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Effect of micronutrients on growth and yield of transplanted rice

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Abstract
A field experiment entitled "Effect of Micronutrients on Growth and Yield of Transplanted Rice" was conducted during late-*Kharif* 2024 at College of Agriculture, Navile, Shivamogga, Karnataka. The results of the experiment showed that among the treatments, (T_7) application of 100 per cent RDF (100:50:50 kg ha^{-1} NPK) + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) showed significantly higher values of plant height (107.00 cm), number of tillers $hill^{-1}$ (22.33), leaf area (1100.00 cm^2 $hill^{-1}$), dry matter accumulation (59.79 g $hill^{-1}$), no. of productive tillers per hill (20.90), panicle length (23.13 cm), panicle weight (2.67g $panicle^{-1}$), no. of grains per panicle (188.49), No. of unfilled grains per panicle (9.45), Chaffiness (5.00%), Test weight (27.44 g), grain yield (6476.6 kg ha^{-1}) and straw yield (8047.1 kg ha^{-1}) respectively, over RDF alone. However, it was on par with T_5.

Keywords: Rice, grain yield, straw yield, micronutrients.

Introduction
Rice (*Oryza sativa* L.) is cultivated as one of the most important cereal crop worldwide. It belongs to family *Poacea*. It is an important staple food crop in Asia. Rice being one of the most widely produced and consumed cereal crop in the world. Among the cereal crop it serves as the principal source of nourishment for over half of the global production (Shende *et al*., 2022) [8]. India ranks first in area and second in production next to China. In India it is cultivated in the area of 47.6 m ha with a production of 1.37 mt and average productivity 4.3 t ha^{-1} 2024). In Karnataka it is grown over an area of 13.28 lakh ha with total production of 42.8 lakh tons and average productivity is 3223 kg ha^{-1} (Anon., 2024) [2]. The major rice growing states are West Bengal, Andhra Pradesh, Chhattisgarh, Tamil Nadu, Karnataka, Assam, Maharashtra, Odisha, Punjab and Gujarat.
Micronutrients are often lacking in soils, crop and food. However, rice is a poor source of many essential minerals nutrients, especially Iron (Fe), Manganese (Mn), Zinc (Zn) and Copper (Cu). Zinc is a crucial element needed to improve crop growth and output; of all micronutrients, Zn is regarded as the most important nutrient. More than 300 enzymes, including carbonic anhydrase, alcoholic dehydrogenase, alkaline phosphate, carboxy peptidase, phospholipase, superoxide dismutase (SOD) and RNA polymerase depend on zinc for their structural and functional integrity (Archana *et al*., 2025) [3]. Hence, it is desirable to apply micronutrients (Zn, Fe, Cu, Mn) along with RDF in meeting the nutrient demand of rice and also enrich micronutrients in rice.

Materials and Methods
The experiment was conducted in College of Agriculture, Navile, Shivamogga, Karnataka during late-*Kharif* 2024 in sandy clay soil to study the "Effect of Micronutrients on Growth and Yield of Transplanted Rice". The experiment was laid out in a randomized complete block design (RCBD) with eight treatments with three replications. The treatments consist of 100 per cent RDF + $ZnSO_4$ (20 kg ha^{-1}) (T_1), 100 per cent RDF + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) (T_2), 100 per cent RDF + $ZnSO_4$ (20 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) (T_3), 100 per cent RDF + $ZnSO_4$ (20 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) (T_4), 100 per cent RDF + $ZnSO_4$ (20 kg ha^{-1}) +

$MnSO_4$ (2.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) (T_5), 100 per cent RDF + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) (T_6), 100 per cent RDF (100:50:50 kg ha^{-1} NPK) + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) (T_7) and 100 per cent RDF alone (T_8). Periodical observations were recorded. The data obtained were subjected to statistical analysis by Fisher's method of analysis of variance as suggested by Panse and Sukhatme (1978) [6] as per the standard procedures.

