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Effect of bio-fortification through organic and inorganic sources of zinc and iron on nutrient content and uptake of aromatic rice

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Abstract
A field experiment entitled "Effect of Bio-fortification through organic and inorganic sources of zinc and iron on growth, yield & quality of aromatic rice" was conducted during kharif season of 2019 at research farm, Bihar agricultural university, Sabour, Bhagalpur. The experiment was laid out in randomized complete block design with ten treatments and replicated thrice. The recommended dose of fertilizers was 80:40:20 (Kg ha^{-1}) N: P_2O_5: K_2O for aromatic rice. The nitrogen, phosphorus and potassium content and uptake in grain and straw of rice were estimated after harvest.

Keywords: organic and inorganic sources, zinc and Iron, NPK content and uptake

1. Introduction

Among the cereals, rice (*Oryza sativa* L.) is the major source of calories for 40% of the world population (Baishya *et al*., 2015) [1]. It is the primary food for 17 countries in the world especially in Asia. Over two billion people in Asia derive their 80% energy from rice. The global area under rice is 163.43 m ha with the production and productivity of 498.95 mt and 3061 Kg ha^{-1}, respectively (USDA 2018-19) [7]. Aromatic rice constitutes a special group of rice and considered as precious treasure of India. Globally micronutrient malnutrition due to deficiency of Zn and Fe has been reported in about two billion people in developing countries. Agronomic bio-fortification of Zn and Fe can be possible by adding micronutrient fertilizers to the soil or by foliar spray of these micro nutrients on the plants or through integration of both the methods. Application of N, P, K with micronutrients Zn and Fe are known to increase the uptake and content of N, P, K, Zn and Fe (Ganghaih *et al.,* 1999) [2]. It has been proved that application of Zn and Fe affects the absorption and utilization of major nutrients (Mishra *et al*., 2009) [5].

2. Materials and Methods

The field of experiment was situated at the permanent experimental plot of Bihar Agricultural College Farm, Bihar Agricultural University, Sabour, Bhagalpur during *kharif* season of 2019. Design of the experimental trial was randomized complete block design (RCBD) and replicated thrice with ten treatments (T1: Absolute control, T2: RDF, T3: RDF+ SA of $ZnSO_4$ @ 25 $Kgha^{-1}$, T4: RDF + 2 FS of 0.5% $ZnSO_4$ at 25 DAT & 1 week after flowering, T5: RDF + SA of $FeSO_4$ @ 25 Kg ha^{-1}, T6: RDF + 2 FS 0.5% $FeSO_4$ at 25 DAT & 1 week after flowering, T7 : RDF + SA of $ZnSO_4$ @ 25 Kg ha^{-1} + SA of $FeSO_4$ @ 25 Kg ha^{-1}, T8 : RDF + 2 FS of 0.5% $ZnSO_4$& 2 FS of 0.5% $FeSO_4$ each at 25 DAT & 1 week after flowering, T9 : RDF + 3 FS of 3% Panch gavya at 25, 50 DAT & 1 week after flowering, T10 : RDF + RDF + 3 FS of vermi-wash at 25, 50 DAT & 1 week after flowering).

2.1 Plant analysis

2.1.1 Collection of samples

The nitrogen, phosphorus and potassium content in grain and straw of rice were estimated after harvest. Plant and grain samples were collected from each plot and carried out to the laboratory in brown colour A4 size envelope. The plant and grain samples were dried at 60± 5Cfor 24 hours and oven dry weight were noted. The samples were powdered and pressed for analysis of N, P, K, Zn and Fe content. The nutrient uptake was computed by multiplying nutrient content of grain and straw with respective yields (kg ha^{-1}).

2.1.2 Determination of Nitrogen
Determination of nitrogen in plant and grain sample by KEL PLUS nitrogen estimation. Pelicans KEL PLUS system designed to performed the Kjeldahhl method to estimate Nitrogen which consists of the following three processes.

