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Zinc and Iron Management in Different Basmati (*Oryza sativa* L.) Varieties under Un-puddled Conditions

Sumeet Kaur[1], Gurinderjit Kaur[2]*, Gurkirat Singh Aulakh[3] and Sumandeep[4]

[1]Department of Agriculture, Khalsa College, Amritsar, Punjab, India

[2]Assistant Professor, Department of Economics. S.G.A.D. Govt. College, Tarn Taran, Punjab, India

[3]Assistant Professor, Department of Agriculture, Khalsa College, Amritsar, Punjab, India

[4]Department of Agriculture, Khalsa College, Amritsar, Punjab, India

*Corresponding author Email: kaurgurinder742gmail.com

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Abstract

A field experiment was carried out at Student's Farm, Khalsa College, Amritsar during *kharif* season, 2023 to study effect of zinc and iron management in different Basmati (*Oryza sativa* L.) varieties under un-puddled conditions**.** The field experiment was laid out in Split plot design having three varieties *i.e.,* V_1 (Pusa Basmati 1509), V_2 (Pusa Basmati 1847) and V_3 (Punjab Basmati 7) in main plot and four different micronutrient applications *i.e.,* T_1 (control), T_2 ($FeSO_4$ @ 1%), T_3 ($ZnSO_4$ @ 25 kg acre^{-1}), T_4 ($FeSO_4$ @ 1% + $ZnSO_4$ @ 25 kg acre^{-1}) in sub-plot. The results revealed that the highest plant height (102.2 cm) was recorded in V_2, while leaf area index (3.53), dry matter accumulation (117.1 q ha^{-1}) and number of tillers m^{-2} (283) were recorded highest in V_3. Also, the highest yield attributes *i.e.,* effective tillers m^{-2} (268), number of filled grains panicle^{-1} (85.8), grain yield (45.3 q ha^{-1}), straw yield (66 q ha^{-1}) and harvest index (40.7%) were observed under V_3. The highest B:C ratio was found in V_1 (2.74). Among micronutrient application, T_4 recorded highest growth attributes *i.e.,* plant height (108.3 cm), leaf area index (3.5), dry matter accumulation (121 q ha^{-1}) and number of tillers m^{-2} (293). Also, highest yield attributes *i.e.,* effective number of tillers m^{-2} (270), number of filled grains panicle^{-1} (87.3), panicle length (26.5cm), 1000 grain weight (23.9), grain yield (45.5q ha^{-1}), straw yield (66 q ha^{-1}) and harvest index (40.7) were observed under T_4. The highest B:C ratio (2.83) was observed in T_2. These findings demonstrate that application of zinc and iron can significantly improve yield of rice under un-puddled conditions.

Keywords: Zinc and Iron management, un-puddled, rice, Basmati varieties, micronutrients.

Introduction

Rice (*Oryza sativa* L.) is a major cereal crop and nutritionally staple food consumed by half of the world's population (Barua and Saikia, 2018). It is mostly cultivated by transplanting the seedlings in puddled conditions that involves the creation of anaerobic environment through continuous submergence of rice fields. The various adverse effects associated with this method include poor soil structure, inefficient water use and more methane emission. All these factors have led to need of cultivation of rice under un-puddled conditions. It involves ploughing and planking of dry soil so that soil become compact and then transplanting of seedlings is done in moist soil conditions. This method can be considered as feasible option to save water and prevent adverse effects of puddling.

The production factors such as selection of a variety plays an important role in enhancing the productivity of rice. Certain rice varieties are better adapted to certain crop setup methods and farmer management approaches (Adilakshmi *et al*., 2022). Rice is available in 5000 varieties, of which Basmati rice occupies special status and is known as the 'Queen of Rice'. Punjab Basmati 7, Pusa Basmati 1847 and Pusa Basmati 1509 are semi-dwarf varieties having extra-long grains with excellent cooking and eating quality characters. Punjab Basmati 7 and Pusa Basmati 1847 are resistant to all ten types of bacterial blight pathogens (Anonymous, 2024). Several researchers reported significantly different responses of different genotypes to various management variables and environments with respect to the growth attributes due to inherent characteristics. It is essential to harness the potential of different basmati varieties under un-puddled conditions to evaluate their performance.

