The Andhra Agric. J 69 (2): 165-171, 2022

Effect of Zinc Fertilization on Growth and Yield of Finger Millet

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ABSTRACT

A field experiment was conducted during *kharif,* 2019 on a sandy loam soils of Agricultural College Farm, Bapatla to study the effect of zinc management treatments on growth & yield of finger millet. The experiment was laid out in a randomised block design with eight treatments and replicated thrice. The results indicated that plant growth characters like plant height, tillers m^{-2}, drymatter accumulation, grain and stover yield were higher with foliar application of nano zinc oxide 500 ppm at 60 and 75 DAS along with soil test based fertilizer application (STBF) which was significantly superior to the rest of the treatments. The lower values of the parameters were recorded with absolute control treatment.

Keywords: *Nano zinc oxide and STBF*

Finger millet also known as ragi is an important millet grown broadly in various regions of India and Africa. It ranks 6^{th} in production after wheat, rice, maize, jowar and pearl millet in India. In India, finger millet is mostly grown and consumed in Karnataka and to a narrow extent in Andhra Pradesh, Tamil Nadu and Odisha. In India, finger millet is cultivated in an area of 10.16 lakh ha with a production of 13.85 lakh tonnes with an average productivity of 1363 kg ha^{-1}. In Andhra Pradesh, it covers an area of 0.32 lakh ha with a production of 0.35 lakh tonnes at an average productivity of 1094 kg ha^{-1} (www.indiastat.com, 2018-2019). In India, finger millet accounts for an area of 60% and 75% of total small millets production. Finger millet is considered one of the nutritious cereals.

Since the introduction of green revolution in Asia, cultivation of high yielding genotypes, adaptation of improved agronomic practices have resulted in higher crop productivity with greater depletion of plant available micro nutrients. Zinc deficiency is one of the most important micro nutrient deficiencies in human diet (Rani and Patro, 2014). It is well known fact that zinc is now considered as fourth most important yield limiting nutrient after nitrogen, phosphorus and potassium. Globally, zinc is now recognized as the fifth major nutrient deficiency after protein, iron, vitamin A and iodine according to the International Zinc Nutrition Consultation Group (IZiNCG) as much as one-third of the world's population may be at risk from inadequate zinc nourishment.

Generally, zinc content in the finger millet plant (shoot) is about 2.3 mg 100 g^{-1} (Barbeau and Hilu, 1993). Moreover, the proper method of nutrient application can be another approach for better uptake and utilization of Zn. Amongst different methods, the foliar spray of micronutrients is an efficient one for the enhancement of crop productivity. This way of nutrient application is easy and simple in improving plant nutritional condition of finger millet. Reasons for effectiveness of foliar spray are simple due to its direct application to the leaves. However, zinc can be applied directly into the soil as well. Soil applied Zn is effective in enhancing the grain yield whereas Zn concentration in grain improves *via* foliar spray of Zn fertilizer (Tariq *et al*., 2014). Therefore, it has been proposed to study the effect of Zn fertilization in finger millet.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural College Farm, Agricultural College, Bapatla during *kharif,* 2019. The experiment was laid out in a randomized block design with eight treatments each replicated thrice. The treatments comprises of T_1: Absolute Control, T_2: STBF, T_3: STBF + FYM @ 10 t ha^{-1}, T_4: STBF + ZnSO4 @ 50 kg ha^{-1} (Soil), $T_{5:}$ STBF + ZnSO4 @ 0.50% at 60 DAS (Foliar spray), T_6: STBF + ZnSO4 @ 0.50% at 60 and 75 DAS (Foliar spray), T_7: STBF + Nano ZnO @ 500 ppm at 60 DAS (Foliar Spray), T_8: STBF + Nano ZnO @ 500 ppm at 60 and 75 DAS (Foliar Spray). Soil of the experimental site was neutral in reaction, sandy loam in texture with 0.27 % organic carbon, 163 kg ha^{-1} of N, 28 kg ha^{-1} of P_2O_5 and 290 kg ha^{-1} of K_2O. The test variety used in this experiment was Sree Chaitanya was sown on 29th July 2019. Thinning and gap filling were done after 10 DAS. Fertilizers were applied as per the treatments. Soil test based nitrogen @ 75 kg ha^{-1} was applied in 2 equal splits *i.e.,* ½ at basal and remaining ½ was top dressed at 30 days after sowing. As initial soil N status was low, additional 15 kg N (25%) apart from recommended dose of nitrogen (60 kg) was added. Entire dose of 40 kg P_2O_5 ha^{-1} in the form of single super phosphate and 30 kg K_2O ha^{-1} in the form of muriate of potash were uniformly applied basally to all the plots. Zinc sulphate @ 50 kg ha^{-1} as basal and nano zinc oxide @ 500 ppm at 60 and 75 DAS was applied as per the treatments.

