International Journal of Research in Agronomy 2024; SP-7(7): 480-483

International Journal of Research in Agronomy

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

www.agronomyjournals.com
2024; SP-7(7): 480-483
Received: 21-04-2024
Accepted: 29-05-2024

Thonduru Raju
Department of Agronomy, College of Agriculture, VC Farm, Mandya, Karnataka, India

DH Roopashree
AICRP for Dryland Agriculture, UAS, GKVK, Bangalore, Karnataka, India

T Bhagyalakshmi
Department of Soil Science and Agricultural Chemistry, College of Agriculture, V C Farm, Mandya, Karnataka, India

CM Sunil
AICRP on Small Millets, ZARS, VC Farm, Mandya, Karnataka, India

Corresponding Author:
DH Roopashree
AICRP for Dryland Agriculture, UAS, GKVK, Bangalore, Karnataka, India

Fortification of fodder maize (*Zea mays* L.) with zinc for enhancing fodder quality, nutrient uptake and economics

Thonduru Raju, DH Roopashree, T Bhagyalakshmi and CM Sunil

DOI: https://doi.org/10.33545/2618060X.2024.v7.i7Sg.1084

Abstract
A field experiment was conducted to evaluate the performance of fodder maize to zinc application during *Kharif* 2022 at College of Agriculture, V. C. Farm, Mandya. The experiment was conducted in Randomized complete Block Design with nine treatments replicated thrice. Treatment combinations include varied levels of soil application (5.0, 7.5, 10.0 kg/ha $ZnSO_4$) and foliar application of zinc (0.3%) at 25 and 45 DAS, which were compared with recommended dose of fertilizer alone. Significantly higher crude protein yield (9.25 q/ha), crude fibre yield (26.42 q/ha) and nutrient uptake (147.91 kg/ha of N, 17.32 kg/ha of P, 102.60 kg/ha of K and 405.29 g/ha of zinc) were found with the application of RDF + $ZnSO_4$ @ 10.0 kg ha^{-1} as soil application + foliar application of zinc @ 0.3% at 45 days after sowing. Among the all treatments higher gross returns, net returns and B:C ratio (Rs. 106536/ha, Rs. 67219/ha and 2.71, respectively) was observed with the application of RDF + $ZnSO_4$ @ 10.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS.

Keywords: Fodder maize, quality, crude protein, crude fibre and Zinc

Introduction
Lower productivity of cattle and buffalos under Indian condition is accountable mainly due to unavailability of quality feed and fodder, improper nutrition, inadequate health-care and management. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients (Anonymous, 2013) [1]. Under current scenario, forage based economical feeding strategies are required to reduce the cost of livestock product as the feed alone constitutes 60-70% of the total milk production cost. However, there is tremendous pressure of livestock on available total feed, fodder, as land available for fodder production has been decreasing, and there is hardly any scope of expansion due to increasing pressure on agricultural land for food and cash crops.

Maize has great potential for higher productivity but it is also an exhaustive crop for nutrient demand. There exist a vicious cycle, as the imbalanced nutrient supply to the crops, often led to low productivity, which in turn also responsible for poor response from the applied inputs, consequently poor nutrient use efficiency and profitability. It is amply visible that micro nutrients are becoming very critical in getting proper response even from macro elements. Among the micro-nutrients, the deficiency of Zn is becoming a pan India problem. It has been widely reported that micronutrients enhance nutritional quality, productivity and resiliency to abiotic (drought, high temp) and biotic (pest and diseases) stresses. These positive effects range from 10 to 70%, dependent on the micronutrient, and occur with or without NPK fertilization (Golldack *et al*., 2014) [8]. Almost 50% Indian soils are deficit in Zn, and symptoms of Zn deficiency in maize crop are frequently encountered. Skewed use of plant nutrients excluding micronutrients is a major concern for higher fodder maize productivity.