As a result of the green revolution in developing countries like India, agricultural produce failed to meet up zinc and iron requirements for human nutrition (Rao *et al*., 2019). Micronutrient malnutrition has been designated as the most serious challenge to humanity. Also, deficiency of micronutrients is of major concern under un-puddled conditions. Availability of zinc is reduced because of reduced release of zinc from highly insoluble fractions in aerobic conditions (Abdullah, 2015) and iron may become limiting because of oxidation of iron from ferrous to ferric form which are less soluble and not easily available to plants (Yadav *et al*., 2013). Though number of literature on zinc and iron dynamics in puddled rice conditions are available but to the best of our knowledge, the study on the effect of zinc and iron on growth and production of rice under un-puddled conditions is limited. Keeping this into consideration, the present study entitled, "Zinc and iron management in different Basmati (*Oryza sativa* L.) varieties under un-puddled conditions" was undertaken.

Materials and Methods

The field experiment was carried out during *kharif* season, 2023 at the student's research farm, Khalsa College, Amritsar [31.63°N latitude and 74.83°E longitude]. The soil of experimental field was sandy loam with soil pH 8.1, low in available nitrogen (195 kg/ha), low in available phosphorus (18 kg/ha), medium in available potassium (263 kg/ha), low in available zinc (0.44 mg/kg) and high in available iron (9.8 mg/kg).

The experiment was laid out in split plot design comprising three varieties V_1 (Pusa Basmati 1509), V_2 (Pusa Basmati 1847) and V_3 (Punjab Basmati 7) in main plot and four micronutrient treatments T_1 (control- no zinc and iron), T_2 (foliar application of $FeSO_4$ @ 1% at 20 days after transplanting), T_3 (soil application of $ZnSO_4$ @ 25 kg/acre at transplanting) and T_4 (foliar application of $FeSO_4$ @ 1% at 20 days after transplanting + soil application of $ZnSO_4$ @ 25 kg/acre at transplanting) in subplots with three replications.

For sowing, nursery field was ploughed twice with disc harrow and cultivated twice with tractor drawn cultivator followed by heavy planking to make soil compact. The basmati varieties were sown on 15 June and were transplanted on 15 July with spacing of 20 x 15 cm. Light irrigation was applied to the main field before transplanting. Recommended dose of fertilizers (N @ 105 kg/ha and P @ 30 kg/ha) was applied to the crop. Nitrogen was applied through urea in two equal splits at 21 days and 42 days after transplanting. Phosphorus was applied as single super phosphate before transplanting. Whole of $ZnSO_4$ (21%) @ 25 kg/acre was applied as basal dose and FeSO4 @ 1% was applied as foliar application @ 20 days after transplanting. Plant height, leaf area index, number of tillers m^{-2} and dry matter accumulation were recorded at harvest by randomly selecting five plants in each experimental unit. Plant height was measured form ground level to the tip of panicle and expressed in centimeters. Dry matter accumulation was recorded by randomly selecting five plants that were sundried for three days and then oven dried at 60°C till constant weight was obtained and data was expressed as q/ha. Leaf area index was calculated using leaf area meter. Total number of tillers and number of effective tillers m^{-2} were counted from five randomly selected plants and were expressed as tillers m^{-2} and panicles m^{-2}. Five plants were randomly selected from each experimental unit for recording panicle length, number of grains $panicle^{-1}$. To obtain 1000 grain weight, 1000 grains were counted and weighed on electronic balance. Grain yield was recorded from each plot and expressed as q/ha. The weight of straw from each plot was also recorded three days after harvest for estimation of straw yield, which was expressed as q/ha. Data was subjected to analysis of variance using OP stat. Economics of different treatments were calculated by taking into account cost of inputs and price of outputs in local market and benefit: cost ratio was calculated by dividing net returns with variable cost.