- Digestion
- Distillation
- Titration

2.1.2.1 Digestion process
In this process, 0.5 g of plant sample was transferred to digestion tube.10 ml of concentrated sulphuric acid and 2 g of digestion activator (salt mixture) to the sample were added. Digestion tube loaded in to the digestion block was heated. At the end of digestion process, the colour of the sample turned into light green colour.

2.1.2.2 Distillation process
During distillation the ammonia radicals are converted to ammonia under excess alkali condition after neutralization the acid in digested sample with 40% alkali (NaOH) on heating. In DISTYL-EM, the digested samples are heated and ammonia liberated due to the addition of 40% NaOH is dissolved in 4% boric acid. The boric acid consisting of ammonia is taken for titration.

2.1.2.3 Titration Process
The solution of boric acid and mixed indicator containing the "distilled off" ammonia was titrated with standardized H_2SO_4. The titration value of a blank solution of boric acid and mixed indicator was determined.

2.1.3 Phosphorus Estimation
Phosphorus content in the plant sample was determined by vanadomolybdo phosphoric yellow colour method in nitric acid medium as described Jackson (1973) [3]. The intensity of the yellow colour was read at 420 nm by using spectrophotometer and expressed in percentage.

2.1.4 Potassium Estimation
The potassium content was determined with the help of flame photometer and estimated with calibration curve. Total uptake of potassium in kg per ha was calculated by multiplying their relative contents with yield and values were added.

2.1.5 Nutrient Uptake
The nutrient uptake was calculated by multiplying percent concentration of a particular nutrient with grain and straw yields. The uptake of the nutrients obtained in respect of grain and straw was summed up to compute the amount of total nutrient removed by the crop.

Nutrient uptake (kg/ha) = Nutrient content (%) × yield (q/ha)

3. Results and Discussion
3.1 Nitrogen content (%) and uptake (kg ha^{-1}) in grain
Data related to Nitrogen content (%) in grain as affected by different treatments are presented in Table 1. Among all the treatments, T7 (1.25%) recorded the highest nitrogen content in grain while lowest was recorded in treatment T1 (1.13%). However, non-significant effect of the treatments was observed.

Data related to Nitrogen uptake (kg ha^{-1}) in grain as affected by different treatments are presented in Table 2. Nitrogen uptake in grain (kg ha^{-1}) was recorded highest in treatment T7 (51.54 kg ha^{-1}) which was statistically at par with all other treatments except T1 (27.99 kg ha^{-1}) and T2 (39.81 kg ha^{-1}).

3.2 Nitrogen content (%) and uptake in straw (kg ha^{-1})
Data related to Nitrogen content (%) in straw as affected by different treatments have been presented in Table 1. Among all the treatments T5 (0.66%) as well as T3 (0.66%) recorded the highest nitrogen content in straw. However, no any significant effect of the treatments was observed.

Data related to Nitrogen uptake (kg ha^{-1}) in straw as affected by different treatments are presented in Table 2. Nitrogen uptake in straw (kg ha^{-1}) was recorded highest in treatment T7 (37.01 kg ha^{-1}) which was statistically at par with all other treatment except T1 (24.06 kg ha^{-1}), T2 (30.91 kg ha^{-1}) and T6 (33.20 kg ha^{-1}).

Table 1: Effect of bio-fortification through organic & inorganic sources of Zn & Fe on nitrogen, phosphorus and potassium content (%) of plant after harvest of aromatic rice

