**Production enhancement of scented rice (Oryza sativa L.) using bio-fertilizer, organic manure and micro-nutrients in Uttar Pradesh’s central plain zone, India**

**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 scented rice 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 seeds per panicle (91.42, 87.61 and 82.87), grain yield per panicle (2.75 g, 2.85 g and 2.65 g), test weight (27.34 g, 27.23 g and 26.61 g), biological yield (16872.62 kg ha-1, 16755.51 kg ha-1 and 16154.61 kg ha-1), grain yield (6152.24 kg ha-1, 5431.41 kg ha-1 and 5214.79 kg ha-1), straw yield (10720.39 kg ha-1, 11324.10 kg ha-1 and 10939.79 kg ha-1) and harvest index (36.46 %, 32.26 % and 32.10 %) 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.), yield attributes and yield, Bio-fertilizer, organic manure and micro-nutrients

**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 the Asian region. It accounts for 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 the past three years. Total production of rice during 2019-20 was recorded as 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 human beings. 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 *el al.,* 2016)**

“The use of organic manures for improving and maintaining the soil health has been in practice since long time but its use is limited due to poor availability and higher cost of nutrients supplied through organic sources. Use of compost, FYM, vermicompost, green manures, green leaf manuring in crop rotation and biofertilizers to enrich soil organic carbon, supply all required plant nutrients and improve soil properties. Organic manures in agriculture add much needed organic and mineral matter to the soil. The organic matter added is an indispensable component of soil and plays an important role in maintenance and improvement of soil fertility and productivity. The proper management of these makes it possible to increase the efficiency of native and added nutrients. The proper use of organic fertilizers ensures better and sustainable yields, correcting some of the micro and secondary nutrient deficiencies. The use of organic fertilizers, increasing nutrient use efficiency, would lower the cost of production. The use of organic fertilizers will also help in maintaining soil health and productivity. Since, soil microbial and enzyme systems are associated with organic manure management, incorporation of organic manures into soil not only plays an important role in soil chemical and biological activity, but also affects the rate at which nutrients become available to crop plants. 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”. **(Sharma *et al.,* 2017)**

“Nitrogen, phosphorus and potassium as major nutrients, zinc and boron as micronutrients play an important role in the yield and quality of rice. The ability of the plants to produce more is dependent on the availability of adequate plant nutrients because cultivation of high yielding varieties coupled with intensive cropping system has depleted the soil fertility, causing multi-nutrient deficiencies in soil-plant system. Under such a situation, use of only one or two primary nutrients will not be sufficient for maintaining the long-term sustainability of crop production”. **(Reena et al., 2017 and Islam et al., 2014)**

“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, Zn is relatively immobile in plant, so 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)**

“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)**

**MATERIAL AND METHODS**

**Number of panicles m-2**

 Quadrant was kept on the field randomly than number of panicles was counted inside the quadrant and the mean value was subjected to statistical analysis.

**Number of panicle plant-1**

Panicles were counted from tagged plants and the mean value was calculated for statistical analysis.

**Panicle length (cm)**

The length of 4 panicles was measured (cm) using measuring scale and the mean value calculated and subjected to statistical analysis.

**Number of seeds panicle-1**

Previously tagged plants were taken for counting number of panicles per plant. After counting productive tillers from the plant, all the panicles were separated. The seed were separated from the panicles and kept without mixing them. Then the numbers of seeds were counted from each panicle and the mean value is used for statistical analysis.

**Grain weight panicle-1**

Four panicles were selected randomly and threshed to obtain grains. Weighted and the mean value used for statistical analysis.

**Test weight (g)**

Four samples ofone thousand seeds were taken from each plot and weighted separately and the mean value was subjected to statistical analysis.

**Biological yield (kg ha-1)**

The biological yield was obtained at harvest from each net plot by taking bundle weight and recorded as kilogram per plot. This was converted into kg per hectare by multiplying factor for statistical analysis.

**Grain Yield (kg ha-1)**

The grain yield obtained after threshing of crop produce of each net plot and was recorded as kilogram per plot. This was converted kg pec hectare by statistical analysis.

**Straw Yield (kg ha-1)**

The straw yield was worked out by subtracting the grain the weight of biological yield per plot in kilogram. It was converted into kg ha-1 by multiplying factor.