Results and Discussion

Effect of varieties and micronutrient application on growth characters of rice

Plant height, leaf area index, number of tillers and dry matter accumulation were significantly influenced by basmati varieties and micronutrient applications. **(Table 1)** depicted that among varieties, the highest plant height (104.5 cm) was recorded in V2 (Pusa Basmati 1847) which was statistically at par with V3 (Punjab Basmati 7), however both were significantly higher than V1 (Pusa Basmati 1509). The highest leaf area index (3.5), number of tillers m^{-2} (283) and dry matter accumulation (117.1 q/ha) were recorded in V3 (Pusa Basmati 7) which was statistically at par with V2 (Pusa Basmati 1847), and both were significantly higher than V1 (Pusa Basmati 1509) which recorded lowest values of these parameters. This might be due to genetic variation in characters of the variety. These results are in conformity with Maurya *et al*., (2021). Among micronutrient application, T4 (foliar application of FeSO4 @ 1% at 20 days after transplanting + soil application of ZnSO4 @ 25 kg/acre at transplanting) recorded highest plant height (108.3 cm), leaf area index (3.5), number of tillers m^{-2} (293) and dry matter accumulation (121.7 q/ha) which was statistically at par with T3 (soil application of ZnSO4 @ 25 kg/acre at transplanting), however, both the treatments were significantly higher than control which recorded lowest values of all these parameters. Highest growth attributes in T4 might be due to effect of increased photosynthetic process, chlorophyll synthesis, protein synthesis and nitrogen fixation in response to the application of Zn and Fe (Rao *et al.,* 2019).

Effect of varieties and micronutrient application on yield attributing characters of rice

Number of effective tillers, panicle length, number of grains $panicle^{-1}$ and thousand grain weight were significantly influenced by basmati varieties. **(Table 2)** depicted that among varieties, the highest number of effective $tillers^{-2}$ (268) and the number of grains $panicle^{-1}$ (85.8) were recorded in V3 (Punjab Basmati 7) which was statistically at par with V2 (Pusa basmati 1847), however, both were significantly higher than V1 (Pusa Basmati 1509). The highest panicle length (25.8 cm) and thousand-grain weight (24.1) were recorded in V2 (Pusa Basmati 1847) which was statistically at par with V1 (Pusa Basmati 1509), both being significantly better than V3 (Punjab Basmati 7). This might be due to genetic makeup of varieties. Tefera *et al*., (2019) also reported similar results.

Table 1: Effect of varieties and micronutrient application on plant height, leaf area index, dry matter accumulation and tillers m^{-2}

Treatments	Plant height (cm)	Leaf area index	Dry matter accumulation (q/ha)	Tillers m^{-2}
Varieties				
V1 (Pusa Basmati 1509)	93.08	2.80	97.37	255
V2 (Pusa Basmati 1847)	104.5	3.42	111.1	275
V3 (Punjab Basmati 7)	102.2	3.53	117.1	283
C.D.(0.05)	8.95	0.26	12.30	19.6
Micronutrients application				
T1 (Control)	92.88	3.03	96.42	250
T2 (Foliar application of FeSO4 @ 1%)	95.33	3.12	101.9	261
T3 (Soil application of ZnSO4 @ 25 kg acre^{-1})	103.3	3.38	114.6	280
T4 (Foliar application of FeSO4 @ 1% + Soil application of ZnSO4 @ 25 kg acre^{-1})	108.3	3.50	121.7	293
C.D. (0.05)	7.59	0.22	11.17	17.6
Interaction	NS	NS	NS	NS

Table 2: Effect of basmati varieties and micronutrient application on effective number of tillers m^{-2}, number of filled grains panicle^{-1}, panicle length, 1000 grain weight, grain yield, straw yield, and harvest index

Treatments	Effective number of tillers m^{-2}	Number of filled grains panicle^{-1}	Panicle length (cm)	1000 grain weight (gm)	Grain yield (q ha^{-1})	Straw Yield (q ha^{-1})	Harvest Index (%)
Varieties							
V1 (Pusa Basmati 1509)	243	75.1	25.1	23.8	40.11	58.5	40.62
V2 (Pusa Basmati 1847)	259	82.4	25.8	24.1	43.80	63.8	40.65
V3 (Punjab Basmati 7)	268	85.8	23.7	22.4	45.35	66.0	40.74
C.D.(0.05)	15.7	6.74	1.19	1.01	1.99	3.22	NS
Micronutrients application							
T1 (Control)	244	75.2	23.3	23.1	39.03	58.0	40.19
T2 (Foliar application of FeSO4 @ 1%)	249	78.1	24.0	23.3	41.35	60.1	40.77
T3 (Soil application of ZnSO4 @ 25 kg acre^{-1})	264	83.8	25.5	23.5	44.83	65.0	40.84
T4 (Foliar application of FeSO4 @ 1% + Soil application of ZnSO4 @ 25 kg acre^{-1})	270	87.3	26.5	23.9	47.15	68.2	40.88
C.D. (0.05)	12.7	4.8	1.41	NS	2.96	4.91	NS
Interaction	NS	NS	NS	NS	NS	NS	NS

