E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(12): 497-501
Received: 15-09-2024
Accepted: 19-10-2024

Sharanagouda
M.Sc. (Agri.), Department of Agronomy, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

GR Denesh
Professor and Scheme Head, AICRP on Rice, ZARS, V. C. Farm, Mandya, Karnataka, India

HR Savitha
Junior Soil Scientist, AICRP on Rice, ZARS, V.C. Farm, Mandya, Karnataka, India

BG Shekara
Professor and Scheme Head, AICRP on Fodder, ZARS, V. C. Farm, Mandya, Karnataka, India

Corresponding Author:
Sharanagouda
M.Sc. (Agri.), Department of Agronomy, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

Studies on time of application of zinc in transplanted rice (*Oryza sativa* L.) for improving growth and yield parameters

Sharanagouda, GR Denesh, HR Savitha and BG Shekara

DOI: https://doi.org/10.33545/2618060X.2024.v7.i12Sh.2240

Abstract
A field experiment was conducted to study the time of application of zinc in transplanted rice during *kharif* - 2023 at ZARS, V. C. Farm, Mandya. The experiment was laid out in Randomized Complete Block Design with eleven treatments replicated thrice. The treatments comprised of zinc sulphate @ 10, 15 and 20 kg ha^{-1} applied each at 10, 20 and 30 DAT, these nine treatments were compared with zinc sulphate @ 20 kg ha^{-1} as basal application and control (without zinc sulphate). The results revealed that zinc sulphate @ 20 kg ha^{-1} applied either at 10 or 20 or at 30 DAT was recorded higher growth and yield parameters at harvest, higher plant height (102.13 cm), number of tillers m^{-2} (416.00), total dry matter accumulation (77.72 g $hill^{-1}$), number of panicles m^{-2} (375.00), grains $panicle^{-1}$ (168.53), grain (6673 to 6797 kg ha^{-1}) and straw yield (7745 to 7835 kg ha^{-1}), harvest index (0.46%), net returns (84623 to 87596 Rs. ha^{-1}) and B:C ratio (2.00 to 2.04) was also recorded higher in the above treatments. Further, all these parameters recorded in the former treatments were statistically comparable to zinc sulphate @ 20 kg ha^{-1} as basal application.

Keywords: Zinc sulphate, transplanted rice, basal application

1. Introduction
Rice is the staple food for more than half of the world population. On a global basis, rice provides 21% and 15% per capita of dietary energy and protein, respectively (Maclean *et al.*, 2002) [6] and it is a major food crop in India. Rice is known as the grain of life food as it supplies majority of starch, protein and micronutrient requirements. Rice has become a common dietary in the world, particularly in developing countries. Rice is the only cereal crop cooked and eaten as a whole grain, making quality considerations for more critical than for any other food crop (Ravindrababu *et al.*, 2013) [12]. Rice provides 50–80% of the energy intake of the people in the developing countries, which is more than that of corn or wheat (Anon., 2006) [2]. The rice occupied an area of 46.27 million ha and with a production of 129.47 million tons in India (Anon., 2022) [3]. The rice production in the recent days is much affected by Zn deficiency in the rice soils. Since, Zn is an important component of various enzymes in the plant and it promotes photosynthesis, carbohydrate and phosphorus metabolism. The typical deficiency of Zn causes rice yield losses in the range of 10-60% and in severe cases, plant death and stand loss can occur (Norman *et al.*, 2003) [10].
Indian soils are deficient in Zinc by 48.8%, first time Zn deficiency in rice was reported in Tarai region of Uttarakhand (Nene, 1966) [7]. The disease appears in patches after two weeks of rice transplanting. Growth is checked, the outer leaves dry out at the tips and a yellowing, followed by rusty discoloration extends marginally downwards. Centre leaves remain comparatively normal, but the root system is poor and discolored. A month or later some recovery and new tillering takes place, but flowering is very poor. The symptoms are similar to those of 'pan-Sukh' (potassium deficiency) (Nene, 1968) [8].
Currently, zinc (Zn) is applied as a basal fertilizer before transplanting rice, typically as a standalone application without mixing it with other fertilizers. However, this application often coincides with the timing of other fertilizer applications and irrigation management. At planting, Farmers are frequently under time pressure due to the need to complete multiple agronomic

