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Research Article

Effect of N, Zn and Fe application on N, P, K content and total uptake in parmal rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted in split-split plot design to study the effect of N, Zn and Fe application on N, P and K content in grain and straw and their total uptake in parmal rice crop. The results of the study showed that N and K content were significantly higher at 125% of RDN as compared to 75% of RDN both in grain and straw. Zn also had significant effect on N and K content; Zn_4 and Zn_2 were statistically at par with each other and were significantly higher than Zn_3 and Zn_1 which were also statistically at par with each other. P content was not affected by N, Zn and Fe application. Total N, P and K uptake by rice crop was significantly affected by N levels and Zn application methods but the effect of Fe on uptake of N, P and K was found to be non-significant.

Keywords: Parmal rice, nutrient uptake, nitrogen, zinc, iron

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Introduction

Rice is a self pollinated, short day plant belonging to the family *Gramineae* and it is the cereal crop with the second highest worldwide production. Rice is the dominant staple food for more than half of the world's population [16]. Primarily, it is grown in more than 100 countries of Asia. But the productivity of rice is low in India as compared to other asian countries. Declining land productivity with negative nutrient balance is the main concerns against the food security problems in the country. Fertilization is one of the most important notable measures that help to increase agricultural production. So, application of adequate amount of mineral nutrients like N, Zn and Fe to crop is one of the important factors in achieving higher productivity. Modern rice varieties obviously require higher amount of nutrients to give higher crop yields. So, it is necessary for improving the efficiency of applied fertilizers, which depends on adequate availability of most essential plant nutrients in a balanced proportion throughout the crop growth period. In recent year's use of fertilizers coupled with intensive cropping have accelerated the exhaustion of micronutrient reserves of soils. It has, thus, become imperative to use the matching doses of required NPK and micro-nutrients.

Nutrient deficiency is another one of the important yield limiting factors includes delayed sowing, intensive cultivation and imbalance and non-judicious fertilizers use. Nitrogen fertilization plays a great role in increasing rice production. Nitrogen is one of the most mobile plant nutrients in the soil. Management of nitrogen is essential for aerobic culture of rice because nitrogen use efficiency (NUE) should be in the range of 40-60 per cent. Application of nitrogen at right time is perhaps the simplest agronomic solution for improving the nitrogen use efficiency. Zn is also known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory co-factor of a large number of enzymes [6]. Major factors which influence the zinc content in soil are pH, carbonate content, organic matter, soil texture and interaction between zinc and other microelements, such as iron. Zinc is important to membrane integrity and phytochrome activities [13]. Zinc is essential for the normal healthy growth and reproduction of plants and plays a key role as a structural constituent or regulatory co-factor of enzymes in many biochemical pathways. Less mobile nutrients (e.g. iron and zinc) low availability in new leaf tissues and shoot tips causing deficiency symptoms visible in the terminal younger part of the canopy.

Iron is also one of the most essential elements but it's use is low and also due to it's less mobility for plant. Among all the micronutrients, plants need iron more than other. Among micronutrients, Iron (Fe) is a cofactor for approximately 140 enzymes that catalyze unique biochemical reactions. Foliar fertilization, which has been developed in the last 60 years, does not totally replace soil fertilization on crops with large leaf area, but may improve the uptake and the efficiency of the nutrients applied to the soil [8]. Foliar fertilization of Fe is increasingly adopted in order to alleviate micro- and macro-nutrient deficiency, but the resulting changes in the distribution of other nutrients may have significant adverse effects on plant growth and yield.

So, the present study was conducted to study the effect of N levels, Zn application methods and foliar application of Fe on N, P, K content in grain and straw and their uptake by the rice crop.

Material and Methods

The present study was conducted to study the effect of N, Zn and Fe application on nutrient content in grain and straw and their uptake in parmal rice crop. To fulfill this objective, an experiment was conducted at student's research farm, Department of Agronomy, PAU, Ludhiana for two consecutive years (during *kharif* season 2013 and 2014). The physico-chemical properties of the experimental soil are depicted in **Table 1**.