Results and Discussion

The obtained data from the experiment is presented in Table 1, 2 and 3. The results showed that among different treatments, 100 per cent RDF (100:50:50 kg ha^{-1} NPK) + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) recorded significantly taller plants (89.33 cm, 104.00 cm and 107 cm at 60 DAT, 90 DAT and harvest, respectively), number of tillers $hill^{-1}$ (26, 24.67 and 22.33 from 60 DAT, 90 DAT and harvest, respectively), leaf area (858.33 cm^2, 1108.33 cm^2, 1100 cm^2 at 60 DAT, 90 DAT and harvest, respectively), dry matter accumulation $hill^{-1}$ (15.83 g $hill^{-1}$, 51.52 g $hill^{-1}$ and 59.79 g $hill^{-1}$ at 60 DAT, 90 DAT and harvest, respectively). Similarly, 100 per cent RDF (100:50:50 kg ha^{-1} NPK) + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) recorded significantly higher no. of productive tillers per hill (20.90), panicle length (23.13 cm), panicle weight (2.67 g $panicle^{-1}$), no. of grains per panicle (188.49), no. of unfilled grains per panicle (9.45), test weight (27.44 g), lowest chaffiness (5.00%), higher grain yield (6476.6 kg ha^{-1}) and higher straw yield (8047.1 kg ha^{-1}). However, it was on par with treatment T_5. This might attributed to combined application of Zn, Mn, Fe and Cu which helps to better source and sink relation results in increased grain size by Abid *et al.* (2011) [1].

An adequate level of zinc in the soil enhanced tillering, which in turn leads to a higher number of panicles per square meter. Additionally, since zinc plays a key role in pollen formation and seed development, the number of grains per panicle is greater in zinc-treated plots compared to the control (Meena and Shivay, 2010) [5].

Higher number of filled grains on this treatment might be due to manganese enhances carbohydrate metabolism and energy availability, both of which are crucial during the grain-filling phase. The lowest chaffiness in this treatment might be due to micronutrient application helps in reducing chaffiness in paddy by improving fertilization efficiency and minimizing spikelet sterility. Adequate levels of Zn, Fe, Cu and Mn ensure balanced nutrient availability during critical reproductive stages, which prevents the formation of empty spikelets. By strengthening enzymatic activities and hormonal regulation during panicle initiation and flowering, these micronutrients reduce grain abortion and promote uniform grain setting, thereby significantly lowering the proportion of chaffy or sterile grains (Santhosh, 2007) [7].

A generally significant positive impact on the grain and straw yields of rice (Siddika *et al.*, 2016) [9] and Hundal *et al.* (2008) [4] found that the combined application of micronutrients like specifically zinc, copper and manganese could contribute to increasing the grain yield of rice. Their observations align with other research noting that supplementation with these micronutrients, either individually or in combination, positively affects rice yield and associated yield component.

Table 1: Plant height and Number of tillers $hill^{-1}$ of rice as influenced by micronutrients at different growth stages

Treatments	Plant height (cm)				Number of tillers $hill^{-1}$			
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
T_1	57.87	67.27	86.67	89.67	10.00	18.00	17.67	16.33
T_2	59.53	72.00	91.00	93.67	11.33	18.67	18.67	17.33
T_3	60.33	74.00	92.00	95.33	11.67	20.33	19.67	18.33
T_4	58.53	70.53	87.87	91.20	11.00	18.33	18.00	16.67
T_5	64.07	84.07	101.33	104.00	12.33	24.33	23.00	21.67
T_6	62.07	78.33	95.00	99.67	12.00	23.33	22.67	20.67
T_7	64.97	89.33	104.00	107.00	14.00	26.33	24.67	22.33
T_8	56.73	65.87	85.20	88.33	9.67	17.33	17.00	15.00
S.Em. ±	1.96	2.50	2.69	3.00	1.11	1.21	1.30	1.11
C.D. @ 5%	NS	7.59	8.164	9.12	NS	3.66	3.95	3.36

Table 2: Leaf area (cm^2 $hill^{-1}$) and Total dry matter (g $hill^{-1}$)1 of rice as influenced by micronutrients at different growth stages

Treatments	Leaf area (cm^2 $hill^{-1}$)				Total dry matter (g $hill^{-1}$)			
	30 DAT	60 DAT	90 DAT	AT HARVEST	30 DAT	60 DAT	90 DAT	AT HARVEST
T_1	444.38	640.67	946.00	885.33	3.55	10.06	34.73	44.79
T_2	480.74	734.67	986.00	995.00	4.26	11.56	39.39	52.29
T_3	504.87	751.50	1008.00	1010.00	4.81	12.67	42.88	53.54
T_4	482.05	715.50	985.50	970.00	4.36	11.89	41.52	50.83
T_5	549.58	825.00	1092.20	1065.00	5.47	15.06	49.55	57.92
T_6	522.75	783.33	1049.87	1055.00	5.03	14.33	47.88	56.88
T_7	551.06	858.33	1108.33	1100.00	5.57	15.83	51.52	59.79
T_8	373.91	623.50	874.50	872.67	3.47	9.89	34.09	47.88
S.Em. ±	36.47	32.65	37.12	42.24	0.54	0.40	1.34	1.98
C.D. @ 5%	NS	99.04	112.61	128.11	NS	1.20	4.07	6.01