Zinc is also essential as a micronutrient (Hafeez *et al*., 2013) [10]. Zinc is the only metal represented in all six enzyme classes (Broadley *et al*., 2007) [4]. It also acts in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, and pollen formation (Brown *et al*., 1993; Cakmak, 2002; Mousavi, 2011) [5, 6, 16].

Zn is required for the synthesis of tryptophan which is a precursor of growth-promoting hormone, i.e. auxin (Shukla and Prasad, 1974) [21]. Not only the growth; zinc also plays an important role in fodder quality too (Mahdi *et al*., 2012; Mohan *et al*., 2015) [13, 15]. Zn has vital role in stabilization of RNA, DNA, ribosomes and is involved in the immune system of animals, deficiency of which affects the health and milk production severely. The deficiency of zinc in soil will lead to poor yield as well as quality of fodder. Since, zinc is also a major nutrient in animal nutrition; if we properly manage its deficiencies in soil the problem associated with lower level of zinc in animals can be rectified. With this hypothesis the current study was planned to access limited information about scheduling, method and dose of zinc application for better quality and yield of maize in different maize cultivars.

Materials and Methods

The field research was conducted at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya (Karnataka) located at 12º 45' and 30º 57' North latitude and 76º 45' and 78 º 24' East longitude with 695 metre above mean sea level. The research station falls under region III and Agro Climatic Zone VI (Southern Dry Zone) of Karnataka. The soil characteristics of the experimental site was sandy loam in texture, low in organic carbon (0.46%), low in available nitrogen (241.34 kg/ha) and zinc (0.45 ppm), and medium in available phosphorus (37.71 kg/ha) and potassium (228.13 kg/ha).

The experiment was laid out in a randomized completely block design (RCBD) with nine treatments and replicated thrice. The treatments were, T_1- Recommended dose of fertilizers (RDF) alone (150 kg N, 750kg P_2O_5 and 40 kg K_2O/ha) without zinc application, T_2- RDF + soil application of 5.0 kg $ZnSO_4$/ha, T_3- RDF + soil application of 7.5 kg $ZnSO_4$/ha, T_4- RDF + soil application of 10.0 kg $ZnSO_4$/ha, T_5- RDF + Foliar application of 0.3% zinc at 45 DAS, T_6- RDF + Foliar application of 0.3% zinc at 25 and 45 DAS, T_7- RDF + soil application of 5.0 kg $ZnSO_4$/ha + Foliar application of 0.3% zinc at 45 DAS, T_8- RDF + soil application of 7.5 kg $ZnSO_4$/ha + Foliar application of 0.3% zinc at 45 DAS and T_9- RDF + soil application of 10.0 kg $ZnSO_4$/ha + Foliar application of 0.3% zinc at 45 DAS.

Sowing was performed on the sufficiently leveled plots with a mild gradient in one side to facilitate proper irrigation and drainage. The fodder maize variety of African Tall with a seed rate of 100 kg ha^{-1} and spacing of spacing of 30 x 10 cm was used in this experiment. All the plots were supplied with (Recommended dose of fertilizer) 150 kg of N/ha and 75 kg of P_2O_5/ha and 40 kg of K_2O/ha in which full dose of P_2O_5, K_2O and half dose of N was applied as basal dose while the remaining half of the N was supplied at 30 DAS. Zinc sulphate was applied as per the treatments *i.e.*, soil application of $ZnSO_4$ and foliar application of 0.3% zinc at 25 and 45 DAS as per the treatments.

To determine the quality of the fodder crop, representative samples were oven-dried at 65±2 °C until it attains constant weight. All the oven dried samples were powdered in Wiley mill using 2 mm sieve for crude protein, and ash content while 1 mm sieve for crude fibre analysis. Proximate principles namely crude protein yield (CPY), crude fiber yield (CFY), was determined according to AOAC, 2005 [2]. The uptake of the N, P, K and zinc was calculated by multiplying their concentrations with respective plot yield of maize fodder and expressed in kg/ha. All data recorded were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) [9] for randomized completely block design. The least significant test was used to decipher the main and interaction effects of treatments at 5% level of significance (p<0.05).

