



Effect of Bio-fertilizer, Organic Manure and Micro Nutrients on Growth Characteristics of Scented Rice (*Oryza sativa* L.)

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 plant height (96.45, 98.02 and 97.55cm), number of tillers m⁻² (285.53, 288.15 and 268.26), fresh weight (66.76, 64.95 and 61.90 g plant⁻¹) and dry weight (55.17, 53.69 and 51.17 g plant⁻¹) at harvest stage 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. Crop growth rate was also recorded significantly highest in the above treatments and found maximum at 45-90 DAT.

Keywords: Scented rice; DAT (Days after transplanting) and CGR (Crop growth rate).

1. 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 2nd largest producer in the world 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).

“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 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” (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. 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” (Kumar et al., 2014).

2. MATERIALS AND METHODS

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). The observations were recorded by using following procedure.

2.1 Plant Height (cm)

Four plants were selected at random from each plot within net plot area. They were tagged and labelled. The same plants were used to measure the height of the plant throughout the experiment. Height was measured using meter scale from bottom to the plant i.e. from the soil surface to the tip of the plant by extending the longer leaf. Average height was calculated by taking mean of all four plants.

2.2 Number of Tillers m⁻²

Number of tillers were recorded by counting tillers number per m² in each plot, then averaged and expressed in terms of number.

2.3 Fresh and Dry Weight (g plant⁻¹)

The samples were cut from each plot. The soil from roots was washed and cleaned using running water. The water was dried from the plants. Then the samples were weighted and fresh weight was recorded.

Then the same samples were kept in sun for 2-3 days for drying before keeping them in hot air oven. After sun drying, the plants were kept in oven for a day with the temperature of 60°C. After complete drying of the plants, the plants were weighted for their dry weight. The recordings were recorded as dry weight.

2.4 Crop Growth Rate (g plant⁻¹ day⁻¹)

It indicates at what rate the crop is growing i.e. weather the crop is growing at a faster rate or slower rate than normal. It is expressed as gram of dry matter produced per day in a specific area. It can be calculated as:

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W₁ and W₂ are dry weights of plant at time t₁ and t₂, respectively.

3. RESULTS AND DISCUSSION

The effect of different varieties, bio-fertilizer and organic manure levels and nutrient management treatments for improving growth characters viz. plant height, number of tillers m⁻², fresh weight, dry weight and crop growth rate are presented in Table 1 and Table 2.

Table 1. Effect of treatments on plant height (cm), number of tillers m⁻², fresh weight (g plant⁻¹) and dry weight (g plant⁻¹) at harvest stage of scented rice

Treatment Combinations	Plant height (cm) at harvest stage			Number of tillers m ⁻² at harvest stage			Fresh weight (g plant ⁻¹) at harvest stage			Dry weight (g plant ⁻¹) at harvest stage		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Varieties												
PB-1509	86.82	87.85	87.34	244.54	263.57	254.05	58.35	60.66	59.51	48.22	50.16	49.19
PB-1121	96.04	96.86	96.45	277.11	293.95	285.53	65.99	67.52	66.76	54.54	55.80	55.17
PB-1	102.02	103.28	102.65	224.36	245.74	235.05	53.86	55.18	54.52	44.52	45.61	45.07
SE (d) ±	1.08	1.18	1.39	2.08	2.27	2.66	1.18	1.27	0.87	0.73	0.82	0.54
CD (P=0.05)	2.99	3.26	3.19	5.73	6.27	6.14	3.26	3.51	1.99	2.00	2.25	1.26
Bio-fertilizer and organic manure												
BGA – 10 kg ha ⁻¹	89.93	90.77	90.35	219.49	238.82	229.16	54.99	56.85	55.92	45.46	46.98	46.22
FYM – 10 t ha ⁻¹	94.49	95.65	95.07	247.71	266.94	257.33	59.15	60.68	59.92	48.88	50.15	49.52
BGA10 kg ha ⁻¹ + FYM 10 t ha ⁻¹	97.46	98.57	98.02	278.81	297.49	288.15	64.07	65.84	64.95	52.95	54.44	53.69
SE (d) ±	1.41	1.52	1.79	2.69	2.93	3.45	1.52	1.64	1.12	0.94	1.05	0.71
CD (P=0.05)	3.06	3.32	3.70	5.87	6.38	7.11	3.32	3.57	2.31	2.04	2.29	1.46
Nutrient Management												
N:P:K (120:60:60 kg ha ⁻¹)	92.30	93.29	93.09	237.94	258.14	248.04	57.67	59.69	58.68	47.66	49.33	48.49
N:P:K (120:60:60 kg ha ⁻¹) + ZnSO ₄ @ 25 kg ha ⁻¹ (Basal) + FeSO ₄ 1% solution sprayed at TS	97.14	97.96	97.55	258.17	278.32	268.26	61.26	62.54	61.90	50.63	51.71	51.17
N:P:K (120:60:60 kg ha ⁻¹) + ZnSO ₄ @ 25 kg ha ⁻¹ (Basal) + FeSO ₄ 1% solution sprayed at PIS	94.85	96.14	95.49	249.89	266.80	258.34	59.28	61.14	60.21	48.99	50.53	49.76
SE (d) ±	0.89	0.96	1.13	1.70	1.85	2.18	0.96	1.04	0.71	0.59	0.67	0.45
CD (P=0.05)	1.80	1.95	2.26	3.46	3.76	4.33	1.95	2.10	1.41	1.20	1.35	0.89