	Treatments	Nitrogen, Phosphorus and Potassium content (%)					
		N content in grain (%)	N content in straw (%)	P content in grain (%)	P content in straw (%)	K content in grain (%)	K content in straw (%)
T_1	Absolute control	1.13	0.65	0.189	0.094	0.226	1.277
T_2	RDF	1.17	0.63	0.203	0.105	0.232	1.293
T_3	RDF + SA of $ZnSO_4$ @ 25 kg ha^{-1}	1.20	0.66	0.214	0.123	0.262	1.327
T_4	RDF + 2 FS of 0.5% $ZnSO_4$ at 25 DAT & 1 week after flowering	1.20	0.65	0.216	0.117	0.242	1.377
T_5	RDF + SA of $FeSO_4$ @ 25 kg ha^{-1}	1.18	0.66	0.202	0.116	0.273	1.377
T_6	RDF + 2 FS 0.5% $FeSO_4$ at 25 DAT & 1 week after flowering	1.24	0.64	0.225	0.118	0.296	1.393
T_7	RDF + SA of $ZnSO_4$ @ 25 kg ha^{-1} + SA of $FeSO_4$ @ 25 kg ha^{-1}	1.25	0.63	0.217	0.145	0.297	1.333
T_8	RDF + 2 FS of 0.5% $ZnSO_4$& 2 FS of 0.5% $FeS0_4$ each at 25 DAT & 1 week after flowering	1.23	0.65	0.206	0.114	0.255	1.400
T_9	RDF + 3 FS of 3% Panch gavya at 25, 50 DAT & 1 week after flowering	1.20	0.64	0.224	0.123	0.259	1.360
T_{10}	RDF + 3 FS of vermi-wash at 25, 50 DAT & 1 week after flowering	1.19	0.63	0.214	0.120	0.278	1.373
	SEm±	0.08	0.01	0.01	0.01	0.01	0.07
	CD (P=0.05)	NS	NS	0.03	0.02	0.04	NS

*RDF=recommended dose of fertilizers, SA=soil application, FS=foliar spray, DAT=days after transplanting

3.3 Phosphorus content (%) and uptake (kg ha^{-1}) in grain
Data related to phosphorus content (%) in grain as affected by different treatments are presented in Table 1. Among all the treatments T6 (0.225%) recorded the highest content of phosphorus in grain, which was statistically at par with all other treatments except T1 (0.189%).
Data related to phosphorus uptake (kg ha^{-1}) in grain as affected by different treatments are presented in Table 2. Phosphorus uptake in grain (kg ha^{-1}) was recorded highest in treatment T7 (8.54 kg ha^{-1}) which was statistically at par with treatment T8 (7.96 kg ha^{-1}).

3.4 Phosphorus content (%) and uptake (kg ha^{-1}) in straw
Data related to phosphorus content (%) in straw as affected by different treatments are presented in Table 1. Among all the treatments T7 (0.145%) recorded the highest phosphorus content in straw while lowest was recorded in T1 (0.094%).
Data related to phosphorus uptake (kg ha^{-1}) in straw as affected by different treatments are presented in Table 2. Phosphorus uptake in straw (kg ha^{-1}) was recorded highest in treatment T7 (8.54 kg ha^{-1}) while lowest was recorded in treatment T1 (3.48 kg ha^{-1}).

3.5 Potassium content (%) and uptake (kg ha^{-1}) in grain
Data related to potassium content (%) in grain as affected by different treatments are presented in Table 1. Among all the treatments T7 (0.297%) has been recorded the highest potassium content in grain followed by T6 (0.296%), T9 (0.259%) and T10 (0.278%).
Data related to potassium uptake (kg ha^{-1}) in grain as affected by different treatments are presented in Table 2. Potassium uptake in grain (kg ha^{-1}) was recorded highest in treatment T7 (12.26 kg ha^{-1}) followed by T6 (10.50 kg ha^{-1})and T10 (10.36 kg ha^{-1}).

3.6 Potassium content (%) and uptake (kg ha^{-1}) in straw
Data related to potassium content (%) in straw as affected by different treatments are presented in Table 1. Among all the treatments T8 (1.400%) recorded the highest content of potassium in straw while lowest potassium content (%) was recorded in T1 (1.277%). However, non-significant effect of the treatments was observed.
Data related to potassium uptake (kg ha^{-1}) in straw as affected by different treatments are presented in Table 2. Potassium uptake in straw (kg ha^{-1}) was recorded highest in treatment T7 (78.74 kg ha^{-1}) which was statistically at par with all other treatments except T1 (47.29 kg ha^{-1}) and T2 (63.42 kg ha^{-1}).