Results and Discussion

Effect on fodder quality

Chemical composition showed that the quality parameters of fodder maize were influenced significantly by soil and foliar application of zinc except ash content. Zinc fertilization through soil and foliar application showed that significant effect on the chemical composition of the fodder maize over no zinc application (Table 1). The quality parameters i.e., crude protein yield, Crude fibre yield and ash per cent (9.25 q/ha, 26.42 q/ha and 6.18%) was maximum with application of RDF + 10 kg/ha $ZnSO_4$ as soil application + foliar application of zinc @ 0.3% at 45 DAS compared to application of RDF alone. The higher crude protein yield of fodder maize might be due to Zn is essential for the activity of RNA polymerase, protects ribosomes and is also involved in function and stability of genetic material that plays a direct role in amino acid synthesis resulting in improved protein content. Similar results were found Kumar *et al*. 2017, Panda *et al.* (2020) [12, 17] and Ramakrishna *et al*. (2022) [19]. Significant improvement of crude fibre yield in fodder maize may be ascribed to the vital role played by zinc in IAA synthesis and protein metabolism. These results are in accordance with those of Koushik *et al*. (2010) [11] and Shanthi *et al*. (2012) [20].

Nutrient uptake by fodder maize

Result of present study showed that nutrient uptake of fodder maize influenced significantly by various treatments. The application of RDF + 10 kg/ha $ZnSO_4$ as soil application + foliar application of zinc @ 0.3% at 45 DAS recorded higher uptake of NPK 147.91, 17.32 and 102.60 kg/ha, respectively, over RDF alone (Table 2). The improvement of nutrient yields was mainly due to higher green fodder yield and dry matter production. Higher nutrient uptake in fodder maize, could be due to favorable effect of Zn application on growth parameters, i.e. plant height, number of leaves and leaf: stem ratio, which increased green fodder yield and dry matter yield (Paramasivan *et al*. 2011) [18]. Among all treatments higher zinc uptake (405.29 g/ha) (Table 2). was observed with application of RDF + $ZnSO_4$ @ 10.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS. It might be due to uptake of Zn nutrient isa function of its improved metabolic reactions and enzyme activity. The increase in uptake of Zn was the combined effect of the substantial increase in zinc concentration and higher dry matter yield of fodder maize. Similar results were in accordance with Meena *et al*. (2013) [14] and Kumar *et al*. (2017) [12].

Economics of fodder maize

Economics in terms of cost of cultivation, gross returns, net returns and B:C ratio are represented in Table 3. The application of RDF +$ZnSO_4$ @ 10 kg/ha as soil application along with foliar application of zinc @ 0.3% at 45 DAS recorded highest cost of cultivation (Rs. 39,317 ha^{-1}) and lowest cost of cultivation was recorded in treatment RDF (Rs. 37,396 ha^{-1}) during the period of investigation. The RDF +$ZnSO_4$ @ 10 kg/ha as soil application along with foliar application of zinc @ 0.3% at 45 DAS (1,06,536, 67,219 Rs. ha^{-1} and 2.71, respectively) recorded higher gross returns, net returns and benefit: cost over all the treatments. It might be due to higher yield attributes. The results were in accordance with Chand *et al*. (2017) [7] and Baljeet *et al*. (2021) [3].