Table 1 Physico-chemical properties of soil before the start of experiment

Parameters	Value
Sand (%)	75.5
Silt (%)	14.3
Clay (%)	10.2
Texture	Loamy sand
pH (1:2)	7.3
EC (dSm^{-1})	0.25
Organic carbon (%)	0.61
Available N (kg ha^{-1})	332
Available P (kg ha^{-1})	53.2
Available K (kg ha^{-1})	120

The soil of the experimental field was loamy sand in texture, pH 7.3, EC 0.25 dSm^{-1}. The soil was medium in organic carbon (0.61%), available N (332 kg ha^{-1}), available P (53.2 kg ha^{-1}) and but low in available K (120 kg ha^{-1}) Table 1. The experiment was laid out in split-split plot design with three levels of nitrogen in main plot (N_1: 75% of RDN, N_2: 100% of RDN, N_3: 125% of RDN) in 3 split doses (the recommended dose of N was 125 kg N ha^{-1}), 4 Zn application treatments in sub plot (Zn_1: No Zn, Zn_2: soil Zn @ 50 kg $ZnSO_4$ ha^{-1}, Zn_3: foliar Zn @ 0.5% and Zn_4: soil Zn @ 50 kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5%) and 2 Fe treatments (Fe_1: No Fe and Fe_2: foliar $FeSO_4$ @ 0.5%). Foliar sprays of Zn and Fe @ 0.5% were applied at anthesis and milking stages of the crop. Soil Zn was applied at the time of transplanting. For soil and foliar application of Zn, the $ZnSO_4.7H_2O$ was used.

Representative samples of grain and straw from each net plot were taken and analyzed for N, P and K contents. N was estimated in a Microkjeldhal unit as described by [2], P by Vanado molybdate method [7] and K by Flame Photometric method. The nutrient uptake was calculated by % of minerals content × yield (kg $ha^{-1)}$ divided by 100. Standard statistical technique as described by [5] adopted for statistical analysis of data recorded and the comparison were made at 5 per cent level of significance.

Results and Discussion

Effect on N, Zn and Fe on N, P and K content in grain and straw

N content in grain

Data regarding the effect of N, Zn and Fe on N content (%) is presented in **Table 2**. Data revealed that at various levels of nitrogen, the N content in treatment N_3: 125% of RDN (1.46 per cent) and N_2: 100% of RDN (1.40 per cent) were statistically at par with each other and which were significantly higher as compared to N_1: 75% of RDN (1.12 per cent) during the study. This might be due to increased availability of nitrogen with increased amount of N application resulted in higher uptake of nitrogen by plant and translocation to grain. These results confirm the findings of [10].

Among Zn application treatments, N content (%) was significantly higher in treatment Zn_4: Soil Zn @50kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5% (1.48 per cent) which was statistically at par with Zn_2: Soil Zn @50kg $ZnSO_4$ ha^{-1} (1.48 per cent) but were significantly higher than Zn_3: foliar Zn @ 0.5% (1.19 per cent) and Zn_1: No Zn (1.18 per cent) which were statistically at par with each other. This might be attributed to synergistic effect of N and Zn while Zn application resulted in more Zn availability which play important role in synthesis of lipid and protein production resulted in more formation of vegetative plant material that ultimately increased N content in grain. The present results are in line with the findings of [15] and [3].

In the treatments of Fe application, the effect of Fe was found to be non-significant on N content during the study.

Table 2 Effect of N levels, Zn and Fe application on N, P and K content in grain and straw of parmal rice (Two years' pooled data)

Treatments	N (%)		P (%)		K (%)	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Nitrogen levels						
N_1-75% of RDN	1.12	0.51	0.62	0.19	0.24	1.18
N_2-100% of RDN	1.40	0.79	0.64	0.20	0.31	1.29
N_3-125% of RDN	1.46	0.85	0.66	0.20	0.34	1.32
C.D at 5 %	0.11	0.08	NS	NS	0.05	0.04
Zinc application methods						
Zn_1- No Zn	1.18	0.57	0.62	0.20	0.24	1.20
Zn_2- Soil Zn @50kg $ZnSO_4$ ha^{-1}	1.48	0.82	0.65	0.20	0.34	1.30
Zn_3- Foliar Zn @ 0.5%	1.19	0.63	0.63	0.19	0.25	1.21
Zn_4- Soil Zn @50kg $ZnSO_4$ ha^{-1} + Foliar Zn @ 0.5%	1.48	0.87	0.65	0.20	0.36	1.32
C.D at 5%	0.27	0.12	NS	NS	0.04	0.03
Iron						
Fe_1- No Fe	1.32	0.71	0.63	0.19	0.29	1.25
Fe_2- Foliar Fe @ 0.5%	1.33	0.72	0.64	0.19	0.30	1.26
C.D at 5%	NS	NS	NS	NS	NS	NS
Interaction (C.D at 5%)						
N x Zn	NS	NS	NS	NS	NS	NS
N x Fe	NS	NS	NS	NS	NS	NS
Zn x Fe	NS	NS	NS	NS	NS	NS
N x Zn x Fe	NS	NS	NS	NS	NS	NS

N content in straw

The perusal of data on nitrogen content (%) in straw as presented in Table 2. N content in treatments N_3: 125% of RDN (0.85 per cent) and N_2: 100% of RDN (0.79 per cent) were statistically at par with each other and which were significantly higher than N_1: 75% of RDN (0.51 per cent). These results confirm the findings of [10].

