as iron and zinc are the most prevalent for human disorders. (Anteneh et al.*,* 2016). “Deficiencies in key micronutrients, such as Vitamin D, iron, zinc, and folate, have been linked to increased risks of cardiovascular diseases, diabetes, neurodegenerative disorders, and cancer. Recent research highlights the synergistic effects of micronutrients, where combined nutrient intake enhances bioavailability and effectiveness, emphasizing the need for diverse dietary patterns like the Mediterranean diet” (Pandarinathan et al., 2024).

Modernization of agriculture does not only affect the diversity of crops but also the diversity of nutrition. Crop production geared towards high yielding cereal crops mainly wheat, rice and maize could significantly reduce the production of nutritionally rich grains. The reliance of few crops is the major reason for wide spread of zinc and iron deficiency. Selective application of particular fertilizers for increased crop productivity and restoration of heavily degraded soils could limit bioavailability of certain micronutrients through fixation. For instance, high level of available phosphorus in the soil is usually ends up in zinc deficiency (Bilski *et al.,* 2012).

Zinc plays an important role in carbohydrate metabolism, detoxification of super oxide radical and imparts resistance to diseases in plants. Since Zn is associated with enzymes its deficiency leads to several disorders in plants. Also, Since Zn is relatively immobile in plant, its deficiency symptoms generally appear on the growing young tissues. Zn deficiency has received great attention in India, because nearly half of the Indian soils are poor in available Zn content. (Shivay *et al.,* 2014)

Zn fertilizer strategy is an effective way to biofortify food crops with Zn and it is also advantageous because it might also contribute to (i) better yields depending on the extent of soil Zn deficiency, (ii) improved seed and seedling vigour, and (iii) reduced root uptake, and its shoot (or grain) accumulation of Cadmium. Applications of Zn to soil to ensure sufficient availability of Zn for root uptake and foliar applications of Zn to enrich vegetative tissues and thus enhance Zn remobilization into grain for achieving successful biofortification of food crops with Zn. (Cakmak and Kutman, 2017).

Iron plays a key role in the synthesis of chlorophyll, carbohydrate production, cell respiration, chemical reduction of nitrate and sulphate and in N assimilation. The Fe is mainly involved in biochemical processes mostly enzymatic oxidation-reduction reactions in plants. In these reactions’ electrons are transferred from an electron donor to an electron acceptor. Iron is also involved in respiration and photosynthesis. Some of the enzymatic involvements of iron are in nitrate reductase activity, reducing cytochrome-C by flavin enzyme and a protein (derived from iron ferredoxin) participating in photosynthesis electron transport. It is a structural component of porphyrin molecules like cytochromes, hemin, hematin, ferritin, ferrochrome and leghemoglobin in plants. Physiological processes of plants have shown that chlorophyll is formed from protoporphyrin by removing iron from hemin, whereas in other organisms, iron is introduced into protoporphyrin to form heme. Iron is necessary for chlorophyll synthesis in plants. It takes part in the plant’s oxidation-reduction reactions and activities in several enzymes systems such as fumaric hydrogenase, catalase and oxidase. (Kumar *et al.,* 2014)

Iron (Fe) is an important micronutrient for living organisms, its deficiency severely impairs plant growth and is a widespread human dietary problem, with particularly high numbers of affected children and female. Rice is a source of energy for more than half of the world’s population. Thus, understanding the mechanisms of Fe uptake and translocation in rice is of utmost importance in the development of rice varieties that are tolerant to low Fe availability and with high seed levels of Fe. (Bashir *et al.,*2010).

