

Original Research Article

Influence of micronutrient application on nutrient content, uptake and residual soil fertility in rice (*Oryza sativa* L.) in Western Uttar Pradesh condition

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 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 ZnSO₄, 100 % NPK+ 25 kg FeSO₄, 100 % NPK + 25kg ZnSO₄+25 kg FeSO₄, 100 % NPK + 12.5 kg ZnSO₄+ 12.5 kg FeSO₄+VAM, 100 % NPK+ZnEDTA+FeEDTA, 100 % NPK + 0.5 % ZnSO₄ at tillering and panicle initiation, 100 % NPK + 0.5 % FeSO₄ at tillering and panicle initiation and 100 % NPK + 0.5 % ZnSO₄+0.5 % FeSO₄ 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 fertilized with 100 % NPK + 0.5% ZnSO₄ + 0.5 % FeSO₄ 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 fertility (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).

Introduction

Rice cultivation is of immense importance to food security of Asia, where more than 90% of the global rice is produced and consumed (Anonymous, 2013). 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 (Anonymous, 2014). 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. Fragmentation of agricultural holdings has further aggravated the issues with variable nutrient supplying capacity both at the spatial and the temporal scale. 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 (Jat *et al.*, 2013). Iron (Fe) is required for biological system, enzyme activation and as an oxygen carrier in nitrogen fixation.

Materials and Methods

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 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 ZnSO₄, 100 % NPK+ 25 kg FeSO₄, 100 % NPK + 25kg ZnSO₄+25 kg FeSO₄, 100 % NPK + 12.5 kg ZnSO₄+12.5 kg FeSO₄+VAM, 100 % NPK+ZnEDTA+FeEDTA, 100 % NPK + 0.5 % ZnSO₄ at tillering and panicle initiation, 100 % NPK + 0.5 % FeSO₄ at tillering and panicle initiation and 100 % NPK + 0.5 % ZnSO₄ + 0.5 % FeSO₄ at tillering and panicle initiation} were tested in RBD with 3 replications.

Results and Discussion

The crop fertilized with 100 % NPK + 0.5 % ZnSO₄ + 0.5 % FeSO₄ 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 (2008). 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 % ZnSO₄ + 0.5 % FeSO₄ 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 % ZnSO₄ + 0.5 % FeSO₄ at tillering and panicle initiation remained at par with 100 % NPK + 25 kg ZnSO₄ + 25 kg FeSO₄ proved significantly better than 100 % NPK and lowest with no nutrient application. Applications 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.* (2008) Gupta and Sharma (2006), Jat *et al.*, (2013) and Dash *et al.*, (2015). 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 sustained it over a long 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 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 % ZnSO₄ + 0.5 % FeSO₄ at tillering and panicle initiation. Applications 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 % ZnSO₄ + 0.5 % FeSO₄ at tillering and panicle initiation remained at par with 100 % NPK + 25 kg ZnSO₄ + 25 kg FeSO₄ proved significantly better than 100 % NPK. A positive nutrient balance in soil with application of NPK has been noticed by Agarwal (2008), with Zn by Sarwar *et al.*, (2008) and with Fe by Yadav and Kumar (2009).

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

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	51.9	36.5	88.4	14.3	8.7	23.0	13.5	93.9	107.4

	+ 25 kg ZnSO 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 kg FeSO ₄ + VAM	49.0	34.8	83.8	12.9	7.3	20.3	11.8	87.8	99.6
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 +	209.4	15.8	209.4	0.43

	VAM				
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

Reference

1. Agarwal, M. (2008). Monitoring soil physical, chemical and microbiological properties and nutrients uptake after 35 years of continuous fertilizer use in rice-wheat system. Ph. D. Thesis submitted to G.B.P.U.A. and T., Pantnagar, India, p. 153.
2. Anonymous,(2013)..Statistical year book, Food and Agriculture Organization of the United Nations. Rome
3. Anonymous,(2014).*Ministry of Agriculture* Department of agriculture and cooperation.
4. Dash, A.K; Singh, H. K; Mahakud, T; Pradhan, K.C and Jena, D. (2015). Interaction effect of nitrogen, phosphorus, potassium with sulphur, boron and zinc on yield and nutrient uptake by rice under rice - rice cropping system in inceptisol of coastal Odisha. *International Research Journal of Agricultural Science and Soil-Science*.5(1),14-21
5. Gautam, A. K., Kumar, D., Shivay, Y. S. and Mishra, B. N. (2008). Influence of nitrogen levels and plant spacing on growth, productivity and quality of two inbred varieties and a hybrid of aromatic rice. *Archives of Agronomy and Soil Science*, 54(5), 515-532.
6. Gupta, V. Sharma, R.S. and Vishwakarma, S.H. (2006). Long term effect of integrated nutrient management on sustainability and soil fertility of rice (*Oryza sativa* L.) wheat (*Triticum aestivum*. L.) cropping system. *Indian Journal of Agronomy*, 51(3), 160-164.
7. Jat, G., Majumdar, S.P., Jat, N.K. and Majundar, S.P. (2013). Potassium and zinc fertilization of wheat (*Triticum aestivum* L.) in Western arid zone of India. *Indian Journal of Agronomy*,58(1) 67-71.
8. Kumar, M. and Singh, A.K. (2008). A study on nutrient uptake by paddy in integrated use of fertilizers and vermicompost. *Asian Journal of Soil Science.*, 3(1), 40-41
9. Sarwar G., Hussain N., Schmeisky H., Suhammad S., Ibrahim M. and Ahmad S. (2008). Efficiency of Various Organic Residues for Enhancing Rice-Wheat Production under Normal Soil Conditions. *Pakistan Journal of Botany*, 40(5), 2107-2113.
10. Yadav, D.S., Kumar, V. and Yadav (2009). Effect of organic farming on productivity. Soil health and economics of rice (*Oryza sativa* L.)- wheat (*Triticum aestivum* L.) system. *Indian Journal of Agronomy*, 54(3), 267-271.