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Research Article

EVALUATION OF EFFECT OF ZINC BIO-FORTIFICATION ON CROP GROWTH AND GRAIN YIELD IN FINGER MILLET (*ELEUSINE CORACANA*)

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ABSTRACT
Millets being less expensive compared to cereals and constitute a major component of diet for the poorer sections of the population, is one of the major choice of fortification with micronutrients such as zinc. In view of this, finger millet, widely grown and commonly consumed in India was explored as a vehicle for fortification with zinc. A field experiment was conducted at Agricultural Research Station, Vizianagaram during *Kharif* 2013-14 to verify the stability of bio-fortification of Zinc on the grain yield and grain zinc content in finger millet. Zinc application through soil as well as foliar spray was comparatively studied in finger millet. The results indicated that soil application of $ZnSO_4$ @ 12.5 kg ha^{-1} at the time of sowing enhances the grain yield by 13.3% grain zinc content by 8.95%, while foliar spray of $ZnSO_4$ @ 0.5% increased the grain zinc content by 10.2% and not the grain yield.

Keywords: *Finger Millet, Zinc, Soil Application, Foliar Spray, Grain Yield, Grain Zinc Content*

INTRODUCTION
Minor millets are claimed to be the future foods for better health and nutrition security. Small millets comprising finger millet, kodo millet, foxtail millet, little millet, barnyard millet and proso millet are crops of antiquity known for their suitability to dry lands and contribution towards food security at farm and regional level. Among small millets, finger millet has gained a wide importance due to its high nutritional value, high fiber with proteins, minerals and essential aminoacids and particularly micronutrients. Singh and Srivastava (2006) reported the iron content of 16 finger millet varieties ranged from 3.61 mg/100g to 5.42 mg/100gm with a mean value of 4.40 mg/100g. According to Vijayakumari *et al.*, (2003) finger millet is the richest source of calcium and iron. Calcium deficiency leading to bone and teeth disorder, iron deficiency leading to anemia can be overcome by introducing finger millet in our daily diet. Singh and Srivastava (2006) observed that the zinc content of the sixteen varieties of finger millet ranged from 0.92 to 2.55 mg/100gm with a mean value of 1.34 mg/100gm. Since the introduction of green revolution in Asia, cultivation of high yielding genotypes, improved agricultural mechanization and production of macronutrient fertilizers with low impurities of trace elements has resulted in higher crop production per unit area with greater depletion of plant available micronutrients. Deficiencies of vitamin A, iron and iodine are widespread in developing countries including India, the deficiency of zinc is also gaining attention. Zinc deficiency is now recognized as one of the most widespread mineral deficiencies in global human nutrition. Zinc is required for the structural and functional integrity of about 2800 proteins, contributes to protein biosynthesis and is a key defense factor in detoxification of highly toxic oxygen free radicals (Andreini *et al.*, 2009). Cakmak (2008), showed that foliar or combined soil and foliar application of zinc fertilizer under field conditions are highly effective and very practical way to maximize uptake and accumulation of zinc in whole wheat grain. Finger millet flour fortified with either zinc oxide or zinc stearte was specifically examined for the bioaccessibility of the fortified mineral, as measured by *in vitro*, stimulated gastrointestinal digestion procedure and storage stability (Bhumika and Kalpana, 2010).In other crops such as wheat and pearl millet, Zinc fertilizers significantly increased the Zinc uptake of wheat grain (Mahendra and Narendra,1983).
Keeping in view the nutritional importance of micronutrients, attempt has been made to study the effect of fortification of Zinc on the yield and quality of grains.

MATERIALS AND METHODS

Field experiment was conducted at Agricultural Research station, Vizianagaram, Andhra Pradesh during *Kharif* 2013-14. The soil is sandy loam in texture, low in organic carbon, available Nitrogen, high in phosphorus and available potassium.

The trail was carried out in randomized block design with three treatments replicated twice comparing the application of Zinc sulphate both as soil application and foliar spray. Uniform cultural practices were carried out in all the three experimental plots. Spacing of 30X10cm was maintained. Plot sizes of 20X10 cm were taken and fertilizers were applied as per the recommended doses (Basal: 25+40+25 NPK kg ha^{-1} and Top: 25 N kg ha^{-1}). The treatments consisted of 100% RDF+ $ZnSO_4$ @ 12.5 kg ha^{-1} as soil application at the time of sowing and foliar application of 100% RDF+ $ZnSO_4$ @ 0.5% in two sprays at flowering and 20 days after flowering. Control plot with only 100%RDF was also maintained.

Observations on Plant height (cm), No. of production tillers per m^2, No. of fingers per ear, mean ear weight (gm) were recorded from five randomly selected plants from each plot. Subsequently the grain yield (g m^{-2}) and grain yield (q ha^{-1}) were estimated after harvest. The quality of grain was also compared by estimating the grain zinc content in all the three treatments.

The data was statistically analysed by ANOVA (Cochran and Cox, 1957) and the differences among means were tested by using critical difference (CD) values at 5% level of probability.

RESULTS AND DISCUSSION

Application of zinc to the soil and as foliar application enhanced the grain content by 8.95% (from 3.13 to 3.41 mg) and 10.2% (from 3.13 to 3.45 mg/ 100g) respectively (Table 1).

Table 1: Effect of Zinc application on growth and yield attributes in finger millet

Treatments	Zn(mg /100g)	Duration(days)	Plant height(cm)	Productive tillers (No.m^{-2})	Fingers/ear	Mean ear weight	Grain yield (g m^{-2})	GY(q /ha)
Control	3.13	115	102.9	65.7	7.43	8.01	411.7	19.5
Soil application	3.41	111	113.3	76.0	7.14	8.05	466.4	24.9
Foliar spray	3.45	111	106.4	68.0	7.57	8.02	419.3	22.1
Mean	3.33	112.3	107.5	76.3	7.33	8.05	428.6	22.2
SEm +_	0.04		1.51	2.40	NS	0.33	NS	
CD	0.21		4.65	7.39		1.02		
CV%	1.49		3.71	8.30	6.54	10.7	10.0	

The grain yield showed a significant increase by 13.3 % (from 411.7 g m^{-2} to 466.4 g m^{-2}) due to increased productive tillers and plant growth under soil application of zinc (Table 1). The zinc application in ragi by foliar spray did not show any significant increase in the grain yield, productive tillers and plant growth (Table 1). The results indicate that soil application of $ZnSO_4$ @ 12.5 kg ha^{-1} at the time of sowing enhances the grain yield by 13.3% and grain Zn content by 8.95%, while foliar spray increased the grain Zn content by 10.2% and not the grain yield. Similar experiments were conducted by Srinivas *et al.*, (2008) to evaluate Zn, B and S status of 1617 farmers fields in 14 districts. Results showed that application of finger millet yielded 44% more stover, 56%more grain yield and 48% total biomass over farmers practice. The extensive Zn, B and S deficiencies was due to poor organic carbon status of soils (Srinivasarao *et al.,* 2006) and depletion under continuous cropping without application of these plant nutrients (Rego *et al.,* 2007). Bhumika and Kalpana (2010) in their experiment proved that addition of zinc salts increased the bioaccessible zinc content by 1.5-3 times of the unfortified flour.

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