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FYM and zinc management for enhanced productivity and profitability of Rice (*Oryza sativa* L.) cv. PB 1718

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Abstract

The alkaline, zinc-deficient soils of western Uttar Pradesh restrict the productivity of high-yielding aromatic rice cultivars like PB-1718 in the region. An integrated nutrient management that include organic farmyard manure (FYM) and micronutrient zinc supplementation can be the strategy to overcome the constraint. A field experiment aimed to evaluate the effect of different combinations of FYM, zinc and recommended doses of fertilizers (RDF) on the agronomic performance and economic feasibility of the rice variety PB 1718. A randomized field experiment with seven nutrient treatments, replicated thrice, was conducted at SVPUAT, Meerut, India. The result revealed that application of 90% RDF + FYM @ 2.5 t ha⁻¹ + Zn @ 12.5 kg ha⁻¹ (T₇) recorded the highest plant height and maximum dry matter accumulation at successive growth stages. The application of 100% RDF + Zinc @ 25.0 kg ha⁻¹ (T₆) achieved the highest number of panicles (275 m⁻²), grain yield (47.4 q ha⁻¹) and straw yield (78.4 q ha⁻¹), which was statistically at par with treatment T₇. The maximum Harvest Index was observed with treatment T₇. Treatment T₇ recorded maximum economic returns, resulted in highest net return and highest benefit-cost ratio (3.70). Multi-year experimental validation is necessary to confirm the long-term sustainability of the approach.

Keywords: FYM, organic, PB1718, rice, zinc

Introduction

Rice (*Oryza sativa* L.) is the primary staple food for over 3.5 billion people globally and contributes approximately 19% of global nutritional energy requirements. In India, rice is cultivated on 47.80 million hectares and produces 135.52 million tonnes annually, with an average yield of 2835 kg ha⁻¹ (DES, 2025). Within India, Uttar Pradesh is a leading state in terms of area and production of rice, with 7.35 million hectares and 20.76 million tonnes production during 2024-25. However, the productivity of rice in Uttar Pradesh (2824 kg ha⁻¹) is still lower than in other leading states, such as Punjab (4428 kg ha⁻¹) and Telangana (3627 kg ha⁻¹). The farming system needs to improve productivity to meet the rising food demand of the growing population. The limited availability of cultivable land poses a challenge to increasing the production. Thus, measures for improving productivity should focus on improving soil fertility, nutrient levels and organic matter content, along with high-potential cultivars. PB 1718, a marker assisted selection (MAS) derived cultivar, has a high yield potential of 46.4 q ha⁻¹ but its performance is dependent on localized soil nutrient optimization. Strategic nutrient management approaches that address both macro- and micronutrient requirements are essential for sustainable intensification of rice production.

Soil nutrient management is an important factor in improving rice production. Ensuring an adequate dose of fertilizer is essential for enhancing grain production and achieving maximum profitability (Khuang, 2008) [5]. Integrated Nutrient Management (INM), which combines organic amendments, like farmyard manure (FYM) with inorganic fertilizers, is a viable approach for improving nutrient-use efficiency and production. Farmyard manure (FYM) and zinc (Zn) are important for improve the soil fertility and crop yield. FYM contains approximately 0.5 per cent N, 0.2 per cent P₂O₅ and 0.5 per cent K₂O and acts as a slow-release source of nutrient. It improves soil structure, water retention capacity, microbial activity and nutrient availability. Zn is important for enzymatic processes, protein synthesis, carbohydrate metabolism and regulation of gene expression (Alloway, 2008) [1]. Zinc deficiency affects approximately 50% of cereal growing

soils globally and 8% of Indian soils are reported to have acute zinc deficiency (Shukla *et al.*, 2021) ^[11]. Previous studies have demonstrated that integrating organic manures with inorganic fertilizers enhances crop yields. However, there is a significant research gap regards to the specific interactions, optimal application rates and economic viability of the application of different levels of FYM and zinc along with reduced chemical fertilizer inputs for PB 1718 under the distinct agro-climatic conditions of western Uttar Pradesh. Therefore, the present investigation was undertaken with the following objectives: i) to study the effect of different levels of farmyard manure and zinc supplementation on the growth and yield attributes of rice variety PB 1718, ii) to evaluate the economic feasibility of these treatments to identify a financially better strategy for farmers.

