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Influence of Micronutrient Application on Nutrient Content, Uptake and Residual Soil Nutrient Status in Rice (*Oryza sativa* L.) in Western Uttar Pradesh Condition

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Authors' contributions

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

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ABSTRACT

A field experiment was conducted to assess the effect of different nutrient treatments on nutrient content, uptake and residual soil fertility in rice crop at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during *kharif* 2022 on clay loam soil, low in

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organic carbon, available nitrogen, phosphorous, zinc and iron, medium to high in available potassium and slightly alkaline in reaction. The treatments comprising of different combinations (10) of NPK, Zn and Fe with VAM {Control,100% NPK, 100% NPK + 25kg $ZnSO_4$,100% NPK+ 25 kg $FeSO_4$, 100% NPK + 25kg $ZnSO_4$+25 kg $FeSO_4$, 100% NPK + 12.5 kg $ZnSO_4$+ 12.5 kg $FeSO_4$+VAM, 100% NPK+ZnEDTA+FeEDTA, 100% NPK + 0.5% $ZnSO_4$ at tillering and panicle initiation, 100% NPK + 0.5% $FeSO_4$ at tillering and panicle initiation and 100% NPK + 0.5% $ZnSO_4$ +0.5% $FeSO_4$ at tillering and panicle initiation}were tested in RBD with 3 replications. Rice variety PB-1637 was transplanted on 23rd July and harvested on 10th November, 2022 with recommended package of practices except the treatments. Nutrient content, uptake and residual soil fertility were significantly affected by different nutrients treatments. Zn, Fe, Zn+Fe and Zn+Fe+VAM application favored nutrient content, uptake and residual soil fertility when compared to 100% NPK. Among the various treatments crop was applied with 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ registered highest nutrient content in grain (N- 1.33% ,P-0.43%, K-0.39%, Zn-36.5 mg kg^{-1} and Fe-127.31 mg kg^{-1}), nutrient uptake in grain (N-57.5 kg ha^{-1},P- 18.6 kg ha^{-1} K-16.8 kg ha^{-1} ,Zn- 157.7 g ha^{-1} and Fe-550.0 g ha^{-1}) and residual soil nutrient status (N-221.1 kg ha^{-1}, P-17.6 kg ha^{-1}, K-214.7 kg ha^{-1}, Organic Carbon-0.47%, Zn-0.98 mg kg^{-1} and Fe-6.56 mg kg^{-1}).

Keywords: Micronutrient; soil nutrition; Oryza sativa; soil fertility.

1. INTRODUCTION

"Rice cultivation is of immense importance to food security of Asia, where more than 90% of the global rice is produced and consumed" [1]. "Rice occupies a pivotal role in Indian agriculture and it contributes to 15% of annual GDP of agriculture and provides 43% calorie requirement for more than 70% of Indians" [2]. "It is cultivated on 43.42 mha area with the production of 105.25 mt and with the average productivity of 24.23 q ha^{-1}. It accounts for about 40.92% of total food grain production and 44.07% of cereal production in the country. Although, the Green Revolution technologies have contributed excessively towards quantum jump in India's agricultural production, but have left behind myriad issues threatening to sustainability concerns. The large scale adoption of conventional blanket fertilizer recommendations and skewed dependence on high analysis fertilizers has led to multiple deficiencies of secondary and micro nutrients coupled with low fertilizer and input use efficiencies. Crop production practices without organic supplements have severely vitiated soil environment. World Health Organization reports regarding mineral deficiencies particularly Zn and Fe in human population have also become a concern and bio-fortification of agricultural produce has become a precedent. Almost 50 % of the world soils used for cereal production faces Zn deficiency. Plant nutrients, although present in small concentration, play a decisive role in growth and development, quality and yield of crops. Zinc, an important constituent of amino acids and vitamin, helps in the formation of chlorophyll, is involved in forming and stabilizing the tertiary structure of enzymes and other proteins. Zinc also has important functions in plants as a component of RNA polymerase enzymes, imparts synthesis of IAA, photosynthesis and auxin activity" [3]. Iron (Fe) is required for biological system, enzyme activation and as an oxygen carrier in nitrogen fixation.