Table 1: Quality parameters of fodder maize influenced by fortification with zinc

Treatments	Crude protein yield (q/ha)	Crude fibre yield (q/ha)	Ash content (%)
T_1: RDF (N:P:K @150:75:40 kg/ha)	6.24	19.38	5.58
T_2: RDF + $ZnSO_4$ @ 5.0 kg /ha as soil application	7.09	21.42	5.62
T_3: RDF + $ZnSO_4$ @ 7.5 kg/ha as soil application	7.92	23.26	5.76
T_4: RDF + $ZnSO_4$ @ 10.0 kg ha^{-1} as soil application	8.56	24.62	6.15
T_5: RDF + foliar application of zinc @ 0.3% at 45 DAS	6.64	20.53	5.50
T_6: RDF + foliar application of zinc @ 0.3% at 25 and 45 DAS	6.97	21.29	6.03
T_7: RDF + $ZnSO_4$ @ 5.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	7.60	22.89	5.74
T_8: RDF + $ZnSO_4$ @ 7.5 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	8.34	24.42	5.91
T_9: RDF + $ZnSO_4$ @ 10.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	9.25	26.42	6.18
S.Em±	0.32	0.94	0.25
CD (P=0.05)	0.96	2.81	NS

Table 2: Nutrient uptake of fodder maize influenced by fortification with zinc

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Zinc uptake (g/ha)
T_1: RDF (N:P:K@150:75:40 kg/ha)	99.43	12.94	70.51	214.50
T_2: RDF + $ZnSO_4$ @ 5.0 kg /ha as soil application	112.98	14.26	83.55	281.09
T_3: RDF + $ZnSO_4$ @ 7.5 kg/ha as soil application	125.81	15.46	87.52	321.03
T_4: RDF + $ZnSO_4$ @ 10.0 kg ha^{-1} as soil application	136.34	16.27	95.73	373.37
T_5: RDF + foliar application of zinc @ 0.3% at 45 DAS	105.74	13.66	75.16	256.54
T_6: RDF + foliar application of zinc @ 0.3% at 25 and 45 DAS	111.55	14.10	80.04	287.40
T_7: RDF + $ZnSO_4$ @ 5.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	120.96	15.16	85.91	314.09
T_8: RDF + $ZnSO_4$ @ 7.5 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	133.50	16.06	92.73	368.25
T_9: RDF + $ZnSO_4$ @ 10.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	147.91	17.32	102.60	405.29
S.Em±	5.21	0.64	3.68	12.63
CD (P=0.05)	15.63	1.80	11.03	37.86

Table 3: Economics of fodder maize influenced by fortification with zinc

Treatments	Cost of cultivation	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C ratio
T_1: RDF (N:P:K @150:75:40 kg/ha)	37396	83088	45692	2.22
T_2: RDF + $ZnSO_4$ @ 5.0 kg /ha as soil application	37821	90240	52419	2.39
T_3: RDF + $ZnSO_4$ @ 7.5 kg/ha as soil application	38034	95966	57932	2.52
T_4: RDF + $ZnSO_4$ @ 10.0 kg ha^{-1} as soil application	38246	100008	61762	2.61
T_5: RDF + foliar application of zinc @ 0.3% at 45 DAS	38467	87264	48797	2.27
T_6: RDF + foliar application of zinc @ 0.3% at 25 and 45 DAS	39538	89544	50006	2.26
T_7: RDF + $ZnSO_4$ @ 5.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	38892	95304	56412	2.45
T_8: RDF + $ZnSO_4$ @ 7.5 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	39105	99528	60423	2.55
T_9: RDF + $ZnSO_4$ @ 10.0 kg/ha as soil application + foliar application of zinc @ 0.3% at 45 DAS	39317	106536	67219	2.71

Conclusion

The present study concludes that the application of RDF (150:75:40 N:P:K kg/ha) along with $ZnSO_4$ @ 10.0 kg ha^{-1} as soil application followed by foliar application of zinc @ 0.3% at 45 days after sowing was found to be promising in increasing the quality parameters like crude protein yield and crude fibre yield in fodder maize. Nutrient uptake of fodder maize like nitrogen uptake, phosphorus uptake, potassium uptake and zinc uptake were found higher with the application of $ZnSO_4$ @ 10.0 kg ha^{-1} as soil application followed by foliar application of zinc @ 0.3% at 45 days after sowing and was economically viable with increase in net returns and benefit cost ratio.

