***Original Research Article***

**An Economic Study on the Production Enhancement of fragrant Rice (*Oryza sativa* L.) in Uttar Pradesh's Central Plain Zone using Bio Fertiliser, Organic Manure, and Micronutrients**

**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. The study was conducted to study the economics of production enhancement on rice through biofertiliser, organic manure, and micronutrients.Field experiments were conducted during the 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 a split-split plot design with three replications. The soil of the 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 net income (Rs 75749.43, Rs 61471.54 and Rs 57129.86) and B:C ratio (2.06, 1.85 and 1.79) 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.), gross income, net income and B:C ratio.

**INTRODUCTION**

“Rice (*Oryza sativa* L.) is the most important staple food of about more than 60% of the 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. 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”. (Anonymous, 2022a).

“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-year 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). “As per the 4th Advance Estimates for 2021-22, the food grain production in the country was estimated to be 315.72 million tonnes in which the total Rice production was estimated to be 130.29 million tonnes and the area under Rice cultivation was estimated to be 46.38 million hectare with a total productivity of 2809 kg per hectare during the year 2021-22” (Rajput 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. Crop diversity and its changes over space and time drive land use intensity and impact biodiversity of agricultural landscapes, while meeting the growing demand for human food and nutrition resources” (Moss et al., 2020; Estrada-Carmona et al., 2022). “The reliance on a few crops is the major reason for the widespread 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, a high level of available phosphorus in the soil usually ends up in zinc deficiency” (Bilski *et al.,* 2012).

“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).

“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). “Integrated nutrient management is a modified nutrient management technique with multifarious benefits, wherein a combination of all possible sources of plant nutrients is used in a crop nutrition package. Several studies conducted in various parts of the world have demonstrated the benefits of INM in terms of steep gain in soil health and crop yields and at the same time, reducing greenhouse gas emissions and other related problems. The INM practice in the cropped fields showed a 1,355% reduction in methane over conventional nutrient management” (Paramesh et al., 2023).

“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 the 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).

**MATERIAL AND METHODS**

**Cost of cultivation (Rs ha-1)**

The cost of cultivation was worked out treatment-wise. The common cost of cultivation of all treatments was added to the respective additional cost involved in each treatment. Based on input rates at the farm, we calculated the cost of cultivation. Costs associated with treatments were calculated separately. To obtain the total cost of cultivation, all expenses incurred in cultivation were taken into account, and treating costs (including interest on working capital) were added.

**Gross income (Rs ha-1)**

For gross income the grain yield kg ha-1 and straw yield kg ha-1 were multiplied by prevailing market price of the produce and gross income worked out.

Gross income = Total income from grain and straw yield

**Net income (Rs ha-1)**

For obtaining the net income, the cost of cultivation was subtracted from the gross income (Rs ha-1).

Net return = Gross return – cost of cultivation

**Benefit: Cost ratio (B:C)**

For calculating the cost benefit ratio, the gross income was divided by the cost of cultivation. The value obtained was considered as the Benefit: Cost ratio.

B:C ratio = Gross income (Rs ha-1) / Cost of Cultivation (Rs ha-1)

**RESULTS AND DISCUSSION**

On the basis of gross income, net income and B: C ratio the most profitable variety identified was PB-1121, which gave 14.87 % and 27.50 % more gross income, 29.14 % and 53.45 % more net income, 0.31 paise and 0.57 paise more B: C ratio compared to PB-1509 and PB-1, respectively. The variety PB-1121 recorded maximum gross income (Rs 147235.25 ha-1), net income Rs 75749.43 ha-1) and B:C ratio (2.06) and significantly higher over the other two varieties.

The application of BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 recorded 5.86 % and 11.68 % more gross income, 11.46 % and 20.65 % more net income and 0.10 and 0.16 paise more B: C ratio compared to only FYM @ 10 t ha-1 and only BGA @ 10 kg ha-1 treatments, respectively. The application of BGA @ 10 kg ha-1 + FYM @ 10 t ha-1 along with NPK doses recorded. maximum gross income (Rs 134285.70 ha-1), net income (Rs 61471.54 ha-1) and B:C ratio (1.85) and significantly superior as compared to FYM @ 10 t ha-1 and BGA @ 10 kg ha-1. The findings are in conformity with the results of Chaudhary *et al.,* (2021).

Among nutrient management treatments, NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) at tillering stage recorded significantly more gross income (6.36 %), net income (12.51 %) and more B: C ratio (0.09 paise) compared to only NPK treatment. The application of NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) at panicle initiation stage resulted in 4.39 % more gross income, 8.52 % more net income and 0.06 paise more B: C ratio compared to only NPK treatment, which found less responsive than FeSO4 applied at tillering stage. Application of NPK + ZnSO4 @ 25 kg ha-1 as basal + FeSO4 (1%) sprayed at tillering stage recorded maximum gross income (Rs 129080.70 ha-1), net income (Rs 57123.86 ha-1) and B:C ratio (1.79) which proved significantly superior as compared to other nutrient management treatments. The above findings are correlated with the Prakash *et al.,* (2015).