Materials and Methods

The experiment was conducted at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology (SVPUAT), Meerut (U.P.) during *Kharif* season 2023. The area received a total of 925.6 mm of rainfall during the experiment crop growth period, from the 24th to the 46th meteorological week of 2023 (Fig. 1). The soil of the experimental site was clay loamy with 46.8, 17.6 and 35.8% sand, silt and clay, respectively. The initial soil analysis of the site indicated an alkaline pH of 7.85, electrical conductivity (EC) of 0.20 dSm⁻¹, organic carbon content of 0.40% (4.0 g kg⁻¹), available nitrogen 190 kg ha⁻¹, available phosphorous was 13.6 kg ha⁻¹, available potassium of 196 kg ha⁻¹ and DTPA extractable Zn of 0.51 mg kg⁻¹. The rice variety PB 1718 was selected as the experimental crop. The field trial was conducted using randomized block design (RBD) consisting of seven distinct nutrient management treatments. Each treatment was replicated thrice. The treatments comprised of Zn and FYM with the combination of Recommended Dose of Fertilizers (RDF) (standard for 100% RDF was selected as NPK @ 120:60:60).

Table 1: Treatment details are as follows

T ₁	Control
T ₂	100% RDF
T ₃	90% RDF + FYM @ 2.5 t ha ⁻¹
T ₄	100% RDF + Zinc @ 5.0 kg ha ⁻¹
T ₅	80% RDF + FYM @ 5.0 t ha ⁻¹
T ₆	100% RDF + Zinc @ 25.0 kg ha ⁻¹
T ₇	90% RDF + FYM @ 2.5 t ha ⁻¹ + Zinc @ 12.5 kg ha ⁻¹

Farmyard manure was applied at the required dose one week prior to transplantation. Urea, Diammonium Phosphate (DAP), Muriate of Potash (MOP), and zinc sulphate were used to provide N, P, K, and Zn, respectively. Growth observations were recorded at 30, 60, 90 days after transplanting (DAT) and at harvest. Grain and straw yields were recorded plot-wise after threshing the produce. The yield of the net plot was converted to q ha⁻¹. The dry weight of straw was collected from the net plot and recorded; the grain yield was recorded in kg per plot and then converted to q ha⁻¹. Economic parameters were calculated based on local market costs of cultivation inputs and prevailing market prices for commodity returns.

Statistical Analysis

Experimental data on growth parameters, yield attributes, and economic outputs were analyzed using analysis of variance (ANOVA). The standard error of the mean (S.E.m.±) was calculated for each parameter. To determine the statistical significance among treatment means, the Critical Difference (CD) was computed at the 5% (p = 0.05) probability level.

Results and Discussion

Growth Parameters

Plant Height

The application of micronutrient zinc and organic farmyard manure significantly increased plant height at all stages of growth compared to the control (T₁), with a relatively higher percentage increase observed in the initial period from 30 to 90 days after transplanting (DAT) than in the later stages of the crop growth period. At 30 DAT, plant height varied from 36.6 cm to 47.0 cm, highest in plots treated with 90% RDF + FYM @ 2.5 t ha⁻¹ + Zinc @ 12.5 kg ha⁻¹ (T₇). Throughout the crop cycle, Treatment T₇ demonstrated superior performance compared to the other treatments, with recorded heights of 97.3 cm at 60 days after transplanting (DAT), 110.6 cm at 90 DAT, and 120.6 cm at harvest (Fig. 2). The control plot (T₁) consistently recorded the minimum plant height across all intervals (36.6 cm, 86.0 cm, 92.1 cm and 94.7 cm, respectively).

The increase in plant height can be attributed to the optimal and balanced application of both macro- and micronutrients. While nitrogen is essential for vegetative cell division and elongation, it was rapidly supplied by inorganic fertilizers, and the incorporated farmyard manure served as a steady slow-releasing nutrient reservoir. Supplementary zinc enhanced nutrient utilization through its synergistic interaction with FYM, acting as a structural promoter of enzymatic function and growth hormones. These findings align with those of Sharma *et al.* (2014) ^[10] and Kumar *et al.* (2019) ^[7], who reported enhanced elongation in rice cultivars managed with integrated nutrient systems.

Dry matter accumulation (g m⁻²)

The plot treated with 90% RDF + FYM @ 2.5 t ha⁻¹ + Zn @ 12.5 kg ha⁻¹ (T₇) exhibited the maximum dry matter accumulation at all development stages, recording 193.40 g m⁻² at 30 DAT, 764.56 g m⁻² at 60 DAT, 956.31 g m⁻² at 90 DAT and 1407.40 g m⁻² at harvest (Table 2). Statistical analysis indicated that the biomass accumulation under T₇ was statistically at par with the application of Zinc @ 25.0 kg ha⁻¹. The control plot (T₁) yielded the minimum dry matter accumulation at all stages.