**Table 1: Effect of treatments on zinc concentration (ppm) and zinc uptake (g ha-1) of scented rice grain.**

|  |  |  |
| --- | --- | --- |
| **Treatment Combinations** | **Zinc concentration (ppm)** | **Zinc uptake (g ha-1)** |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| **Varieties** |
| PB-1509 | 31.38 | 32.00 | 31.69 | 157.83 | 164.53 | 161.18 |
| PB-1121 | 34.88 | 35.45 | 35.17 | 212.09 | 221.34 | 216.72 |
| PB-1 | 32.54 | 33.32 | 32.93 | 132.08 | 138.10 | 135.09 |
| SE (d) ± | 0.81 | 0.23 | 0.25 | 1.80 | 2.27 | 2.51 |
| CD (P=0.05) | 0.50 | 0.62 | 0.58 | 4.98 | 6.27 | 5.79 |
| **Bio-fertilizer and organic manure** |
| BGA – 10 kg ha-1 | 31.51 | 32.20 | 31.86 | 150.09 | 156.07 | 153.08 |
| FYM – 10 t ha-1 | 32.93 | 33.59 | 33.26 | 167.07 | 174.38 | 170.73 |
| BGA10 kg ha-1 + FYM 10 t ha-1 | 34.36 | 34.97 | 34.67 | 184.84 | 193.53 | 189.19 |
| SE (d) ± | 0.23 | 0.29 | 0.32 | 2.34 | 2.93 | 3.25 |
| CD (P=0.05) | 0.51 | 0.64 | 0.67 | 5.10 | 6.38 | 6.70 |
| **Nutrient Management** |
| N:P:K (120:60:60 kg ha-1) | 32.45 | 33.12 | 32.79 | 155.54 | 161.41 | 158.48 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at TS | 33.41 | 34.04 | 33.73 | 173.15 | 180.88 | 177.02 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at PIS | 32.93 | 33.60 | 33.27 | 167.31 | 174.69 | 171.00 |
| SE (d) ± | 0.15 | 0.19 | 0.20 | 1.48 | 1.85 | 2.05 |
| CD (P=0.05) | 0.30 | 0.38 | 0.41 | 3.00 | 3.76 | 4.09 |

TS - Tillering Stage and PIS - Panicle Initiation Stage

**Table 2: Effect of treatments on iron concentration (ppm) and iron uptake (g ha-1) of scented rice grain.**

|  |  |  |
| --- | --- | --- |
| **Treatment Combinations** | **Iron concentration (ppm)** | **Iron uptake (g ha-1)** |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| **Varieties** |
| PB-1509 | 34.48 | 35.04 | 34.76 | 173.39 | 180.10 | 176.75 |
| PB-1121 | 37.52 | 38.04 | 37.78 | 228.12 | 237.49 | 232.81 |
| PB-1 | 35.41 | 36.14 | 35.78 | 143.70 | 149.76 | 146.73 |
| SE (d) ± | 0.19 | 0.13 | 0.19 | 1.82 | 2.26 | 2.51 |
| CD (P=0.05) | 0.51 | 0.35 | 0.45 | 5.02 | 6.25 | 5.79 |
| **Bio-fertilizer and organic manure** |
| BGA – 10 kg ha-1 | 34.38 | 35.02 | 34.70 | 163.62 | 169.57 | 166.59 |
| FYM – 10 t ha-1 | 35.79 | 36.41 | 36.10 | 181.47 | 188.84 | 185.16 |
| BGA10 kg ha-1 + FYM 10 t ha-1 | 37.23 | 37.78 | 37.51 | 200.13 | 208.93 | 204.53 |
| SE (d) ± | 0.23 | 0.13 | 0.23 | 2.34 | 2.93 | 3.24 |
| CD (P=0.05) | 0.51 | 0.29 | 0.48 | 5.10 | 6.38 | 6.70 |
| **Nutrient Management** |
| N:P:K (120:60:60 kg ha-1) | 35.32 | 35.94 | 35.63 | 169.65 | 175.56 | 172.61 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at TS | 36.28 | 36.86 | 36.57 | 187.85 | 195.66 | 191.76 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at PIS | 35.80 | 36.41 | 36.11 | 181.72 | 189.13 | 185.43 |
| SE (d) ± | 0.15 | 0.26 | 0.26 | 1.48 | 1.85 | 2.05 |
| CD (P=0.05) | 0.30 | 0.53 | 0.52 | 3.00 | 3.76 | 4.09 |

TS - Tillering Stage and PIS - Panicle Initiation Stage

**MATERIAL AND METHODS**

DTPA extractable zinc and iron were measured on atomic absorption spectrophotometer (ECIL AAS 4141) as described by Lindsay and Norvell, (1978).