tasks within a short period, such as final land preparation, leveling, seedling uprooting, and planting. As a result, many farmers mix zinc with other basal fertilizers. Moreover, applying zinc as a basal fertilizer can be having questions due to its unavailability at the start of the season. Additionally, rice requires zinc primarily during the active tillering stage, and zinc applied at the basal stage may bind to soil particles, phosphorus fertilizers, or metal ions, forming precipitates that are not available to the plants. To address these concerns, an experiment was conducted.

2. Material and Methods

The field experiment was conducted during *kharif* 2023 at Zonal Agricultural Research Station, V. C. Farm, Mandya to study the time of application of zinc sulphate on growth and yield of transplanted rice. The location is situated in Southern Dry Zone (6) of Karnataka at 12º 30' N latitude and 76º 76' E longitude. The actual rainfall of V. C. Farm, Mandya during crop growing period was 297.40 mm. The major part of the rainfall was received in the month of October (89.50 mm). The mean maximum air temperature varied from 28.2 °C to 32.3 °C. The highest mean maximum air temperature was noticed during August (32.3 °C). The mean minimum air temperature ranged from 18.0 °C to 20.6 °C. The lowest mean minimum temperature recorded during December (18.0 °C). The mean bright sunshine hours varied from 6.4 to 7.2 hours during July to December. The relative humidity varied from 82 to 85.8% and 57.8 to 68.4% in morning and afternoon hours, respectively during the crop growing period of 2023. The soil is classified as Typic Rhodustalfs and is sandy loam in texture. The soil of experimental site was sandy loam in texture with an average particle content of 48.56 per cent coarse sand, 31.42 per cent fine sand, 07.62 per cent silt and 12.37 per cent clay. The soil was slightly acidic in reaction (pH 5.50), organic carbon content was medium (0.57%) with the electrical conductivity of the soil was 0.16 (dS m^{-1}). The soil was low in available nitrogen (233.03 kg ha^{-1}), medium in available phosphorus (47.24 kg ha^{-1}), low in available potassium (129.30 kg ha^{-1}) and adequate in initial zinc content (1.26 mg/kg of soil).

The experiment was laid out in Randomized Complete Block Design with eleven treatments comprised of zinc sulphate @ 10, 15, and 20 kg ha^{-1} applied each at 10, 20 and 30 DAT, these nine combinations compared with zinc sulphate @ 20 kg ha^{-1} as basal application and control (without zinc sulphate) treatments. The experimental plot was divided into three blocks that represents three replications and each block was sub divided into 11 plots where, treatments were distributed randomly.

The 21 days aged seedlings of KMP 220 rice variety were transplanted in puddled soil with a spacing of 25cm between rows and 10 cm between plants in the row. Inorganic fertilizers *viz*., urea, single super phosphate and muriate of potash were used to supply nutrients. The recommended dose of fertilizer (RDF) used was 100N: 50 P2O5: 50K2O kg/ha as per UASB package of practice. Farm yard manure was used as organic source of nutrient @ 10 t/ha^{-1} and was incorporated 15 days before planting. Phosphorus fertilizer was applied entirely as basal dose. Potassium fertilizer was applied in 2 splits *viz*., 50% at the time of sowing as basal and remaining 50% as top dressing at 50 days after transplanting (DAT). Nitrogen was applied in 3 splits *viz*., 50% at the time of sowing as basal and remaining fertilizers was applied as top dressing in two equal splits of 25% each at 30 & 50 DAT. The calculated quantity of zinc sulphate micronutrient was applied as basal, at 10, 20 and 30 DAT as per the treatment. The all other crop management practices were followed as per UASB package of practice.