Results revealed that except for thousand grain weight, all other yield attributes were significantly influenced by micronutrient application. The highest values of number of effective tillers, panicle length and number of grains panicle^{-1} were recorded with T4 (foliar application of FeSO4 @ 1% at 20 days after transplanting + soil application of ZnSO4 @ 25 kg/acre at transplanting) which was statistically at par with T3 (soil application of ZnSO4 @ 25 kg/acre at transplanting), however, both treatments were significantly higher than control which recorded the lowest values. Highest number of effective tillers might be due to improved metabolic activity with micronutrients that enhanced floral primordia development in many tillers (Janardhan *et al.*, 2019). Higher value of panicle length might be due to increased transportation of photosynthates from source to sink due to application of zinc (Jena *et al.*, 2006). Higher number of filled grains might be due to increased synthesis of carbohydrates and their transport to the site of grain formation (Barua and Saikia, 2018).

Effect of varieties and micronutrient application on grain yield, straw yield and harvest index of rice

Results further depicted that among the varieties, highest grain yield (45.3 q/ha), straw yield (66 q/ha), and harvest index (40.7%) were recorded in V3 (Punjab Basmati 7), which was statistically at par with V2 (Pusa Basmati 1847), and both were significantly higher than V1 (Pusa Basmati 1509), which recorded lowest values. The variation in the yield might be due to the variation in yield components *viz.,* number of panicles, number of filled grains, leaf area index etc. These results were in conformity with Rehman *et al.,* (2011). **(Table 2)** further showed that in the case of micronutrient application, the highest grain yield (47.1 q/ha), straw yield (68.2 q/ha) and harvest index (40.9%) were obtained with T4 (foliar application of FeSO4 @ 1% at 20 days after transplanting + soil application of ZnSO4 @ 25 kg/acre at transplanting) which was statistically at par with T3 (soil application of ZnSO4 @ 25 kg/acre at transplanting), both were significantly higher than T2 (foliar application of FeSO4 @ 1% at 20 days after transplanting) and T1 (control). Treatment T1 (control) recorded the lowest grain, straw yield and harvest index. This could be because the micronutrient application was not done, which reflected in the soil's extremely low capacity to support growth and yield characteristics. Qureshi *et al.,* (2018) reported similar outcomes of unfortified plots with lower productive parameters in rice. The increased yield due to zinc and iron application was attributed to better performance of crop growth and yield parameters through adequate availability of major and minor micronutrients in the soil, which in turn, favourably influenced physiological processes and buildup of photosynthates (Tabassum *et al.,* 2013).

Effect of varieties and micronutrient application on economic analysis of rice

(Table 3) showed that the highest gross returns, net returns and highest B:C ratio were observed under V1 (Pusa Basmati 1509) followed by V3 (Punjab Basmati 7) and V2 (Pusa Basmati 1847). Among the micronutrient applications, the highest gross returns and net returns were observed under T4 (foliar application of FeSO4 @ 1% at 20 days after transplanting + soil application of ZnSO4 @ 25 kg/acre at transplanting) and the highest B:C ratio was observed under T2 (foliar application of FeSO4 @ 1% at 20 days after transplanting).