Observations on plant height, number of tillers m^{-2} and drymatter accumulation (kg ha^{-1}) were recorded from five randomly selected plants from each plot. Subsequently the grain yield (kg ha^{-1}) and stover yield (kg ha^{-1}) were estimated after harvest.

All the data recorded in this study were subjected to statistical analysis using Fisher's method of analysis of variance as outlined by Fisher (1950). Statistical significance was tested by applying F-test at 0.05 level of probability.

RESULTS AND DISCUSSION

GROWTH PARAMETERS

Plant height

Growth parameters such as plant height, number of tillers m^{-2} and drymatter production were significantly influenced by zinc management treatments (Table 1). Among all the treatments tested, the plant height at 30 and 60 DAS was significantly influenced by the basal application of zinc sulphate @ 50 kg ha^{-1} along with soil test based fertilizer application (67.9 and 97.1 cm respectively). Whereas at 90 DAS and at harvest, it was significantly influenced by the foliar application of nano zinc oxide @ 500 ppm at 60 and 75 DAS along with soil test based fertilizer application and recorded significantly the highest plant height (118.0 cm and 122.2 cm) at 90 DAS and at harvest and the treatments T_8 and T_4 (basal application of zinc sulphate @ 50 kg ha^{-1} along with soil test based fertilizer application) remained on par. Supplementation of Zn during different stages of plant growth through soil and foliar application might have helped the plant in natural translocation and assimilation of nutrients to shoot and leaf portions. Kumar *et al.* (2012) stated that zinc regulates the enzyme metabolism and augments the cell division hence surges the internodal elongation. Similar results of augmented plant height with foliar application of zinc was also reported by Saraswathi *et al.* (2017) and Choudhary *et al.* (2014).

Number of tillers m^{-2}

Among different treatments, number of tillers m^{-2} were the highest in case of T_8 *i.e.* foliar application of nano ZnO @ 500 ppm at 60 and 75 DAS along with soil test based fertilizer application (234.1). These treatments were followed by T_4 *i.e.* STBF + ZnSO4 @ 50 kg ha^{-1} (Soil) (209.8) and T_7 *i.e.* foliar application of nano ZnO @ 500 ppm at 60 DAS along with soil test based fertilizer application (201.3). The lowest number of tillers m^{-2} were registered with absolute control (128.7). Foliar application of nano zinc might have resulted in rapid absorption, better translocation and efficient fertilization of the zinc. Role of zinc in various physiological processes was well described by different scientists. Zinc is involved in the biosynthesis of indole acetic acid (IAA) which in turn results in better development of growth parameters (Parthosapathy and Savalgi, 2006). The increased number of tillers due to application of micronutrients may be related to their physiological role in plants. Similar findings were reported by Rameshraddy *et al.,* (2019).

Drymatter accumulation

Influence of the treatments was similar at 30 DAS and at 60 DAS with respect to drymatter production. The treatment T_4 *i.e.* STBF + soil application of 50 kg ha^{-1} $ZnSO_4$ as soil application recorded significantly the highest drymatter accumulation (1459 kg ha^{-1} and 6100 kg ha^{-1} respectively). At 90 DAS and harvest, the treatment T_8 *i.e.* STBF + foliar application of 500 ppm nano ZnO at 60 and 75 DAS recorded the maximum drymatter accumulation. However, it was on par with STBF + 50 kg ha^{-1} $ZnSO_4$ as basal (T_4) (9289 kg ha^{-1} and 10150 kg ha^{-1} respectively). Zn is a component of enzymes which involve in photosynthesis and nitrogen metabolism thus improving the nitrogen uptake by the plant which facilitates in attaining higher rates of growth and development. Zn acts as a catalyst in various plant physiological processes and also involves in synthesis of auxin which results in increase of plant growth parameters like height and more number of tillers which in turn helps in higher drymatter accumulation. Similar trend was experienced in a study conducted by Rameshraddy *et al.* (2019), Arshewar *et al.* (2018) and Saraswathi *et al.* (2017).