3. Results and Discussion

3.1 Plant height

The application of zinc sulphate @ 20 kg ha^{-1} at 30 DAT recorded higher plant height (102.13 cm) followed by zinc sulphate @ 15 kg ha^{-1} at 30 DAT (100.60 cm) and were significantly superior over zinc sulphate @ 10 kg ha^{-1} at 20 DAT (95.33 cm) and control without zinc sulphate (93.37 cm). However, plant height recorded in former treatments at harvest was statistically similar with rest of the zinc management treatments (97.00 to 98.53 cm). Table 1. The zinc sulphate application met the plant demand, which is required in biosynthesis of auxin production and also for enhancing apical dominance resulted in increased cell division and stem elongation for producing taller plants. (Noel, 2019 [9] and Prakhar *et al.* (2022) [11].

3.2 Tillers per meter square

The higher number of tillers m^{-2} in rice at harvest recorded with zinc sulphate @ 20 kg ha^{-1} applied at 10 DAT (416.00) which was statistically on par with zinc sulphate @ 20 kg ha^{-1} applied at 20 or 30 DAT or as basal application (395.00 to 405.33), however was significantly superior as compared to rest of the application of zinc sulphate treatments (360.00 to 394.67) or control (356.67). Table 1. Synchronized application of zinc sulphate resulted in production of auxin and thereby eye buds to produce more tiller in rice (Sumaiya *et al.* 2022) [14].

3.3 Dry matter production (g $hill^{-1}$)

The total dry matter production per hill at 60 DAT was higher with the zinc sulphate @ 20 kg ha^{-1} applied at 10 DAT (20.92 g), followed by zinc sulphate @ 20 kg ha^{-1} applied at 20 or 30 DAT or zinc sulphate @ 15 kg ha^{-1} at 10 to 20 DAT or @ 20 kg ha^{-1} as basal application (17.87 to 20.52 g), however was statistically superior as compared to rest of the treatments (14.18 to 16.99 g). Similar trend of dry matter production in leaf and stem was noticed in the former treatments Table 1. The optimum zinc availability in rice plants helps to improve cell division and elongation, apart from better photosynthetic activity as resulted in higher total dry matter production. The comparable results were reported by Suvarna *et al.* (2015) [15] and Prakhar *et al.* (2022) [11] for incorporation of 20 to 50 kg Zn ha^{-1} as basal.

Table 1: Plant height (cm) and number of tillers m^{-2} at harvest stage and dry matter production (g $hill^{-1}$) in leaf, stem and total at 60 DAT as influenced by time of application of zinc in transplanted rice

Treatments	Plant height (cm) at harvest	Number of tillers m^{-2} at harvest	Dry matter production (g $hill^{-1}$) at 60 DAT		
			Leaf	Stem	Total
T_1: Zinc sulphate @ 20 kg ha^{-1} as basal dose	97.57	395.00	8.57	11.95	20.52
T_2: Zinc sulphate @ 10 kg ha^{-1} as soil application at 10 DAT	98.53	380.33	7.33	8.62	15.95
T_3: Zinc sulphate @ 10 kg ha^{-1} as soil application at 20 DAT	95.33	363.00	6.87	8.47	15.34
T_4: Zinc sulphate @ 10 kg ha^{-1} as soil application at 30 DAT	98.10	360.00	6.75	8.09	14.84
T_5: Zinc sulphate @ 15 kg ha^{-1} as soil application at 10 DAT	97.00	394.67	7.77	10.61	18.38
T_6: Zinc sulphate @ 15 kg ha^{-1} as soil application at 20 DAT	97.97	388.33	7.55	10.31	17.87
T_7: Zinc sulphate @ 15 kg ha^{-1} as soil application at 30 DAT	100.60	377.00	7.47	9.52	16.99
T_8: Zinc sulphate @ 20 kg ha^{-1} as soil application at 10 DAT	98.03	416.00	8.72	12.20	20.92
T_9: Zinc sulphate @ 20 kg ha^{-1} as soil application at 20 DAT	97.20	404.67	8.54	11.52	20.06
T_{10}: Zinc sulphate @ 20 kg ha^{-1} as soil application at 30 DAT	102.13	405.33	8.34	10.98	19.32
T_{11}: Control (without Zinc sulphate)	93.37	356.67	6.70	7.48	14.18
S.Em ±	2.07	8.54	0.51	1.18	1.04
CD @ 5%	6.07	25.04	1.51	NS	3.06