2. MATERIALS AND METHODS

A field experiment was conducted to assess the effect of different nutrient treatments on nutrient content, uptake and residual soil nutrient status in rice crop at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during *kharif* 2022 on clay loam soil, low in organic carbon, available nitrogen, phosphorous, zinc and iron, medium to high in available potassium and slightly alkaline in reaction. The treatments comprising of different combinations (10) of NPK, Zn and Fe with VAM {Control,100% NPK, 100% NPK + 25kg $ZnSO_4$,100% NPK+ 25 kg $FeSO_4$, 100% NPK + 25kg $ZnSO_4$+25 kg $FeSO_4$, 100% NPK + 12.5 kg $ZnSO_4$+12.5 kg $FeSO_4$+VAM, 100% NPK+ZnEDTA+FeEDTA, 100% NPK + 0.5% $ZnSO_4$ at tillering and panicle initiation, 100% NPK + 0.5% $FeSO_4$ at tillering and panicle initiation and 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at tillering and panicle initiation}were tested in RBD with 3 replications.

3. RESULTS AND DISCUSSION

The crop was applied with with 100 % NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at tillering and panicle initiation reported highest total uptake of N (100.9 kg ha^{-1}), P (31.3 kg ha^{-1}), K (120.2 kg ha^{-1}), Zn (528.8 g ha^{-1}) and Fe (1280.3 g ha^{-1}) as against the lowest of 52.3, 8.6, 65.8, kg ha^{-1} 258.7 g ha^{-1}, and 297.9 g ha^{-1} respectively in crop receiving no fertilizer. The trend was similar for uptake in grain and straw and content in grain and straw. Further the grains had more accumulation of N, P and Fe than straw while reverse trend was observed with K and Zn. "Favorable effect of NPK application on nutrient uptake by rice has also been reported" by Kumar and Singh [4]. The crop having highest accumulation also had highest dry matter assimilation and nutrient content which ascertained highest uptake of most of the nutrients. The nutrient content in grain and straw was significantly influenced by different nutrient treatments involving micronutrients. The content of N, P, K, Zn and Fe varied from 1.10 to 1.33%, 0.25 to 0.43%, 0.21 to 0.39%, 22.14 to 36.50 ppm and 67.04 to 127.31 ppm in grain respectively, the highest, being in crop receiving 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at tillering and panicle initiation and lowest with no nutrient application. Respective content in straw ranged from 0.48 to 0.68%, 0.04 to 0.20%, 1.27 to 1.62%, 42.07 to 58.17 ppm and 46.05 to 114.47 ppm again being the highest with 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at tillering and panicle initiation remained at par with 100% NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$ proved significantly better than 100% NPK and lowest with no nutrient application. "Application of Zn and Fe alone or together with 100% NPK increased contents in grains and straw over 100% NPK. This is in accordance to the kind of relationship between nutrient content in plant tissues and the concentration in growing medium, the soil. Application of fertilizers readily increases the availability of nutrient concerned in the soil solution thereby enhancing its absorption by the plant roots and further translocation to the site of action. Favorable effect of NPK on nutrient content of rice has also been noted" by Gautam et al. [5] Gupta et al. [6], Jat et al. [3] and Dash et al. [7]. The beneficial effect of Zn and Fe when applied in conjunction with organic, inorganic and bio-fertilizers might have helped in increasing and balancing the availability of essential plant nutrients and organic fertilizers helped it to be sustained it over a long period of time. "Simultaneous release of organic acid which act as chelating agent might have facilitated the availability and absorption of micro-nutrients as indicated by plant nutrient content and residual soil fertility. Soil residual fertility exhibited significant variation under different micro nutrient management attributed to differential crop removals and additions. Available nitrogen, phosphorus, potassium, zinc, iron and organic carbon varied from 201.6 to 221.1 kg ha^{-1}, 14.8

Table 1. Effect of different nutrients treatments on N, P and K content (%) in rice grain and straw at harvest