TS - Tilling Stage and PIS - Panicle Initiation Stage

Table 2. Effect of treatments on crop growth rate (g plant⁻¹ day⁻¹) at 45-90 DAT and 90-harvesting stage of scented rice

Treatment Combinations	Crop growth rate (g plant ⁻¹ day ⁻¹) 0-45 DAT			Crop growth rate (g plant ⁻¹ day ⁻¹) 45-90 DAT			Crop growth rate (g plant ⁻¹ day ⁻¹) 90 DAT-harvest stage		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Varieties									
PB-1509	0.35	0.40	0.37	0.56	0.54	0.55	0.29	0.33	0.31
PB-1121	0.38	0.42	0.40	0.61	0.60	0.61	0.41	0.41	0.41
PB-1	0.31	0.34	0.32	0.49	0.49	0.49	0.34	0.33	0.34
SE (d) ±	0.007	0.006	0.004	0.008	0.007	0.005	0.02	0.01	0.008
CD (P=0.05)	0.02	0.02	0.01	0.02	0.02	0.01	0.04	0.03	0.01
Bio-fertilizer and organic manure									
BGA – 10 kg ha ⁻¹	0.32	0.35	0.33	0.53	0.52	0.53	0.30	0.31	0.31
FYM – 10 t ha ⁻¹	0.34	0.38	0.36	0.57	0.55	0.56	0.33	0.35	0.34
BGA10 kg ha ⁻¹ + FYM 10 t ha ⁻¹	0.38	0.43	0.40	0.57	0.57	0.57	0.41	0.39	0.40
SE (d) ±	0.010	0.008	0.006	0.011	0.009	0.006	0.02	0.01	0.01
CD (P=0.05)	0.02	0.02	0.01	0.02	0.02	0.01	0.04	0.03	0.02
Nutrient Management									
N:P:K (120:60:60 kg ha ⁻¹)	0.33	0.37	0.35	0.54	0.52	0.53	0.33	0.35	0.34
N:P:K (120:60:60 kg ha ⁻¹) + ZnSO ₄ @ 25 kg ha ⁻¹ (Basal) + FeSO ₄ 1% solution sprayed at TS	0.36	0.40	0.38	0.56	0.55	0.56	0.37	0.36	0.37
N:P:K (120:60:60 kg ha ⁻¹) + ZnSO ₄ @ 25 kg ha ⁻¹ (Basal) + FeSO ₄ 1% solution sprayed at PIS	0.34	0.38	0.36	0.56	0.54	0.55	0.36	0.36	0.36
SE (d) ±	0.009	0.007	0.005	0.007	0.006	0.004	0.01	0.009	0.007
CD (P=0.05)	0.001	0.01	0.01	0.01	0.01	0.008	0.02	0.00	0.01

TS - Tillering Stage and PIS - Panicle Initiation Stage

Among different varieties, PB-1121 exhibited significant increase in plant height, number of tillers m^{-2} , fresh weight, dry weight and crop growth rate at maturity compared to PB-1509 and PB-1, respectively. The variation in growth entities are an inherent character of individual varieties visible in different location and reported by different scientist viz. Nayak Somanath et al., (2022) and Ahmad et al., (2021).