The minimum DMA observed in the control plots confirmed that unmanaged alkaline soils restrict vegetative development owing to inherent nutrient limitations. The significant enhancement of DMA following zinc application is linked to the fundamental biological role of zinc in enzyme activation, protein synthesis, carbohydrate metabolism and growth hormone (auxin) production. When integrated with organic amendments, FYM modifies the soil environment, improving nutrient availability and structural water retention, which sustains the biomass production. Amanullah and Inamullah (2016) ^[2] also concluded that balanced zinc nutrition in accelerating dry matter partitioning.

No. of tillers

The number of tillers in rice significantly differed by the application of Zn micronutrient and FYM along with RDF at all stages compared to the control throughout the experiment. The number of tillers per m² varied from 96.00 to 145.60 at 30 DAT, 140.0 to 212.80 at 60 DAT, 201.0 to 269.0 at 90 DAT and 192.0 to 287.0 at harvest. The maximum number of tillers per m² was found with treatment T₆ (100% RDF + Zinc @ 25.0 kg ha⁻¹) at all stages of rice cultivation, namely, at 30 DAT, 60 DAT, 90 DAT and harvest. The minimum number of tillers per m² (96.0, 140.0, 201.0 and 192.0) was recorded in the control treatment plot (T₁) at 30, 60 and 90 DAT and at harvest. Statistically T₆ was at par with T₇ at 30 DAT and significantly superior to rest of the treatments at 60, 90 DAT and harvest.

This significant increase in vegetative tillers under treatments with high Zn inputs (T_6 and T_7) suggests that nutrient management minimizes tiller mortality. Adequate zinc availability promotes advanced enzymatic activity and auxin metabolism in plant tissues, increasing nutrient uptake and early bud initiation. Different treatment combinations showed significant improvement over 100% NPK and the control, suggesting that combining macro- and micronutrients optimizes vegetative development. These results align with the findings of Khan *et al.* (2007)^[4] and Sharma *et al.* (2014)^[10].

Test weight

A non-significant increase in the test weight of grain was observed. The highest and lowest 1000-grain weights were observed for T_6 and Control (T_1) at 21.53 g and 19.52 g, respectively. The highest 1000 grain weight was recorded with T_6 followed by T_7 .

Test weight remained statistically constant owing to the strong genetic control within the PB 1718 variety, the increase in panicle numbers directly laid the foundation for higher final grain yields. The result is consistent with the findings of Kumar *et al.* (2022)^[6] and Sharma *et al.* (2014)^[10].

Effect on yield

Grain, straw yield and biological yield

Among the different treatments, the highest grain and straw yield of 47.4 q ha⁻¹, 78.4 q ha⁻¹, respectively, were recorded with the application of 100% RDF + Zn @ 25.0 kg ha⁻¹, which was at par with 46.9 q ha⁻¹, 77.0 q ha⁻¹ with the application of 90% RDF along with FYM at 2.5 t ha⁻¹ rate and zinc @ 12.5 kg ha⁻¹. The highest biological yield of 125.80 q ha⁻¹ was obtained with treatment T_6 , which was at par with the yield obtained with the application of 90% RDF + FYM @ 2.5 t ha⁻¹ + zinc at 12.5 kg ha⁻¹ along with 100% RDF and with 100% RDF + Zinc @ 5.0 kg ha⁻¹ (Fig. 3). The lowest yield was recorded in the control.

The increase in grain and straw yields was attributed to the positive impact of Zn on root proliferation and nutrient uptake. Adding zinc and RDF enhances photosynthetic activity and improves nutrient translocation from source to sink tissues, providing a continuous nutrient supply throughout the reproductive phase. In the alkaline soils of western Uttar Pradesh,

high pH levels restrict zinc solubility and bioavailability further limiting crop yields. Direct zinc application reduces this constraint and prevents yield losses associated with interveinal chlorosis or stunted growth. The integrated treatment (T_7) enhances nutrient-use efficiency and allows for a 10% reduction in chemical fertilizer inputs without reducing yield. These outcomes match those reported by Singh *et al.* (2018)^[14] and Saxena *et al.* (2019)^[9].

Harvest Index

A Non-significant influence of FYM and Zn treatments along with RDF was observed on Harvest index of Rice. Among the treatments, the application of 90% RDF+ FYM @2.5 t ha⁻¹ + Zinc @ 12.5 kg ha⁻¹ resulted in the maximum Harvest Index followed by 100% RDF + Zinc @ 25.0 kg ha⁻¹. The minimum harvest index was observed in the control T_1 .