Treatments		Nutrient content (%)					
		N		P		K	
		Grain	Straw	Grain	Straw	Grain	Straw
T_1	Control	1.10	0.48	0.25	0.04	0.21	1.27
T_2	100 % NPK	1.16	0.51	0.27	0.06	0.23	1.37
T_3	100 % NPK + 25 kg $ZnSO_4$	1.27	0.59	0.35	0.14	0.33	1.52
T_4	100 % NPK + 25 kg $FeSO_4$	1.19	0.53	0.30	0.08	0.25	1.40
T_5	100 % NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$	1.32	0.66	0.40	0.19	0.37	1.58
T_6	100 % NPK + 12.5 kg $ZnSO_4$ + 12.5 kg $FeSO_4$ + VAM	1.25	0.57	0.33	0.12	0.30	1.44
T_7	100 % NPK + Zn EDTA + Fe EDTA	1.29	0.61	0.37	0.15	0.35	1.55
T_8	100 % NPK + 0.5 % $ZnSO_4$ at tillering and panicle initiation	1.31	0.63	0.38	0.17	0.36	1.57
T_9	100 % NPK + 0.5 % $FeSO_4$ at tillering and panicle initiation	1.21	0.55	0.31	0.11	0.27	1.42
T_{10}	100 % NPK + 0.5 % $ZnSO_4$ + 0.5 % $FeSO_4$ at tillering and panicle initiation	1.33	0.68	0.43	0.20	0.39	1.62
	SEm ±	**0.04**	**0.02**	**0.01**	**0.005**	**0.01**	**0.05**
	CD at 5 %	**0.13**	**0.06**	**0.03**	**0.014**	**0.03**	**0.15**

to 17.6 kg ha^{-1}, 192.1 to 214.7 kg ha^{-1}, 0.38 to 0.98 mg ha^{-1}, 3.05 to 6.56 mg kg^{-1} and 0.41 to 0.47% after harvest of rice, the lowest being with control and the highest with the use of 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at tillering and panicle initiation. Application of Zn and Fe alone or together with 100% NPK significantly increased the available nitrogen in soil over 100% NPK possibly due to better root growth. Application of micro nutrients benefited the soil significantly in respect of available nitrogen and phosphorus. Available soil nutrients (available N, P, K, Zn and Fe) were significantly lower in unfertilized plots as against highest in plots receiving 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at tillering and panicle initiation remained at par with 100% NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$ proved significantly better than 100% NPK. A positive nutrient balance in soil with application of NPK has been noticed" by Agarwal [8], with Zn by Sarwar et al. [9] and with Fe by Yadav and Kumar [10].

Table 2. Effect of different nutrients treatments on Zn and Fe content (mg kg^{-1}) in rice grain and straw at harvest

Treatments		Nutrient content (mg kg^{-1})			
		Zn		Fe	
		Grain	Straw	Grain	Straw
T_1	Control	22.14	42.07	67.04	46.05
T_2	100 % NPK	22.43	42.37	73.34	51.84
T_3	100 % NPK + 25 kg $ZnSO_4$	26.03	43.83	76.34	56.32
T_4	100 % NPK + 25 kg $FeSO_4$	23.47	58.73	74.14	54.24
T_5	100 % NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$	35.40	57.32	125.57	112.54
T_6	100 % NPK + 12.5 kg $ZnSO_4$ + 12.5 kg $FeSO_4$ + VAM	23.65	42.57	75.74	58.63
T_7	100 % NPK + Zn EDTA + Fe EDTA	32.47	43.85	80.47	54.21
T_8	100 % NPK + 0.5 % $ZnSO_4$ at tillering and panicle initiation	33.32	55.57	122.67	110.67
T_9	100 % NPK + 0.5 % $FeSO_4$ at tillering and panicle initiation	23.60	42.85	74.93	58.63
T_{10}	100 % NPK + 0.5 % $ZnSO_4$ + 0.5 % $FeSO_4$ at tillering and panicle initiation	36.50	58.17	127.31	114.47
	SEm ±	**0.9**	**1.8**	**3.2**	**2.6**
	CD at 5 %	**2.7**	**5.2**	**9.3**	**7.7**