Table 3: Effect of varieties and micronutrient application on economic analysis of rice

Treatments	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Varieties			
V1 (Pusa Basmati 1509)	149385	109469	2.74
V2 (Pusa Basmati 1847)	135780	96364	2.44
V3 (Punjab Basmati 7)	140585	101669	2.61
Micronutrients application			
T1 (Control)	128799	93883	2.68
T2 (Foliar application of FeSO4 @ 1%)	136455	100839	2.83
T3 (Soil application of ZnSO4 @ 25 kg $acre^{-1}$)	147939	107398	2.60
T4 (Foliar application of FeSO4 @ 1% + Soil application of ZnSO4 @ 25 kg $acre^{-1}$)	155595	114354	2.77

Conclusion

On the basis of the present investigation, it can be concluded that the variety, V_3 (Punjab Basmati 7) and micronutrient treatment, T_4 (combined application of FeSO4 @ 1% as foliar + ZnSO4 @ 25 kg/acre as soil application) gives highest yield. But in terms of highest benefit:cost ratio, variety V_1 (Pusa Basmati 1509) and micronutrient treatment T_2 (Foliar application of $FeSO_4$ @ 1%) are best suited due to dynamic market prices.

Author's contribution

Conceptualization of the research work and designing of experiments by Gurinderjit Kaur, Gurkirat Singh Aulakh; Execution of field/lab experiments data and data collection by Sumeet Kaur and Sumandeep; Analysis of data and interpretation by Sumeet Kaur, Gurinderjit Kaur and Gurkirat Singh Aulakh; Preparation of manuscript by Sumeet Kaur and Sumandeep.

References

Abdullah AS. 2015. Zinc Availability and Dynamics in the Transition from Flooded to Aerobic Rice Cultivation. *Journal of Plant Biology and Soil Health,* 2(1): 1-5.

Adilakshmi G, Kumar R, Kumar V, Kumar V and Singh SK. 2022. Performance of Rice Varieties at different Moisture Regimes under Direct Seeded condition. *Biological Forum - An International Journal*, 14(1): 1336-1340.

Anonymous. 2024. *Package of practices for* crop of Punjab, *kharif.* 2026. Punjab Agriculture University, Ludhiana; 43(1): 13-15.

Barua D and Saikia M, (2018). Agronomic biofortification in rice varieties through zinc fertilization under aerobic condition. *Indian Journal of Agricultural Research*, 52(1): 89-92.

Janardhan S, Rani IU, Rani PP. and Venkateswarlu B. 2019. Effect of Zinc and Iron Fertilization on Growth and Yield of Direct Sown Rice. *The Andhra Agricultural Journal*, 66(1): 121-125.

Jena PK, Rao CP and Subbaiah G. 2006. Effect of zinc management practices on growth, yield and economics in rice. *Crop Production*, 43(4): 326-328.

Maurya R, Singh MK, Nagargade M, Yadav DK. and Pratap V. 2021. Performance of various rice (*Oryza sativa* L.) varieties under variable nitrogen levels in the eastern Uttar Pradesh. *Journal of Experimental Biology and Agricultural Sciences*, 9(spl-3): 330-335.

Qureshi A, Singh DK. and Kumar A. 2018. Climate Smart Nutrient Management (CSNM) for enhanced use efficiency and productivity in rice and wheat under rice-wheat cropping system. *International Journal of Current Microbiology and Applied Sciences,* 7(spl-7): 4166-4173.

Rao GBS, Rex R, Immanuel R, Ramesh S, Baradhan G. and Sureshkumar SM. 2019. Effect of zinc and iron fertilization on growth and development of rice. *Plant Archives*, 19(Spl.2): 1887-1880.

Rehman H, Maqsood S, Basra A. and Farooq M. 2011. Field appraisal of seed priming to improve the growth, yield and quality of direct seeded rice. *Turkish Journal of Agriculture and Forestry,* 35: 357-365.

Tabassum S, Khamparia RS. and Singh S. 2013. Effect of zinc and organic manures on yield attributes and yield of rice. *BIOINFOLET - A Quarterly Journal of Life Sciences*, 10(3a): 879-881.

Tefera W, Dilnesaw Z, Michael TK, Adane A. and Getie A. 2019. Performance evaluation of six rice varieties at bele sugar development project, Ethiopia. *International Journal of Advanced Research in Biological Science*s, 6(2): 121-128.

Yadav GS, Shivay YS, Kumar D. and Babu S. 2013. Enhancing iron density and uptake in grain and straw of aerobic rice through mulching and Rhizo-foliar fertilization of iron. *African Journal of Agricultural Research,* 8: 5447-5454.