Increase in harvest index over the control and sole 100% NPK due to addition of zinc and FYM is driven by effective dry matter partitioning between source and sink as influenced by nutrient management. Amanullah and Inamullah (2016)^[2] reported an effective partitioning resulted in greater HI upon the application of Zn.

Economic feasibility of different parameters

The result indicated that different treatments had a significant impact on gross returns, net returns and benefit-cost ratio. The highest gross return were recorded with application of 100% RDF + Zinc @ 25.0 kg ha⁻¹, at par with 90% RDF+ FYM @2.5 t ha⁻¹ + Zinc @ 12.5 kg ha⁻¹. Both of the treatments were significantly superior to the rest of the treatment. The maximum B: C ratio of 3.7 was observed with the treatment T_7 (Table 3). The minimum gross return and net return were observed with T_1 , control.

The highest initial cultivation costs occurred in treatments utilizing farmyard manure (FYM). However, because a single application of FYM provides residual soil benefits that last for roughly three years, the long-term management expenses for plots under treatments T_7 , T_3 and T_5 are expected to drop progressively in subsequent seasons. T_6 recorded highest gross, net return and higher B: C ratio. Combined application of organic manure and inorganic fertilizers led to higher monetary returns, as also observed by Singh *et al.* (2016)^[12] and Tomar *et al.* (2018)^[15].

Table 2: Effect of different treatment combination on plant height, Dry matter accumulation and number of tillers at different stages. (DAT – Days after transplanting)

Treatment	Plant Height(cm)				Dry matter accumulation (g m ⁻²)				Number of tillers m ⁻²			
	30 DAT	60 DAT	90 DAT	At Harvest	30 DAT	60 DAT	90 DAT	At Harvest	30 DAT	60 DAT	90 DAT	At Harvest
T_1	36.6	86.0	92.1	94.7	102.33	509.26	725.04	813.60	96.0	140.0	201.0	192.0
T_2	41.1	90.3	99.4	102.2	170.36	703.70	878.43	1168.15	120.0	168.0	230.0	247.0
T_3	42.6	92.1	102.9	106.6	179.23	724.43	939.3	1211.63	124.4	173.6	246.0	256.0
T_4	44.0	94.4	105.9	115.0	187.86	743.00	927.23	1351.23	136.4	190.4	253.0	270.0
T_5	43.0	91.1	103.7	112.8	181.06	727.93	896.37	1295.42	129.0	179.2	249.0	260.0
T_6	45.1	95.0	107.8	118.0	191.80	760.96	927.23	1401.40	145.6	212.8	269.0	287.0
T_7	47.0	97.3	110.6	120.6	193.40	764.56	956.31	1407.40	142.3	207.2	259	278
S.Em.±	0.33	0.62	0.55	0.67	2.76	2.82	10.24	12.82	1.09	1.33	2.21	1.75
CD at 5%	0.99	1.93	1.72	2.07	8.09	8.28	31.55	37.62	3.36	4.02	6.78	5.42

Table 3: Effect of different treatment combination on yield attributing characters, yield and economic parameters

Treatment	No. of panicles m ⁻²	Test weight (g)	Grain Yield (q ha ⁻¹)	Straw Yield (q ha ⁻¹)	Biological Yield (q ha ⁻¹)	Harvest Index (%)	Total Cost (Rs.)	Gross Return (Rs.)	Net Return (Rs.)	B:C
T_1	180	19.52	28.0	51.20	79.20	35.35	28581	89127	60546	3.11
T_2	234	19.91	41.20	69.00	110.20	37.39	39677	130500	90823	3.29
T_3	244	20.28	43.40	72.90	116.30	37.32	39818	137493	97675	3.45
T_4	256	20.87	44.90	76.40	121.30	37.02	40177	142340	102163	3.54
T_5	249	20.43	43.60	73.10	116.70	37.36	39959	138110	98151	3.46
T_6	275	21.53	47.40	78.40	125.80	37.68	42177	150040	107863	3.56
T_7	266	21.39	46.90	77.00	123.90	37.85	39818	148500	108682	3.70
S.Em. ±	4.09	2.40	0.83	1.12	2.08	7.56		1707	1707	0.04
CD @ 5%	12.63	NS	2.56	3.45	6.4	NS		5262	5262	0.14