Table 3. Effect of different nutrients treatments on N, P and K uptake (kg ha^{-1}) in rice grain and straw at harvest

Treatments		Nutrient uptake (kg ha^{-1})								
		N			P			K		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	Control	29.5	22.8	52.3	6.7	1.9	8.6	5.6	60.2	65.8
T_2	100 % NPK	40.9	30.4	71.3	9.5	3.6	13.1	8.1	81.8	89.9
T_3	100 % NPK + 25 kg $ZnSO_4$	51.9	36.5	88.4	14.3	8.7	23.0	13.5	93.9	107.4
T_4	100 % NPK + 25 kg $FeSO_4$	46.3	31.8	78.1	11.7	4.8	16.5	9.7	84.0	93.7
T_5	100 % NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$	55.0	41.6	96.6	17.4	12.2	29.1	15.6	99.5	115.0
T_6	100 % NPK + 12.5 kg $ZnSO_4$ + 12.5	49.0	34.8	83.8	12.9	7.3	20.3	11.8	87.8	99.6

Treatments		Nutrient uptake (kg ha^{-1})								
		N			P			K		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
	kg $FeSO_4$ + VAM									
T_7	100 % NPK + Zn EDTA + Fe EDTA	53.0	38.1	91.1	15.2	9.4	24.6	14.4	96.9	111.3
T_8	100 % NPK +0.5%$ZnSO_4$ at tillering and panicle initiation	54.4	39.6	94.0	15.8	10.7	26.4	14.9	98.6	113.5
T_9	100 % NPK +0.5% $FeSO_4$ at tillering and panicle initiation	47.2	33.2	80.4	12.1	6.6	18.7	10.5	85.6	96.2
T_{10}	100 % NPK +0.5% $ZnSO_4$ +0.5% $FeSO_4$ at tillering and panicle initiation	57.5	43.4	100.9	18.6	12.8	31.3	16.8	103.4	120.2
	SEm ±	**1.8**	**1.3**	**3.1**	**0.5**	**0.3**	**0.8**	**0.5**	**3.2**	**3.7**
	CD at 5 %	**5.3**	**3.7**	**8.9**	**1.5**	**0.8**	**2.3**	**1.3**	**9.3**	**10.6**

Table 4. Effect of different nutrients treatments on Zn and Fe uptake (g ha^{-1}) in rice grain and straw at harvest

Treatments		Nutrient uptake (g ha^{-1})					
		Zn			Fe		
		Grain	Straw	Total	Grain	Straw	Total
T_1	Control	59.3	199.4	258.7	179.7	218.3	397.9
T_2	100 % NPK	79.2	252.9	332.1	258.9	309.5	568.4
T_3	100 % NPK + 25 kg $ZnSO_4$	106.5	270.9	377.3	312.2	348.1	660.3
T_4	100 % NPK + 25 kg $FeSO_4$	91.3	352.4	443.7	288.4	325.4	613.8
T_5	100 % NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$	147.6	361.1	508.7	523.6	709.0	1232.6
T_6	100 % NPK + 12.5 kg $ZnSO_4$ + 12.5 kg $FeSO_4$ + VAM	92.7	259.7	352.4	296.9	357.6	654.5
T_7	100 % NPK + Zn EDTA + Fe EDTA	133.5	274.1	407.5	330.7	338.8	669.5
T_8	100 % NPK + 0.5 % $ZnSO_4$ at tillering and panicle initiation	138.3	349.0	487.3	509.1	695.0	1204.1
T_9	100 % NPK + 0.5 % $FeSO_4$ at tillering and panicle initiation	92.0	258.4	350.4	292.2	353.5	645.8
T_{10}	100 % NPK + 0.5 % $ZnSO_4$ + 0.5 % $FeSO_4$ at tillering and panicle initiation	157.7	371.1	528.8	550.0	730.3	1280.3
	SEm ±	**4.2**	**10.9**	**15.0**	**13.6**	**16.4**	**30.1**
	CD at 5 %	**12.1**	**31.5**	**43.4**	**39.4**	**47.5**	**86.9**