GRAIN AND STOVER YIELD

From the table 2 & fig. 1 the grain yield and stover yield of finger millet were significantly influenced by the different treatments applied. Among all the treatments observed, significantly the highest grain yield (2700 kg ha^{-1}) was observed with the foliar application of nano zinc oxide @ 500 ppm at 60 and 75 DAS along with soil test based fertilizer application. The higher values of straw yield (4347 kg ha^{-1}) was recorded with STBF + foliar application of nano ZnO @ 500 ppm at 60 and 75 DAS (T_8) which was on compared with STBF + foliar application of nano ZnO @ 500 ppm at 60 DAS (T_7), STBF + soil application of 50 kg ha^{-1} $ZnSO_4$ as basal (T_4). Harvest index was not significantly altered by different treatments.

The increased yield due to zinc addition could be attributed to the involvement of zinc in metalloenzyme system, regulatory functions and in auxin production. The favorable influence of applied zinc on yield may be due to its catalytic or stimulatory effect on most of the physiological and metabolic processes on plants (Mandal *et al.,* 2009). Participation of zinc in biosynthesis of indole acetic acid (IAA) and its role in initiation of primordial reproductive parts and partitioning of photosynthates towards them are responsible for increased yield

Table 1. Growth parameters at different intervals of finger millet as influenced by zinc management treatments

Treatments	Plant height (cm)				Number of tillers m^{-2}	Drymatter accumulation ($kg\ ha^{-1}$)			
	30 DAS	60 DAS	90 DAS	At harvest	90 DAS	30 DAS	60 DAS	90 DAS	At harvest
T_1: Absolute Control	40.10	60.30	79.50	84.00	128.70	824.00	2100.00	3708.00	4300.00
T_2: STBF	55.20	79.90	99.40	104.00	134.50	1153.00	4900.00	7738.00	8750.00
T_3: STBF + FYM @ 10 t ha^{-1}	61.10	88.00	105.20	108.40	200.00	1248.00	5302.00	8750.00	9790.00
T_4: STBF + $ZnSO_4$ @ 50 kg ha^{-1} (Soil)	67.90	97.10	115.20	118.10	209.80	1459.00	6100.00	9289.00	10150.00
T_5: STBF + $ZnSO_4$ @ 0.50% at 60 DAS (Foliar spray)	55.00	85.30	105.00	107.60	152.20	1190.00	4992.00	7892.00	9100.00
T_6: STBF + $ZnSO_4$ @ 0.50% at 60 and 75 DAS (Foliar spray)	51.80	83.00	106.30	107.00	158.90	1182.00	5002.00	8312.00	9200.00
T_7: STBF + Nano ZnO @ 500 ppm at 60 DAS (Foliar Spray)	53.20	82.20	110.10	114.00	201.30	1210.00	5091.00	9091.00	10100.00
T_8: STBF + Nano ZnO @ 500 ppm at 60 and 75 DAS (Foliar spray)	59.00	87.10	118.00	122.20	234.10	1262.00	5102.00	9648.00	10600.00
S.Em ±	3.12	2.93	3.92	4.45	6.30	50.40	205.30	267.20	264.90
CD (P = 0.05)	9.40	8.80	11.80	13.50	19.20	153.00	622.00	810.00	803.00
CV (%)	9.70	6.20	6.60	7.30	6.80	7.50	7.40	6.00	5.20

Table 2. Grain yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of finger millet as influenced by zinc management treatments