**Harvest index (%)**

The harvest index was computed with the help of following formula.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Harvest index | = | Economical yield | x | 100 |
| Biological yield |

**RESULTS AND DISCUSSION**

Variety PB-1121 recorded highest number of panicles m-2 (263.57), number of panicles plant-1 (11.21), panicle length (28.78 cm), number of seeds panicle-1 (91.42), grain weight panicle-1 (2.75 g) and test weight (27.34 g) maximum biological yield (16872.62 kg ha-1), grain yield (6152.24 kg ha-1), straw yield (10720.33 kg ha-1) and harvest index (36.46 %) in comparison with PB-1509 and PB-1 Several findings on the performance of different varieties of rice have been reported by **Nayak Somanate *et al.* (2022), Shikha *et al.* (2022), Ahmad Nafees *et al.* (2021), and Mohindra *et al.* (2017).**

The application of BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 along with NPK doses recorded significantly more number of panicles m-2 (251.29), number of panicles plant-1 (10.47), panicle length (27.92 cm), number of seeds panicle-1 (87.61), grain weight panicle-1 (2.85 g) and test weight (27.23 g) biological yield (16755.51 Kg ha-1), grain yield (5431.41 kg ha-1), straw yield (11324.10 kg ha-1) and harvest index (32.26%) as compared to FYM @ 10 t ha-1 and BGA @ 10 kg ha-1 treatments. **Neeraj *et al.* (2017)** reported that the application of FYM had increased the available of N, P, S, Fe, Zn, Cu and Mn content in soil. The residual effect of FYM maintained higher content of available P. K and Zn. These are supported by findings of **Chaudhary *et al.* (2021), Patel *et al.* (2013) and Jadhav *et al.* (2003).**

Application of NPK (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) sprayed at tillering stage recorded maximum number of paniclem-2 (251.58), number of panicle plant-1 (9.73), panicle length (27.21 cm), number of seeds panicle-1 (82.87), grain weight panicle-1 (2.65 g) and test weight (26.61 g) biological yield (16154.61 kg ha-1), grain yield (5214.79 kg ha-1) straw yield (10939.79 kg ha-1) and harvest index (32.10%) as compared to other treatments.The above findings are supported by the reports of **Kandali *et al.* (2015) and Singh *et al.* (2012).**

**Table 1: Effect of treatments on Number of seeds panicle-1, Grain weight panicle-1, Test weight (g) of scented rice**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment Combinations** | **Number of seeds panicle-1** | **Grain weight panicle-1 (g)** | **Test weight (g)** |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| **Scented Rice Varieties** |
| PB-1509 | 74.94 | 83.35 | 79.15 | 2.54 | 2.73 | 2.64 | 25.92 | 26.50 | 26.21 |
| PB-1121 | 85.54 | 97.29 | 91.42 | 2.64 | 2.86 | 2.75 | 27.13 | 27.54 | 27.34 |
| PB-1 | 66.44 | 75.05 | 70.75 | 2.24 | 2.44 | 2.34 | 25.03 | 25.68 | 25.35 |
| **SE (d) ±** | **0.45** | **0.64** | **0.67** | **0.07** | **0.07** | **0.09** | **0.11** | **0.12** | **0.14** |
| **CD (P=0.05)** | **1.24** | **1.76** | **1.55** | **0.19** | **0.20** | **0.20** | **0.31** | **0.33** | **0.33** |
| **Bio-fertilizer and organic manure** |
| BGA – 10 kg ha-1 | 68.37 | 77.24 | 72.81 | 2.13 | 2.36 | 2.25 | 25.13 | 25.61 | 25.37 |
| FYM – 10 t ha-1 | 76.00 | 85.78 | 80.89 | 2.44 | 2.64 | 2.54 | 26.03 | 26.57 | 26.30 |
| BGA -10 kg ha-1 + FYM 10 t ha-1 | 82.55 | 92.67 | 87.61 | 2.75 | 2.94 | 2.85 | 26.93 | 27.53 | 27.23 |
| **SE (d) ±** | **0.59** | **0.82** | **0.87** | **0.09** | **0.09** | **0.11** | **0.15** | **0.15** | **0.18** |
| **CD (P=0.05)** | **1.28** | **1.79** | **1.80** | **0.19** | **0.20** | **0.23** | **0.32** | **0.33** | **0.38** |
| **Nutrient Management** |
| N:P:K (120:60:60 kg ha-1) | 73.45 | 82.82 | 78.13 | 2.14 | 2.34 | 2.24 | 25.73 | 26.25 | 25.99 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at TS | 78.12 | 87.62 | 82.87 | 2.54 | 2.76 | 2.65 | 26.33 | 26.89 | 26.61 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at PIS | 75.35 | 85.26 | 80.31 | 2.44 | 2.64 | 2.54 | 26.03 | 26.57 | 26.30 |
| **SE (d) ±** | **0.37** | **0.52** | **0.55** | **0.06** | **0.06** | **0.07** | **0.09** | **0.09** | **0.12** |
| **CD (P=0.05)** | **0.75** | **1.05** | **1.10** | **0.11** | **0.12** | **0.14** | **0.19** | **0.19** | **0.23** |