Note: Zn- $ZnSO_4$ (20 kg ha^{-1}), Mn- $MnSO_4$ (2.5 kg ha^{-1}), Fe -$FeSO_4$ (5 kg ha^{-1}), Cu- $CuSO_4$ (1.5 kg ha^{-1})
NS – Non significant
RDF- 100:50:50 kg ha^{-1}

Table 3: Grain yield and straw yield of paddy as influenced by application of micronutrients

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	5300.0	7223.8
T_2	5490.0	7660.6
T_3	5596.6	7218.5
T_4	5373.3	6689.0
T_5	6190.0	7517.5
T_6	5906.6	7608.0
T_7	6476.6	8047.1
T_8	5062.6	6902.1
S.Em. ±	174.28	296.08
C. D. @ 5%	528.63	898.08

Note: $ZnSO_4$ (20 kg ha^{-1}), Mn- $MnSO_4$ (2.5 kg ha^{-1}), Fe -$FeSO_4$ (5 kg ha^{-1}), Cu- $CuSO_4$ (1.5 kg ha^{-1})
RDF- 100:50:50 kg ha^{-1}

Table 3: Yield parameters of paddy as influenced by application of micronutrients

Treatments	No. of productive tillers hill^{-1}	Panicle length (cm)	Panicle weight (g panicle^{-1})	No. of grains panicle^{-1}	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Chaffiness (%)	Test Weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 – RDF + $ZnSO_4$	15.17	17.83	2.03	171.34	147.41	23.95	14.01	25.69	5300.0	7223.8
T_2 – RDF + $ZnSO_4$ + $MnSO_4$	16.00	20.50	2.16	179.83	159.08	20.76	11.51	26.06	5490.0	7660.6
T_3 – RDF + $ZnSO_4$ + $FeSO_4$	17.27	20.58	2.30	184.11	169.27	14.84	8.06	24.49	5596.6	7218.5
T_4 – RDF + $ZnSO_4$ + $CuSO_4$	15.73	19.27	2.23	175.57	149.09	26.51	15.02	26.81	5373.3	6689.0
T_5 – RDF + $ZnSO_4$ + $MnSO_4$ + $FeSO_4$	18.70	22.03	2.41	193.82	181.74	12.08	6.50	27.20	6190.0	7517.5
T_6 – RDF + $ZnSO_4$ + $MnSO_4$ + $CuSO_4$	17.39	21.10	2.37	189.46	172.41	17.05	9.00	26.34	5906.6	7608.0
T_7 – RDF + $ZnSO_4$ + $MnSO_4$ + $CuSO_4$ + $FeSO_4$	20.90	23.13	2.67	197.94	188.49	9.45	5.00	27.44	6476.6	8047.1
T_8- RDF Only	14.74	16.17	1.98	166.10	136.16	29.95	18.01	22.61	5062.6	6902.1
S.Em. ±	1.22	1.10	0.049	6.54	6.21	0.71	0.42	0.99	174.28	296.08
C. D. @ 5%	3.71	3.34	0.149	6.21	18.83	2.17	1.28	NS	528.63	898.08

Note: $ZnSO_4$ (20 kg ha^{-1}), Mn- $MnSO_4$ (2.5 kg ha^{-1}), Fe -$FeSO_4$ (5 kg ha^{-1}), Cu- $CuSO_4$ (1.5 kg ha^{-1})
NS – Non significant
RDF- 100:50:50 kg ha^{-1}

Conclusion

The study revealed that, application 100 per cent RDF (100:50:50 kg ha^{-1} NPK) + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $CuSO_4$ (1.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) higheer growth and yield parameters of transplanted rice. However, it was on par with application of 100 per cent RDF (100:50:50 kg ha^{-1} NPK) + $ZnSO_4$ (20 kg ha^{-1}) + $MnSO_4$ (2.5 kg ha^{-1}) + $FeSO_4$ (5 kg ha^{-1}) and lowest was recorded in RDF alone.

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