**Determination of zinc & iron contents in rice grain**

**Zinc**

**Sample preparation:** 1.0g oven dried grain sample were grounded and digested using diacid mixture (9:4 HNO3: HClO4) and made up to 10 ml using deionized water on cooling.

**Stock standard solution:** Dissolve 0.500g of zinc metal in a minimum volume of (1+1) analytical grade of HCl and dilute to 1.0 liter with 1 % (v/v) HCl. 100 ml of this solution is diluted to 100 ml to get 100 ppm zinc solution. The final standard solutions are prepared from this 100-ppm solution.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Zinc in (ppm) | = | R | x | 100 |
| Wt. of sample |

Where,

 R = Value of AAS

**Iron**

**Sample Preparation:** 1.0 g oven dried grain sample are grounded and digested using diacid mixture (9:4 HNO3: HClO4) and made up to 100 ml using deionized water on cooling.

**Stock standard solution:** Dissolve 1.0 g of pure iron wire in 50 ml of (1+1) analytical grade HNO3. Dilute to 1 liter with deionized water. Add 5.0 ml of concentrated H2SO4 and make up the volume with deionized water. This would give a stock solution of 1000 ppm iron. From this solution a 100 ppm solution is prepared which used for preparing final standard solutions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Zinc in (ppm) | = | R | x | 100 |
| Wt. of sample |

Where,

 R = Value of AAS

The uptake of zinc and iron was computated with following formula:

Uptake (g ha-1) = Concentrated in ppm x yield t ha-1

**RESULTS AND DISCUSSION**

**Zinc concentration and uptake**

Mondal *et al.,* (2009) have reported that soil as well as foliar application of Zn to rice grown on Zn deficient soils enhances both the grain yield and grain Zn concentration. Qaisrani (2011) reported that application of 25 kg ZnSO4 ha-1 recorded maximum grain yield and zinc concentration in rice grain as compared to other treatment.

The variety PB-1121 was found to be enriched with maximum zinc concentration (35.17 ppm) and zinc uptake (216.72 g ha-1) and significantly superior as compared to PB-1509 and PB-1.

Application of BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 recorded significantly more zinc concentration (34.67 ppm) and zinc uptake (189.19 g ha-1) in rice grain compared to FYM @ 10t ha-1 and BGA @ 10 kg ha-1 treatments. Similar findings were reported by Maneesh Kumar *et al.,*(2020).

Application of NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) sprayed at tillering stage has recorded the maximum zinc concentration (33.73 ppm) and zinc uptake (177.02 g ha-1) in rice grain as compared to other nutrient management treatments. Similar findings were reported by Bharambe *et al.,*(2004) and Denre *et al.,*(2017) reported that there is increasing evidence showing that foliar or combined soil foliar application of Zn fertilizers under field conditions are highly effective and very practical way to maximize uptake and accumulation of Zn in rice grain.

**Iron concentration and uptake**

The variety PB-1121 recorded maximum and significantly more iron concentration (37.78 ppm) and iron uptake (232.81g ha-1) over other two varieties.

BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 recorded maximum and significantly more iron concentration (37.51 ppm) and iron uptake (204.53 g ha-1) over FYM 10 t ha-1 and BGA @ 10 kg ha-1 treatments.

NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) sprayed at tillering stage recorded highest and significantly better iron concentration (36.57 ppm) and iron uptake (191.76 g ha-1) in rice grain over other nutrient management treatments. Similar findings were reported by Chaudhary *et al.,*(2021), Suresh and Salakinkop (2016) and Ram *et al.,*(2013).

Prakash *et al.,* (2015) have reported variation in Zn & Fe concentration and their uptake in different rice varieties.

**CONCLUSION**

Among three varieties PB-1121, three bio-fertilizer and organic manure levels BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 and three nutrient management treatments NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) sprayed at tillering stage showed higher zinc concentration (35.17ppm, 34.67ppm and 33.73ppm, respectively) and iron concentration (37.78ppm, 37.51ppm and 36.57ppm, respectively).

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