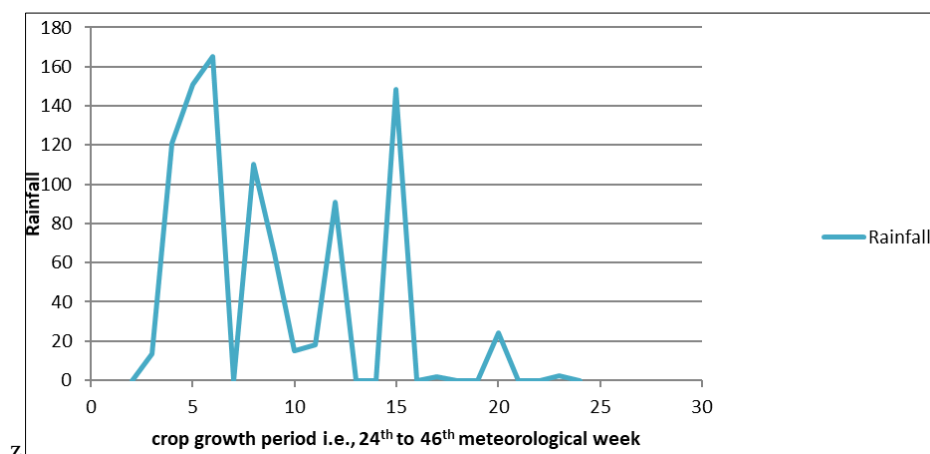


Fig 1: Depicting the rainfall during the crop growth period 24th to 46th meteorological week of year 2023

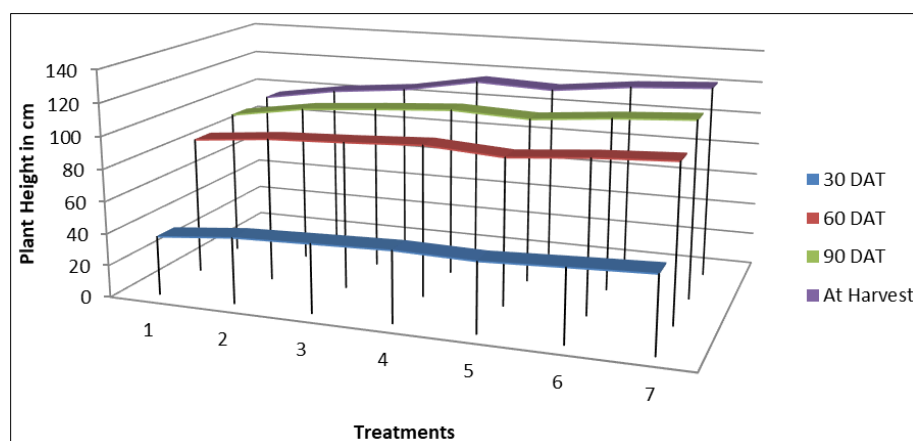


Fig 2: Shows the effect of different combination of FYM and zinc on Plant height of rice

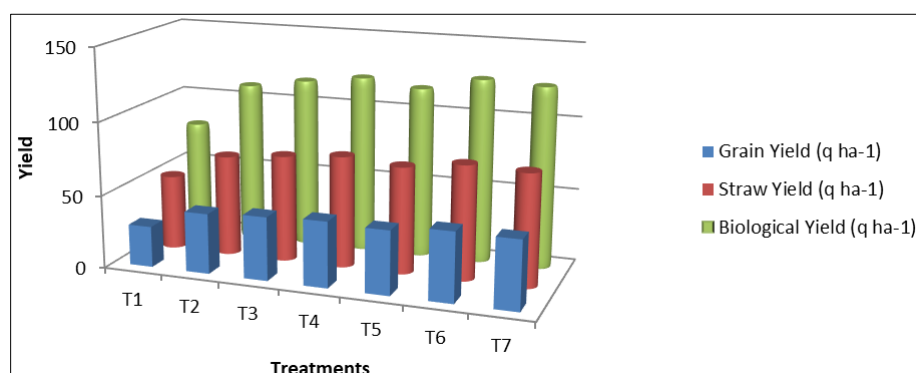


Fig 3: Shows the effect of different combination of FYM and zinc on Rice yield

Conclusion

Based on the finding of the study it can be concluded that integrated application of farmyard manure at the rate of 2.5 t ha^{-1} in combination with zinc at 12.5 kg ha^{-1} and 90% of recommended dose of fertilizers proved effective in increasing the yield attributing character, yield and economic parameters. The combined application of FYM and zinc along with RDF resulted in significantly higher grain yield compared to their individual application, highlighted the synergistic effect between organic and inorganic nutrient sources. The finding suggests the possibility of reducing chemical fertilizers without compromising yield through the judicious integration of organic manure and micronutrients. However, validation of these results through multi-year and multi-location studies is necessary to confirm their long-term effects on productivity and economic feasibility of

treatment combination.

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