With respect to Zn application treatments, Zn_4: Soil Zn @50kg $ZnSO_4$ ha^{-1} + Foliar Zn @ 0.5% (0.87 per cent) was statistically at par with Zn_2: Soil Zn @50kg $ZnSO_4$ ha^{-1} (0.82 per cent) but significantly higher than Zn_3: foliar Zn @ 0.5% (0.63 per cent) and Zn_1: No Zn (0.57 per cent) which were statistically at par with each other during both the years of study. The present results are in agreement with the findings of [15] and [3].

With respect to Fe application, effect of Fe was found to be non-significant on N content during the study.

P content in grain

The scrutiny of data as presented in Table 2 revealed that phosphorus content (%) in grain was not significantly affected by nitrogen, zinc and iron application methods during the study.

P content in straw

The data regarding P content (%) in straw is presented in Table 2 revealed that application of nitrogen, zinc and iron had no significant effect on phosphorus content in straw during the study.

K content in grain

The data in respect to potassium content (%) in grain is presented in Table 2. At different levels of nitrogen application, the treatment N_3: 125% of RDN (0.34 per cent) was significantly higher than N_1: 75% of RDN (0.24 per cent) but was statistically at par with N_2: 100% of RDN (0.31 per cent). This might be due to more availability of nitrogen in soil due to increased level of nitrogen resulted in more absorption of nitrogen from the soil which induced increase in cell number and volume, and the consequent changes in cell water, requires a corresponding increase in the uptake of potassium to maintain the osmotic concentrations of leaf tissues to maintain turgor so much of the total N and K required by crops is therefore taken up to sustain development and expansion of the leaf canopy during the early months of growth and later in sink part. Similar results earlier reported by [15] and [3].

Among Zn application treatments, K content was significantly higher in treatment Zn_4: Soil Zn @50kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5% (0.36 per cent) which was statistically at par with Zn_2: Soil Zn @50kg $ZnSO_4$ ha^{-1} (0.34 per cent) but was significantly higher than Zn_3: foliar Zn @ 0.5% (0.25 per cent) and Zn_1: No Zn (0.24 per cent) which were statistically at par with each other during the study. This might be due to synergetic interaction between Zn and K, application of Zn through soil plus foliar increased the availability of K in soil solution and in plant which was absorbed by the roots and translocated from root to shoot and finally to the sink part and Zn sufficiency is associated with marked increases in K efflux from roots and shoots into growth medium. These results are in line with the findings of [9].

In Fe application treatment, effect of iron was found to be non-significant during the study.

K content in straw

The data on potassium content in straw is presented in Table 2. At different levels of nitrogen, the treatments N_3: 125% of RDN (1.32 per cent) was significantly higher than N_1: 75% of RDN (1.18 per cent) and N_3: 125% of RDN (1.32 per cent) was statistically at par with N_2: 100% of RDN (1.29 per cent). Similar results were reported by [15] and [3].

Among Zn application treatments, K content was significantly higher in treatment Zn_4: Soil Zn @50kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5% (1.32 per cent) was statistically at par with Zn_2: Soil Zn @50kg $ZnSO_4$ ha^{-1} (1.30 per cent) which were significantly higher than Zn_3: foliar Zn @ 0.5% (1.21 per cent) and Zn_1: No Zn (1.20 per cent) which were statistically at par with each other. These results are in line with the findings of [9].

With respect to Fe application, effect of Fe was found to be non-significant on N content during the study.

Effect of N, Zn and Fe application on total N, P and K uptake by rice crop

N uptake

Nitrogen levels had significant effect on uptake of nitrogen **Table 3**. At different levels of nitrogen, treatment N_3: 125% of RDN (200.73 kg ha^{-1}) recorded significantly higher N uptake as compared to N_2: 100% of RDN (182.83 kg ha^{-1}) which was also significantly higher than N_1: 75% of RDN (124.75 kg ha^{-1}). These results are in line with the findings of [11] and [12].