Table 5. Effect of different nutrients treatments on available nitrogen, phosphorus, potassium (kg ha^{-1}) and organic carbon (%) in soil at harvest

Symbol	Treatments	Available nutrients (kg ha^{-1})			Organic carbon (%)
		N	P	K	
T_1	Control	201.6	14.8	192.1	0.41
T_2	100 % NPK	204.8	15.3	201.1	0.42
T_3	100 % NPK + 25 kg $ZnSO_4$	210.8	16.0	208.8	0.44
T_4	100 % NPK + 25 kg $FeSO_4$	206.9	15.4	204.8	0.42
T_5	100 % NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$	218.5	16.5	213.1	0.46
T_6	100 % NPK + 12.5 kg $ZnSO_4$ + 12.5 kg $FeSO_4$ + VAM	209.4	15.8	209.4	0.43
T_7	100 % NPK + Zn EDTA + Fe EDTA	212.6	16.1	210.5	0.44
T_8	100 % NPK + 0.5 % $ZnSO_4$ at tillering and panicle initiation	215.4	16.3	212.7	0.45
T_9	100 % NPK + 0.5 % $FeSO_4$ at tillering and panicle initiation	207.1	15.6	207.6	0.43
T_{10}	100 % NPK + 0.5 % $ZnSO_4$ + 0.5 % $FeSO_4$ at tillering and panicle initiation	221.1	17.6	214.7	0.47
SEm ±		**4.9**	**0.6**	**7.4**	**0.02**
CD at 5 %		**14.6**	**1.7**	**21.3**	**NS**

Table 6. Effect of different nutrients treatments on available zinc and iron (mg kg^{-1}) in soil at harvest

Symbol	Treatments	Available nutrients (mg kg^{-1})	
		Zinc	Iron
T_1	Control	0.38	3.05
T_2	100 % NPK	0.41	3.10
T_3	100 % NPK + 25 kg $ZnSO_4$	0.86	3.46
T_4	100 % NPK + 25 kg $FeSO_4$	0.42	3.12
T_5	100 % NPK + 25 kg $ZnSO_4$ + 25 kg $FeSO_4$	0.95	6.15
T_6	100 % NPK + 12.5 kg $ZnSO_4$ + 12.5 kg $FeSO_4$ + VAM	0.43	3.22
T_7	100 % NPK + Zn EDTA + Fe EDTA	0.89	3.48
T_8	100 % NPK + 0.5 % $ZnSO_4$ at tillering and panicle initiation	0.91	6.04
T_9	100 % NPK + 0.5 % $FeSO_4$ at tillering and panicle initiation	0.43	3.14
T_{10}	100 % NPK + 0.5 % $ZnSO_4$ + 0.5 % $FeSO_4$ at tillering and panicle initiation	0.98	6.56
SEm ±		**0.02**	**0.15**
CD at 5 %		**0.06**	**0.44**

4. CONCLUSION

From the above experiment it can be concluded that the nutrient content, uptake and residual soil fertility were significantly affected by different nutrients treatments. Zn, Fe, Zn+Fe and Zn+Fe+VAM application favored nutrient content, uptake and residual soil fertility when compared to 100% NPK. Among the various treatments crop applied with 100% NPK + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ registered highest nutrient content in grain(N- 1.33% ,P-0.43% , K-0.39%, Zn-36.5 mg kg^{-1} and Fe-127.31 mg kg^{-1}), nutrient uptake in grain(N-57.5 kg ha^{-1},P- 18.6 kg ha^{-1} K-16.8 kg

ha^{-1} ,Zn- 157.7 g ha^{-1} and Fe-550.0 g ha^{-1}) and residual soil nutrient status(N-221.1 kg ha^{-1}, P-17.6 kg ha^{-1}, K-214.7 kg ha^{-1}, Organic Carbon-0.47 %, Zn-0.98 mg kg^{-1} and Fe-6.56 mg kg^{-1}).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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