The application of BGA @ 10 kg ha^{-1} + FYM @ 10 t ha^{-1} improved the growth characters significantly compared to FYM @ 10 t ha^{-1} and BGA @ 10 kg ha^{-1} treatment. The better efficiency of organic matter might be due to the fact that the organic manure especially FYM would have provided micro nutrients such as Zn, Cu, Fe, Mn and Mg to an optimum level. All of these micro nutrients play important role in chlorophyll constituent's formation which in turn increases rate of photo synthesis. Application of BGA @ 10 kg ha^{-1} + FYM @ 10 t ha^{-1} increased plant height (3.10 % and 8.49 %), number of tillers m^{-2} (11.98 % and 25.74 %), fresh weight (8.40 % and 16.15 %), dry weight (7.77 % and 12.14 %) at harvest stage and crop growth rate (1.79 % and 7.55 %) at 45-90 DAT when compared to FYM @ 10 t ha^{-1} and BGA @ 10 kg ha^{-1} treatments, respectively. The better efficiency of organic matter might be due to the fact that the organic manure especially FYM would have provided micro nutrient at optimum level which play important role in chlorophyll formation which increase rate of photosynthesis and ultimately growth of the plant. These results are in accordance with the findings of Chaudhary et al., (2021) and Tilahun et al., (2013).

Among nutrient management treatments application of NPK + $ZnSO_4$ @ 25 kg ha^{-1} as basal + $FeSO_4$ (1%) at tillering stage recorded significant improvement in growth characters viz. plant height (4.79 %), number of tillers m^{-2} (7.54 %), fresh weight (5.49 %), dry weight (5.27 %) at harvest stage and crop growth rate (5.66 %) at 45-90 DAT as compared to only NPK treatment (Control). Whereas, the application of NPK + $ZnSO_4$ @ 25 kg ha^{-1} as basal + $FeSO_4$ (1%) at panicle initiation stage recorded a lesser improvement in growth characters viz. plant height (2.58 %), number of tillers m^{-2} (3.99 %), fresh weight (2.61 %), dry weight (2.62 %) at harvest stage and crop growth rate (3.77 %) at 45-90 DAT more compared to only NPK

treatment (Control) but inferior to NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ (1%) at tillering stage.

Beneficial effect of Zn through soil incorporation and foliar application of $FeSO_4$ at tillering stage to affect an increase in growth characteristics in this study may probably be assigned to harmonious plant physiology as stated in several studies of Denre et al., (2017) and Kandali et al., (2015), (Tilahun-Tadesse et al., 2013).

An examination of the data revealed that among different varieties PB-1121 recorded maximum crop growth rate (0.61 and 0.41 at 45-90 DAT and 90 DAT – harvest stage, respectively) followed by PB-1509 and PB-1. It is also noticed that among all the varieties crop growth rate was maximum at 45-90 DAT, stage and therefore decreasing crop growth rate was noticed at 90 DAT to harvest stage. Similar findings were also reported by Shikha et al., (2022).

The application of BGA @ 10 kg ha^{-1} + FYM @ 10 t ha^{-1} recorded significantly higher crop growth rate (0.57 and 0.40 at 45-90 DAT and 90 DAT – harvest stage, respectively) followed by FYM @ 10 t ha^{-1} applied individually. These results are in accordance with the findings of Ranjitha and Reddy (2014).

Under nutrient management treatments application of NPK + $ZnSO_4$ as basal + $FeSO_4$ at tillering stage recorded significantly more crop growth rate (0.56 and 0.37 at 45-90 DAT and 90 DAT – harvest stage, respectively) followed by NPK + $ZnSO_4$ as basal + $FeSO_4$ at panicle initiation stage and minimum crop growth rate i.e., 0.53 at 45-90 DAT and 0.34 at 90 DAT – harvest stage, respectively recorded under only NPK treatments. Similar to the findings of Dubey et al., (2016).

4. 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 + $ZnSO_4$ @ 25 kg ha^{-1} as basal + $FeSO_4$ (1%) sprayed at tillering stage showed significantly higher value of plant height (96.45, 98.02 and 97.55 cm, respectively), number of tillers m^{-2} (285.53, 288.15 and 268.26, respectively), fresh weight (66.76, 64.95 and

61.90 g plant⁻¹, respectively) and dry weight (55.17, 53.69 and 51.17 g plant⁻¹, respectively). Crop growth rate was maximum at 45-90 DAT.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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 writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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