Table 3 Effect of N levels, Zn and Fe application on total N, P and K uptake (kg ha^{-1}) by parmal rice crop (Two years' pooled data)

Treatments	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})
Nitrogen levels			
N_1-75% of RDN	124.75	60.39	130.83
N_2-100% of RDN	182.83	64.76	157.56
N_3-125% of RDN	200.73	68.75	167.08
C.D at 5 %	12.61	4.10	9.99
Zinc application methods			
Zn_1- No Zn	135.58	61.05	134.90
Zn_2- Soil Zn @50kg $ZnSO_4$ ha^{-1}	193.35	66.60	163.57
Zn_3- Foliar Zn @ 0.5%	142.85	61.88	138.89
Zn_4- Soil Zn @50kg $ZnSO_4$ ha^{-1} + Foliar Zn @ 0.5%	205.97	69.01	169.96
C.D at 5%	10.70	4.50	9.91
Iron			
Fe_1- No Fe	166.97	64.08	150.43
Fe_2- Foliar Fe @ 0.5%	171.90	65.20	153.23
C.D at 5%	NS	NS	NS
Interaction (C.D at 5%)			
N x Zn	NS	NS	NS
N x Fe	NS	NS	NS
Zn x Fe	NS	NS	NS
N x Zn x Fe	NS	NS	NS

Among Zn application methods, significantly higher uptake was recorded in treatment Zn_4: Soil Zn @50kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5% (205.97 kg ha^{-1}) followed by Zn_2: Soil Zn @50kg $ZnSO_4$ ha^{-1} (193.35 kg ha^{-1}) which were significantly higher than Zn_3: foliar Zn @ 0.5% (142.85 kg ha^{-1}) and Zn_1: No Zn (135.58 kg ha^{-1}) which were statistically at par with each other. The present findings support the results of [1].

Iron application through foliar sprays had no significant effect on N uptake by rice crop.

P uptake

Data regarding P uptake is presented in (Table 3), which revealed that treatment N_3: 125% of RDN (68.75 kg ha^{-1}) and N_2: 100% of RDN (64.76 kg ha^{-1}) were statistically at par with each other and were significantly higher than N_1: 75% of RDN (60.39 kg ha^{-1}) during the study. These results are in accordance with the findings of [4].

Among Zn application treatments, P uptake was significantly higher in treatment Zn_4: Soil Zn @50kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5% (69.01 kg ha^{-1}) which was statistically at par with Zn_2: Soil Zn @50kg $ZnSO_4$ ha^{-1} (66.60 kg ha^{-1}) and which were significantly higher than Zn_3: foliar Zn @ 0.5% (61.88 kg ha^{-1}) and Zn_1: No Zn (61.05 kg ha^{-1}) which were also statistically at par with each other.

With respect to Fe application, effect of Fe was found to be non-significant on P uptake during the study.

K uptake

The results indicated Table 3 that at different levels of nitrogen, N_3: 125% of RDN (167.08 kg ha^{-1}) recorded significantly higher K uptake as compared to N_2: 100% of RDN (157.56 kg ha^{-1}) and N_1: 75% of RDN (130.83 kg ha^{-1}). Similar results were reported earlier by [14].

With respect to Zn application methods, in Table 3, data indicated that Zn_4: Soil Zn @ 50kg $ZnSO_4$ ha^{-1} + foliar Zn @ 0.5% (169.96 kg ha^{-1}) and Zn_2: Soil Zn @ 50kg $ZnSO_4$ ha^{-1} (163.57 kg ha^{-1}) were statistically at par with each other and significantly higher than Zn_3: foliar Zn @ 0.5% (138.89 kg ha^{-1}) and Zn_1: No Zn (134.90 kg ha^{-1}) which were also statistically at par with each other.

The effect of Fe application on K uptake was found to be non-significant.

Conclusion

Based on the above results, it may be concluded that N_3: 125% of RDN level of nitrogen significantly increased the N and K content in both grain and straw but no significant effect on P content. Similarly, Soil + foliar application of Zn also increased the N and K content in grain and straw but no effect on P. Foliar application of Fe had no effect on N, P and K content both in grain and straw during the study. With respect to total N, P and K uptake by rice crop, N_3: 125% of RDN level of nitrogen and soil + foliar applied Zn significantly increased the uptake of N, P and K with respect to low level of nitrogen, soil Zn and foliar Zn alone.

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