Note: NS: Non-significant, DAT- Days after transplanting

3.4 Panicles per meter square

Zinc sulphate @ 20 kg ha^{-1} applied at 10 DAT recorded significantly higher panicles $meter^{-2}$ (375.00) as compared to zinc sulphate @ 10 kg ha^{-1} at 20 to 30 DAT or control without zinc sulphate (304.00 to 332). However, was statistically at par with rest of the zinc management practices (338.00 to 371.00) (Table 2). The results shows that zinc sulphate application up to 30 DAT had positive influence on productive panicles, similar type of results were also reported by Ibrahim *et al.* (2019) [5] for application of $ZnSO_4$ @ 10 kg ha^{-1} at 14 DAT and Sumaiya *et al.* (2022) [14].

3.5 Grain and straw yield (kg ha^{-1})

Application of zinc sulphate @ 20 kg ha^{-1} at 10 DAT recorded higher grain yield (6797 kg ha^{-1}) which was on par with zinc sulphate @ 20 kg ha^{-1} at 20 or 30 DAT or zinc sulphate @ 20 kg ha^{-1} as basal application (6673 to 6779 kg ha^{-1}) and were statistically superior over rest of the treatments (5574 to 5979 kg ha^{-1}) (Table 2). Similar trend in straw yield was observed. The zinc sulphate @ 20 kg ha^{-1} applied at 10 or 20 or 30 DAT or as basal application recorded 19.71 to 21.94% higher grain yield as compared to control without zinc sulphate. Further, no significant variation in grain yield among the application at 10 or 20 or 30 DAT or as basal application shows the flexibility in the time application upto 20 to 30 days for adequate uptake to perform normal physiological activity as catalysed by zinc in rice. Higher yield with the zinc fertilization due to its involvement in many metabolic enzyme systems, regulatory functions, auxin production, enhanced synthesis of carbohydrates and their transport to the site of grain production. All these are evidenced by taller plant height, better tiller production, more leaf area and index and higher yield parameters (Table 1) as noticed in this experiment. The results obtained are in line with Dinesh *et al.* (2017) [4] and Angelin and Stalin (2017) [1] with the application of Zn @ 7.5 to 50 kg ha^{-1} as basal and Ibrahim *et al.* (2019) [5] by the 10 kg ha^{-1} $ZnSO_4$ application at 14 DAT.

3.6 Economics of rice production

3.6.1 Cost of cultivation (Rs. ha^{-1})

Among zinc management practices zinc sulphate @ 10 kg ha^{-1} applied at 10 to 30 DAT resulted in lower zinc management cost (1,150 Rs. ha^{-1}) and total cost of cultivation (84,028 Rs. ha^{-1}) followed by zinc sulphate @ 15 kg ha^{-1} at 10 to 30 DAT (1,275 and 84,153 Rs. ha^{-1}, respectively) as compared to rest of the treatments (1,400 and 84,278 Rs. ha^{-1}, respectively). The lower cost in the former treatments was due to less cost invested on zinc fertilizer as compared to other treatments.

3.6.2 Gross and net returns (Rs. ha^{-1})

The higher gross and net returns (1,71,874 and 87,596 Rs. ha^{-1}, respectively) recorded in zinc sulphate @ 20 kg ha^{-1} applied at 10 DAT followed by zinc sulphate @ 20 kg ha^{-1} as basal application (1,71,236 and 86,959 Rs. ha^{-1}, respectively) and zinc sulphate @ 20 kg ha^{-1} at 20 to 30 DAT (1,68,901 to 1,69,808 and 84,623 to 85,531 Rs. ha^{-1}, respectively). While, lower gross and net returns (1,41,126 and 58,249 Rs. ha^{-1}, respectively) was recorded in control without zinc sulphate as compared to rest of the zinc management practices. The significant increase in grain and straw yield with the zinc sulphate @ 20 kg ha^{-1} either at 10 to 30 DAT or as basal application as resulted in higher gross and net returns. The results obtained were in conformity with findings of Sudhagar rao *et al.* (2020) [13] and Sumaiya *et al.* (2022) [14] with the $ZnSO_4$ @ 10 to 25 kg ha^{-1} as basal application.