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1: Absolute Control	902	2198	29
T_2: STBF	1956	3750	34.2
T_3: STBF + FYM @ 10 t ha^{-1}	2121	3900	35.2
T_4: STBF + $ZnSO_4$ @ 50 kg ha^{-1} (Soil)	2298	4150	35.6
T_5: STBF + $ZnSO_4$ @ 0.50% at 60 DAS (Foliar spray)	2008	4050	33.1
T_6: STBF + $ZnSO_4$ @ 0.50% at 60 and 75 DAS (Foliar spray)	2053	4080	33.4
T_7: STBF + Nano ZnO @ 500 ppm at 60 DAS (Foliar Spray)	2354	4200	35.9
T_8: STBF + Nano ZnO @ 500 ppm at 60 and 75 DAS (Foliar	2700	4347	38.3
S.Em ±	78.92	178.72	0.11
CD (P = 0.05)	239	542	NS
CV (%)	7	7.9	7.2

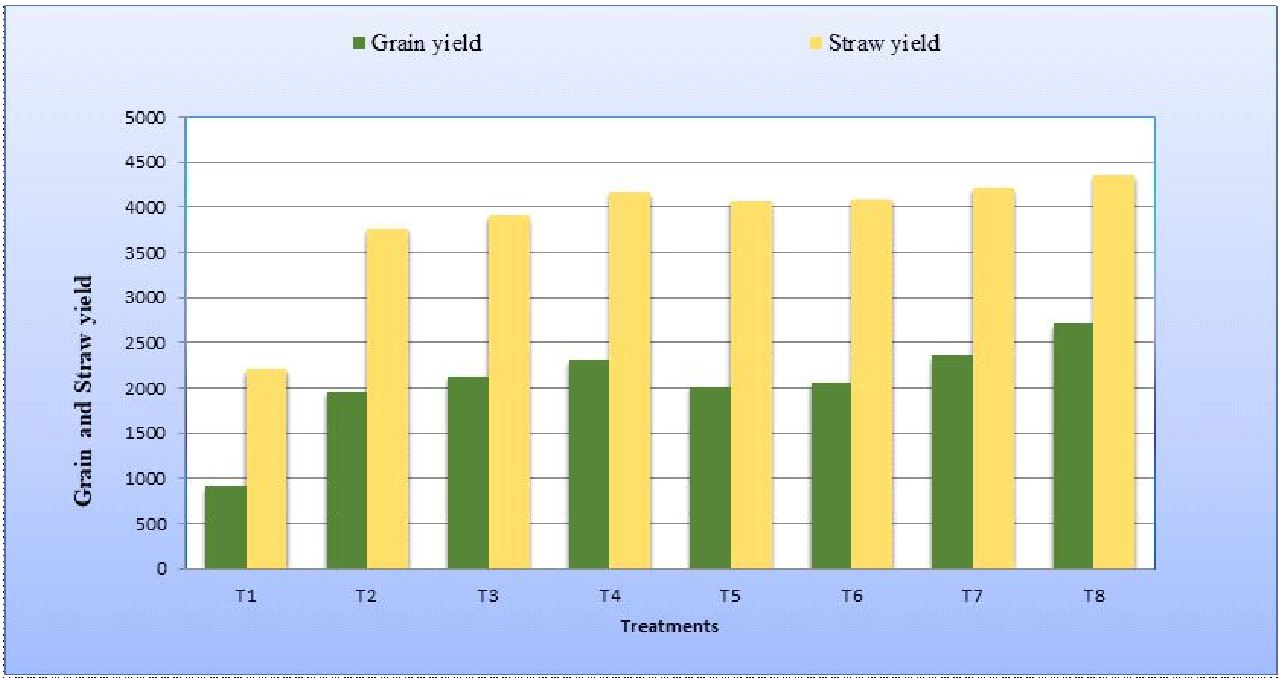

Fig 1. Grain and Stover yield (kg ha^{-1}) of finger millet as influenced by zinc management treatments

(Takaki and Kushizaki, 1970). Corroborative results have also been reported by Jyung *et al.* (1975), Aruna *et al.* (2006) and Vandana *et al*. (2009).

CONCLUSION

Based on the above results and discussions, it can be concluded that foliar application of nano zinc oxide @ 500 ppm at 60 and 75 DAS along with soil test based fertilizer application resulted in higher growth and yield of finger millet.

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