**Table 2: Effect of treatments on Biological yield (kg ha-1), Grain yield (kg ha-1), Straw yield (kg ha-1) and Harvest index (%) of scented rice**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment Combinations** | **Biological yield (kg ha-1)** | **Grain yield (kg ha-1)** | **Straw yield (kg ha-1)** | **Harvest index (%)** |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| **Varieties** |
| PB-1509 | 15489.48 | 15701.46 | 15595.47 | 5019.77 | 5130.47 | 5075.12 | 10469.70 | 10570.92 | 10520.31 | 32.41 | 32.67 | 32.54 |
| PB-1121 | 16778.58 | 16966.65 | 16872.62 | 6071.69 | 6232.78 | 6152.24 | 10706.89 | 10733.88 | 10720.39 | 36.19 | 36.73 | 36.46 |
| PB-1 | 14932.48 | 15136.50 | 15034.49 | 4049.44 | 4135.52 | 4092.48 | 10883.04 | 11000.98 | 10942.01 | 27.09 | 27.29 | 27.19 |
| **SE (d) ±** | **272.25** | **290.85** | **345.02** | **95.26** | **108.85** | **125.27** | **109.32** | **68.00** | **111.49** | **0.88** | **0.14** | **0.14** |
| **CD (P=0.05)** | **751.63** | **802.98** | **795.61** | **262.99** | **300.52** | **288.87** | **301.81** | **187.74** | **257.11** | **0.24** | **0.38** | **0.33** |
| **Bio-fertilizer and organic manure** |
| BGA – 10 kg ha-1 | 14832.24 | 15004.95 | 14918.59 | 4739.59 | 4824.14 | 4781.87 | 10092.64 | 10180.74 | 10136.69 | 31.76 | 31.95 | 31.86 |
| FYM – 10 t ha-1 | 15722.15 | 15934.80 | 15828.48 | 5046.86 | 5166.27 | 5106.57 | 10675.29 | 10768.52 | 10721.91 | 31.93 | 32.24 | 32.09 |
| BGA - 10 kg ha-1 + FYM 10 t ha-1 | 16646.15 | 16864.87 | 16755.51 | 5354.45 | 5508.36 | 5431.41 | 11291.69 | 11356.51 | 11324.10 | 32.01 | 32.50 | 32.26 |
| **SE (d) ±** | **351.38** | **374.79** | **444.91** | **122.98** | **140.55** | **161.73** | **140.56** | **68.14** | **135.28** | **0.12** | **0.17** | **0.18** |
| **CD (P=0.05)** | **765.44** | **816.43** | **918.30** | **267.89** | **306.18** | **333.82** | **306.20** | **148.43** | **279.21** | **N.S.** | **0.38** | **0.38** |
| **Nutrient Management** |
| N:P:K (120:60:60 kg ha-1) | 15043.28 | 15253.70 | 15148.49 | 4759.62 | 4867.35 | 4813.49 | 10283.66 | 10386.35 | 10335.01 | 31.89 | 32.14 | 32.02 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at TS | 16064.21 | 16245.00 | 16154.61 | 5149.32 | 5280.25 | 5214.79 | 10914.90 | 10964.68 | 10939.79 | 31.88 | 32.32 | 32.10 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at PIS | 15722.04 | 15934.91 | 15828.48 | 5046.96 | 5166.17 | 5106.57 | 10675.07 | 10768.73 | 10721.90 | 31.93 | 32.23 | 32.08 |
| **SE (d) ±** | **222.23** | **237.04** | **281.39** | **77.78** | **88.89** | **102.29** | **88.89** | **136.22** | **140.87** | **0.07** | **0.11** | **0.12** |
| **CD (P=0.05)** | **450.82** | **480.86** | **559.96** | **157.78** | **180.32** | **203.55** | **180.33** | **276.34** | **280.33** | **N.S.** | **N.S.** | **N.S.** |

**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 value of seeds per panicle (91.42, 87.61 and 82.87, respectively), grain yield per panicle (2.75 g, 2.85 g and 2.65 g, respectively), test weight (27.34 g, 27.23 g and 26.61 g, respectively), biological yield (16872.62 kg ha-1, 16755.51 kg ha-1 and 16154.61 kg ha-1, respectively), grain yield (6152.24 kg ha-1, 5431.41 kg ha-1 and 5214.79 kg ha-1, respectively), straw yield (10720.39 kg ha-1, 11324.10 kg ha-1 and 10939.79 kg ha-1, respectively) and harvest index (36.46 %, 32.26 % and 32.10 %, respectively).

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