3.6.3 B:C ratio

Application of zinc sulphate @ 20 kg ha^{-1} at 10 DAT recorded higher B:C ratio (2.04) followed by zinc sulphate @ 20 kg ha^{-1} as basal application (2.03) or at 20 to 30 DAT (2.00 to 2.01,) as compared to rest of the zinc management practices (1.70 to 1.92) (Table 3). The results obtained are in conformity with Sudhagar rao *et al.* (2020) [13] and Sumaiya *et al.* (2022) [14] with the $ZnSO_4$ @ 10 to 25 kg ha^{-1} as basal application.

Table 2: Number of panicles m^{-2}, grains panicle^{-1}, grain yield, straw yield and harvest index in transplanted rice as influenced by time of application of zinc

Treatments	Panicles m^{-2}	Grains panicle^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1: Zinc sulphate @ 20 kg ha^{-1} as basal dose	371	167.67	6779	7751	0.46
T_2: Zinc sulphate @ 10 kg ha^{-1} as soil application at 10 DAT	338	146.73	5979	7268	0.45
T_3: Zinc sulphate @ 10 kg ha^{-1} as soil application at 20 DAT	332	146.40	5848	7332	0.44
T_4: Zinc sulphate @ 10 kg ha^{-1} as soil application at 30 DAT	329	145.27	5956	7343	0.45
T_5: Zinc sulphate @ 15 kg ha^{-1} as soil application at 10 DAT	359	155.53	6250	7440	0.46
T_6: Zinc sulphate @ 15 kg ha^{-1} as soil application at 20 DAT	349	148.00	6356	7494	0.46
T_7: Zinc sulphate @ 15 kg ha^{-1} as soil application at 30 DAT	353	148.73	6317	7508	0.46
T_8: Zinc sulphate @ 20 kg ha^{-1} as soil application at 10 DAT	375	168.53	6797	7835	0.46
T_9: Zinc sulphate @ 20 kg ha^{-1} as soil application at 20 DAT	364	156.53	6714	7749	0.46
T_{10}: Zinc sulphate @ 20 kg ha^{-1} as soil application at 30 DAT	356	156.07	6673	7745	0.46
T_{11}: Control (without Zinc sulphate)	304	142.33	5574	6484	0.46
S.Em ±	13.43	8.98	237.80	238.70	0.01
CD @ 5%	39.00	NS	698	700	NS

Note: NS: Non-significant, DAT- Days after transplanting

Table 3: Economics of transplanted rice as influenced by time of application of zinc in transplanted rice

Treatments	Zinc management cost (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1: Zinc sulphate @ 20 kg ha^{-1} as basal dose	1400	82878	84278	171236	86959	2.03
T_2: Zinc sulphate @ 10 kg ha^{-1} as soil application at 10 DAT	1150	82878	84028	152314	68287	1.81
T_3: Zinc sulphate @ 10 kg ha^{-1} as soil application at 20 DAT	1150	82878	84028	149668	65640	1.78
T_4: Zinc sulphate @ 10 kg ha^{-1} as soil application at 30 DAT	1150	82878	84028	152049	68022	1.81
T_5: Zinc sulphate @ 15 kg ha^{-1} as soil application at 10 DAT	1275	82878	84153	158752	74599	1.89
T_6: Zinc sulphate @ 15 kg ha^{-1} as soil application at 20 DAT	1275	82878	84153	161235	77083	1.92
T_7: Zinc sulphate @ 15 kg ha^{-1} as soil application at 30 DAT	1275	82878	84153	160419	76267	1.91
T_8: Zinc sulphate @ 20 kg ha^{-1} as soil application at 10 DAT	1400	82878	84278	171874	87596	2.04
T_9: Zinc sulphate @ 20 kg ha^{-1} as soil application at 20 DAT	1400	82878	84278	169808	85531	2.01
T_{10}: Zinc sulphate @ 20 kg ha^{-1} as soil application at 30 DAT	1400	82878	84278	168901	84623	2.00
T_{11}: Control (without Zinc sulphate)	0	82878	82878	141126	58249	1.70