Table 2: Effect of bio-fortification through organic & inorganic sources of Zn & Fe on nitrogen, phosphorus and potassium uptake (kg ha^{-1}) of plant after harvest of aromatic rice

Treatments		Nitrogen, Phosphorus and Potassium uptake (kg ha^{-1})					
		N uptake in grain (kg ha^{-1})	N uptake in straw (kg ha^{-1})	P uptake in grain (kg ha^{-1})	P uptake in straw (kg ha^{-1})	K uptake in grain (kg ha^{-1})	K uptake in straw (kg ha^{-1})
T_1	Absolute control	27.99	24.06	4.78	3.48	5.61	47.29
T_2	RDF	39.81	30.91	6.84	5.17	7.90	63.42
T_3	RDF + SA of $ZnSO_4$ @ 25 kg ha $^{-1}$	45.65	36.40	7.42	6.79	10.04	73.26
T_4	RDF + 2 FS of 0.5% $ZnSO_4$ at 25 DAT & 1 week after flowering	43.94	34.70	7.55	6.29	8.91	73.77
T_5	RDF + SA of $FeSO_4$ @ 25 kg ha $^{-1}$	43.17	34.97	7.37	6.15	10.11	72.62
T_6	RDF + 2 FS 0.5% $FeSO_4$ at 25 DAT & 1 week after flowering	43.90	33.20	7.25	6.12	10.50	72.21
T_7	RDF + SA of $ZnSO_4$ @ 25 kg ha $^{-1}$ + SA of $FeSO_4$ @ 25 kg ha $^{-1}$	51.54	37.01	8.54	8.54	12.26	78.74
T_8	RDF + 2 FS of 0.5% $ZnSO_4$& 2 FS of 0.5% $FeS0_4$ each at 25 DAT & 1 week after flowering	47.44	35.72	7.96	6.32	9.81	77.34
T_9	RDF + 3 FS of 3% Panch gavya at 25, 50 DAT & 1 week after flowering	44.85	35.24	7.70	6.72	9.66	74.47
T_{10}	RDF + 3 FS of vermi-wash at 25, 50 DAT & 1 week after flowering	44.16	34.52	7.61	6.56	10.36	74.87
SEm±		2.83	1.06	0.21	0.47	0.64	3.42
CD (P=0.05)		8.39	3.14	0.62	1.41	1.91	10.15

Nutrient uptake and content are associated with metabolic activities of plants with concentration and distribution of ions in the external medium. It has been proved that application of Zn and Fe affects the absorption and utilization of major nutrients (Mishra *et al*. 2009) [5].
Persual of the data indicated that major nutrients i.e., NPK uptake in grain and straw was found highest in treatment T7 (soil application of $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} along with RDF). The increased N, P and K uptake could be due to favourable effect of Zn on metabolic process and better growth. Synergistic effect between Zn and Fe with N, K and S might have resulted in increased uptake of N and K (Suresh *et al*. 2015) [6]. The similar observation was observed by Zhang *et al.* (2008) [8].

4. Conclusion
From the above result, it could be concluded that the treatment T7 (RDF + SA of $ZnSO_4$ @ 25 kg ha^{-1} + SA of $FeSO_4$ @ 25 kg ha^{-1}) recorded highest content of nitrogen (1.25%), phosphorus (0.189%) and potassium (0.297%) as well as highest uptake of nitrogen (51.54 kg ha^{-1}), phosphorus (8.54 kg ha^{-1}) and potassium (12.26 kg ha^{-1}) in grain. Hence soil application of inorganic sources of Zn ($ZnSO_4.7H_2O$) and Fe ($FeSO_4.7H_2O$) along with RDF may be recommended for profitable cultivation of aromatic rice due to its contribution in developing stronger assimilating sources *viz*, nutrient content and uptake in grain and straw.

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