**Table 1: Effect of treatments on Grain yield (Kg ha-1) and Straw yield (Kg ha-1) of scented rice**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment Combinations** | **Grain yield (kg ha-1)** | | | **Straw yield (kg ha-1)** | | |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| **Varieties** | | | | | | |
| PB-1509 | 5019.77 | 5130.47 | 5075.12 | 10469.70 | 10570.92 | 10520.31 |
| PB-1121 | 6071.69 | 6232.78 | 6152.24 | 10706.89 | 10733.88 | 10720.39 |
| PB-1 | 4049.44 | 4135.52 | 4092.48 | 10883.04 | 11000.98 | 10942.01 |
| SE (d) ± | 95.26 | 108.85 | 125.27 | 109.32 | 68.00 | 111.49 |
| CD (P=0.05) | 262.99 | 300.52 | 288.87 | 301.81 | 187.74 | 257.11 |
| **Bio-fertilizer and organic manure** | | | | | | |
| BGA – 10 kg ha-1 | 4739.59 | 4824.14 | 4781.87 | 10092.64 | 10180.74 | 10136.69 |
| FYM – 10 t ha-1 | 5046.86 | 5166.27 | 5106.57 | 10675.29 | 10768.52 | 10721.91 |
| BGA10 kg ha-1 + FYM 10 t ha-1 | 5354.45 | 5508.36 | 5431.41 | 11291.69 | 11356.51 | 11324.10 |
| SE (d) ± | 122.98 | 140.55 | 161.73 | 140.56 | 68.14 | 135.28 |
| CD (P=0.05) | 267.89 | 306.18 | 333.82 | 306.20 | 148.43 | 279.21 |
| **Nutrient Management** | | | | | | |
| N:P:K (120:60:60 kg ha-1) | 4759.62 | 4867.35 | 4813.49 | 10283.66 | 10386.35 | 10335.01 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at TS | 5149.32 | 5280.25 | 5214.79 | 10914.90 | 10964.68 | 10939.79 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at PIS | 5046.96 | 5166.17 | 5106.57 | 10675.07 | 10768.73 | 10721.90 |
| SE (d) ± | 77.78 | 88.89 | 102.29 | 88.89 | 136.22 | 140.87 |
| CD (P=0.05) | 157.78 | 180.32 | 203.55 | 180.33 | 276.34 | 280.33 |

TS - Tillering Stage and PIS - Panicle Initiation Stage

**Table 2: Effect of treatments on Gross income (Rs ha-1), Net income (Rs ha-1) and B:C ratio of scented rice**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment Combinations** | **Gross income (Rs ha-1)** | | | **Net income (Rs ha-1)** | | | **B:C ratio** | | |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| **Varieties** | | | | | | | | | |
| PB-1509 | 120416.90 | 130243.40 | 125330.15 | 49288.26 | 58067.03 | 53677.65 | 1.69 | 1.80 | 1.75 |
| PB-1121 | 141345.90 | 153124.60 | 147235.25 | 70217.24 | 81281.62 | 75749.43 | 1.99 | 2.13 | 2.06 |
| PB-1 | 102501.90 | 110987.00 | 106744.45 | 31373.21 | 39144.04 | 35258.63 | 1.44 | 1.54 | 1.49 |
| SE (d) ± | 1767.88 | 1991.48 | 2306.19 | 1024.37 | 1316.34 | 2306.19 | 0.02 | 0.02 | 0.03 |
| CD (P=0.05) | 4880.76 | 5498.06 | 5318.07 | 2877.76 | 3634.14 | 5318.09 | 0.06 | 0.05 | 0.06 |
| **Bio-fertilizer and organic manure** | | | | | | | | | |
| BGA – 10 kg ha-1 | 114151.90 | 123049.90 | 118600.90 | 44679.94 | 52863.60 | 48771.77 | 1.64 | 1.75 | 1.69 |
| FYM – 10 t ha-1 | 121394.60 | 131451.80 | 126423.20 | 49937.64 | 58947.15 | 54442.39 | 1.69 | 1.81 | 1.75 |
| BGA10 kg ha-1 + FYM 10 t ha-1 | 128718.10 | 139853.30 | 134285.70 | 56261.14 | 66681.94 | 61471.54 | 1.78 | 1.91 | 1.85 |
| SE (d) ± | 2284.01 | 2576.71 | 1978.01 | 1346.83 | 1698.28 | 2981.96 | 0.03 | 0.02 | 0.03 |
| CD (P=0.05) | 4975.49 | 5613.10 | 4082.62 | 2933.93 | 3699.54 | 6154.78 | 0.06 | 0.05 | 0.07 |
| **Nutrient Management** | | | | | | | | | |
| N:P:K (120:60:60 kg ha-1) | 116023.90 | 125717.90 | 120870.90 | 45474.24 | 54488.28 | 49981.74 | 1.64 | 1.76 | 1.70 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at TS | 123909.60 | 134251.80 | 129080.70 | 52490.91 | 61768.80 | 57129.86 | 1.73 | 1.85 | 1.79 |
| N:P:K (120:60:60 kg ha-1) + ZnSO4 @ 25 kg ha-1 (Basal) + FeSO4 1% solution sprayed at PIS | 121396.20 | 131450.30 | 126423.25 | 49977.57 | 59300.61 | 54639.09 | 1.70 | 1.82 | 1.76 |
| SE (d) ± | 1444.43 | 1629.69 | 1885.93 | 851.86 | 1074.08 | 1885.93 | 0.02 | 0.02 | 0.02 |
| CD (P=0.05) | 2930.23 | 3306.07 | 3752.99 | 1728.11 | 2178.92 | 3752.99 | 0.04 | 0.03 | 0.04 |