Note: NS: Non-significant, DAT- Days after transplanting

4. Conclusion

Form this study it can be inferred that, application of Zinc sulphate @ 20 kg ha^{-1} at 10 to 30 days after transplanting produced better growth and yield parameters, higher grain and straw yield along with higher net return and B:C ratio, similar to zinc sulphate @ 20 kg ha^{-1} as basal application. Hence, time of application of zinc sulphate can be extended upto 30 DAT in transplanted rice.

5. References

1. Angelin SR, Stalin P. Response of irrigated rice to applied zinc under varying available zinc status of rice soils in Tamil Nadu. Int J Chem Stud. 2017;5(4):27-31.
2. Anonymous. High-Iron and Zinc rice [Internet]. 2006 [cited 2024 Dec 25]. Available from: http://www.knowledgebank.irri.org/factsheets/Otherresources/HealthandNutrition/fs-FeandZn.pdf
3. Anonymous. Area production and productivity of India. Directorate of Economics; c2022. Available from: www.indiastat.com
4. Dinesh Kumar, Rajesh Kumar, Prashant Singh, Pushpendra Kumar. Effect of different zinc management practices on growth, yield, protein content, nutrient uptake and economics on rice under partially reclaimed salt-affected soil. J Pharmacogn Phytochem. 2017;6(5):638-640.
5. Ibrahim MA, Islam MA, Khaliq QA, Rouf MA. Effect of zinc fertilizer application on growth yield and yield contributing characters in rice. Asian J Adv Agri Res. 2019;9(2):1-10.
6. Maclean JL, Dawe DC, Hardy B, Hettel GP. Rice almanac: Source book for the most important activity on earth. Int Rice Res Inst. 2002;3:3-8.
7. Nene YL. Symptoms, causes and control of Khaira disease of Paddy. Bull Ind Phytopathol Soc. 1966;3:97-101.
8. Nene YL. Khaira disease of Rice and its control. Int Rice Comm News Lett. 1968;17(1):1-8.
9. Baylon NJ. Levels of zinc application on the agronomic characteristics and yield performance of lowland rice. Int Peer Rev J. 2019;37:122-131.
10. Norman RJ, Wilson JR, Slaton NA. Soil fertilization and mineral nutrition in U.S. mechanized rice culture. In: Proceedings of the Rice Conference. 2003. pp. 331-412.
11. Prakhar KN, Singh T, Amit ST, Divanshu G, Atul KN. Effect of zinc and KSB levels on growth, yield and quality

of paddy (*Oryza sativa* L.). Pharma Inno J. 2022;11(9):2860-2866.
12. Ravindrababu V, Shreya K, Kuldeep SD, Usharani G, Nagesh P. Evaluation of popular rice hybrid for quantitative, qualitative and nutritional aspects. Int J Sci Res Pub. 2013;3:2250-3153.
13. Sudhagar Rao GB, BalachandraKaumar V, Rex Immanuel R, Nambi J, Suthin Raj T. Influence of zinc and iron fortified micronutrients on the growth, yield and economics of rice (*Oryza sativa* L.). Crop Res. 2020;55(5 & 6):3.
14. Sumaiya Afrin MD, Parvez Anwar MD, Rashedur Rahman, Ahmed Khairul Hasan, Farzana Bintay Forhad, Sabina Yeasmin AKM, *et al*. Comparative performance and economics of different zinc application approaches in Boro rice. Fund Appl Agri. 2022;7(2):121-130.
15. Suvarna PK, Reddy SN, Andy ASS, Reddy SK. Quarterly effect of zinc nutrition on dry matter production, yield and uptake by aromatic rice. Int Quart J Envi Sci. 2015;9(1&2):513-516.