References

1. Anonymous. Vision-2050. Indian Grassland and Fodder Research Institute, ICAR, Jhansi; c2013.
2. AOAC. Official methods of analysis, Association of Official Analytical Chemist, 18th Ed; c2005.
3. Baljeet BL, Singh M, Kumar S, Bhattacharjee S, Onte S. Effect of potassium and foliar spray of zinc on yield, nutrient bio-fortification, and economics of fodder maize (*Zea mays* L.). Ann Agric Res. 2021;42(4):382-390.
4. Broadley MR, White PJ, Hammond JP, Zelko I, Lux A. Zinc in plants. New Phytol. 2007;173:677-702.
5. Brown PH, Cakmak I, Zhang Q. Form and function of zinc plants. In: Zinc in Soils and Plants. Springer Publication. Netherlands; c1993. p. 93-106.
6. Cakmak I. Plant nutrition research: Priorities to meet human needs for food in sustainable ways. Plant Soil. 2002;247:3-24.
7. Chand SW, Susheela R, Sreelatha D, Shanti M, Hussain SA. Effect of zinc fertilization on yield and economics of baby corn (*Zea mays* L.). J Pharmacol Phytochem. 2017;6(5):989-992.
8. Golldack D, Li C, Mohan H, Probst N. Tolerance to drought and salt stress in plants: unraveling the signaling networks. Front Plant Sci. 2014;5:1051.
9. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley and Sons, Singapore; c1984. p. 680.

10. Hafeez B, Khanif YM, Saleem M. Role of zinc in plant nutrition-a review. J Exp Agric Int. 2013;3:374-391.
11. Koushik MK, Pareek P, Singh P, Sumeriya HK. Response of fodder sorghum [*Sorghum bicolor* (L.) Moench] to iron and zinc. Forage Res. 2010;36(3):181-184.
12. Kumar R, Singh M, Meena BS, Ram H, Parihar CM, Kumar S, *et al*. Zinc management effects on quality and nutrient yield of fodder maize (*Zea mays* L). Indian J Agric Sci. 2017;87(8):1013-1017.
13. Mahdi SS, Hasan B, Singh L. Influence of seed rate, nitrogen and zinc on fodder maize (*Zea mays* L.) in temperate conditions of Western Himalayas. Indian J Agron. 2012;57(1):85-88.
14. Meena SK, Mundra SL, Singh P. Response of maize (*Zea mays* L.) to nitrogen and zinc fertilization. Indian J Agron. 2013;58(1):127-128.
15. Mohan S, Singh M, Kumar R. Effect of nitrogen, phosphorus and zinc fertilization on yield and quality of kharif fodder-A review. Agric Rev. 2015;36:218-226.
16. Mousavi SR. Zinc in crop production and interaction with phosphorus. Aust J Basic Appl Sci. 2011;5:1503-1509.
17. Panda A, Bhattacharjee S, Bhale VM, Kadam S, Deshmukh MR. Performance of Maize (*Zea mays* L.) based on yield attributes, nutrient uptake, quality and economics under different zinc-based nutrient management regimes. Res J Agric Sci. 2020;11:613-619.
18. Paramasivan M, Kumaresan K, Malarvizhi P. Effect of balanced nutrition on yield, nutrient uptake and soil fertility of Maize (*Zea mays* L.) in vertisol of Tamil Nadu. Indian J Agron. 2011;56(2):133-137.
19. Ramakrishna CH, Lata AM, Murali B, Madhavi A, Venkateshwarlu M. Yield and silage quality of fodder maize (*Zea mays* L.) as influenced by zinc fertilization. Pharma Innov J. 2022;11(5):1799-1802.
20. Shanthi M, Nagalaksmi D, Naik BR, Chandrika V, Chiranjeevi CH. Study on forage quality of various maize cultivars produced under different use patterns. Forage Res. 2012;37(4):234-237.
21. Shukla UC, Prasad KG. Ameliorative role of zinc on maize growth under alkali soil condition. Washington DC, USA. Agron J. 1974;66:804-806.