TS - Tillering Stage and PIS - Panicle Initiation Stage

**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 net income (Rs 75749.43 ha-1, Rs 61471.54 ha-1and Rs 57129.86 ha-1, respectively) and B:C ratio (2.06, 1.85 and 1.79, respectively).

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**REFERENCES**

1. Anonymous (2022a).Agricultural Statistics at a Glance 2022. Directorate of Economics & Statistics, Department of Agriculture, Co-operation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India, New Delhi.
2. Anonymous (2022b). Statistical report, 2022. Directorate of Agriculture, Krishi Bhawan, Lucknow (U.P.)
3. Antech, A. Melash, Dejene, K. Mengistu, Dereje, A. Aberra (2016). Linking Agriculture with Health through Genetic and Agronomic Biofortification. *Scientific Research Publishing*, 7:295-307.
4. Bilski J, Jacob D, Soumaila F, Kraft C, Farnsworth A (2012). Agronomic biofortification of cereal crop plants with Fe, Zn and Se, by the utilization of coal fly ash as plant growth media. *Advances in Bioresearch*; 3(4):130-136
5. Chaudhary K., H C Tripathi, Kuldeep Singh, Shweta, A. Kumar (2021). Response of INM in rice in rice–wheat cropping system. *The Indian Journal of Agricultural Sciences* 91(1): 39-43.
6. Islam, M.R., Shaikh, M. S., Siddique, A. B. and Sumon, M. H. (2014) Yield and nutrient uptake by rice as influenced by integrated use of manures and fertilizers. *J. Bangladesh Agril. Univ*. 12 (1): 73-78.
7. Prakash C.G., Shivay Y.S., and Pooniya V (2015). Response of basmati rice (*Oryza sativa*) varieties to zinc fertilization. *Indian Journal of Agronomy* 60(3): 403-409.
8. Reena, Pandey, S. B; Tiwari, D. D., Nigam, R. C., Singh A. K. and Kumar, S. (2017). Effect of integrated nutrient management on yield and nutrients uptake of wheat and soil health. *Int. Arch. App. Sci. Technol*. 8 (3): 25-28.
9. Sharma A., Singh S.V., Patel A., Yadav R.A. (2017).Growth and yield of scented rice (*Oryza sativa* L.) as influenced by integrated nutrient management practices. *Research on crops*. 18 (3): 409-414
10. Rajput, A., Chaturvedi, P., Verma, A., & Singh, D. (2024). Growth, Variability and Decomposition Analysis of Rice in Major States of India. *Journal of Experimental Agriculture International*, *46*(7), 8–14.
11. Moss, C., Lukac, M., Harris, F., Outhwaite, C. L., Scheelbeek, P. F., Green, R., ... & Dangour, A. D. (2020). The effects of crop diversity and crop type on biological diversity in agricultural landscapes: a systematic review protocol. *Wellcome open research*, *4*, 101.
12. Pandarinathan, S., khatri, A., Niharika, M., Karthikeyan, K., Jagadeesan, R., Mohapatra, R., & Jena, J. P. (2024). Role of Micronutrients in Preventing Chronic Diseases: A Review. *European Journal of Nutrition & Food Safety*, *16*(12), 159–178.
13. Estrada-Carmona, N., Sánchez, A. C., Remans, R., & Jones, S. K. (2022). Complex agricultural landscapes host more biodiversity than simple ones: A global meta-analysis. *Proceedings of the National Academy of Sciences*, *119*(38), e2203385119.
14. Paramesh, V., Mohan Kumar, R., Rajanna, G. A., Gowda, S., Nath, A. J., Madival, Y., ... & Toraskar, S. (2023). Integrated nutrient management for improving crop yields, soil properties, and reducing greenhouse gas emissions. *Frontiers in Sustainable Food Systems*, *7*, 1173258.