

RESEARCH ARTICLE :

Effect of nano ZnO on growth and yield of finger millet (*Eleusine coracana* (L.) Garten.)

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SUMMARY : With the growing limitation in arable land and water resources, the development of agriculture sector is only possible by increasing resources use efficiency with the minimum damage to agro ecology through effective use of modern technologies. Among these, nano technology has the potential to revolutionize agriculture system. An investigation was initiated to examine the effect of nano scale zinc oxide particle on plant growth and development. In view of the widespread cultivation of ragi in India and other parts of the globe and view of the potential influence of zinc on its growth, this crop was chosen as the model system. A pot culture experiment was conducted during *Rabi* 2016-2017 with the foliar application of nano scale zinc oxide particle at lower rate dose compared to the chelated zinc sulphate recommended and we recorded higher grain yield (9.60 g plant⁻¹) and straw yield (15.87 g plant⁻¹) in T₇ which receive nano ZnO @ 500 ppm ha⁻¹ as foliar spray, respectively, compared to chelated zinc sulphate. The inhibitory effect with the higher dose nano particle concentration (nano ZnO @ 1250 ppm) reveals the need for judicious usage of this particle in such application, this study show that the use of nano fertilizers causes an increase in nutrient use efficiency, reduces soil toxicity associated with over dosage and reduces the frequency of the application. Hence, nanotechnology a high potential for achieving sustainable agriculture, especially in developing countries.

KEY WORDS:

Nenotechnology, Nanoscale, Chelated zinc sulphate, Zinc oxide, Nano fertilizer

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BACKGROUND AND OBJECTIVES

Agriculture is the backbone of most developing countries, with more than 60% of the population reliant on it for their livelihood. Agricultural scientists are facing a wide spectrum of challenges such as stagnation in crop yields, low nutrient use efficiency, declining soil organic matter, multi-nutrient deficiencies, climate change, shrinking arable

land and water availability and shortage of labor besides exodus of people from farming. In spite of immense constraints faced, we need to attain a sustainable growth in agriculture at the rate of 4% to meet the food security challenges. Therefore, in the future, emphasis should be laid on production of high quality food with the required level of nutrients and proteins, (Pijls *et al.*, 2009; Ghaly and alkoaik, 2010). The issue of micronutrient deficiency

is related with food security Micronutrient deficiencies in human being as well as crop plants are difficult to diagnose and consequently the problem is termed as 'hidden hunger' (Stein *et al.*, 2008). This hidden hunger may cause nearly 40% reduction in crop productivity among them Zinc (Zn) deficiency is most wide spread nutritional disorder. Most of the Indian soils are found to be Zn deficient, hence, the food crops grown in those soils contain less amount of Zn. In order to overcome Zn disorder, several strategies are being employed including supplementation, fortification, diversification and biofortification. Among these strategies biofortification of food crops with Zn is considered to be cheaper and sustainable.

To address these problems, there is a need to explore one of the frontier technologies such as 'Nanotechnology. It is a new emerging and interesting field of science is currently applied in many areas. It has great application in the field of agriculture. Nano particles (NPs) are commonly accepted as materials with at least two dimensions between 1-100 nm. "Nanotechnology is the art and science of manipulating matter at nanoscale. Because nano particles are spherical or faceted metal particles typically < 100nm in size. These nano particles are having high surface area (30-50 m²/g), high activity, better catalytic surface, rapid chemical reaction, rapidly dispersible and adsorb abundant water. So nano fertilizers may increase the efficiency of nutrient uptake, enhance yield and nutrient content in the edible parts and also minimize its accumulation in the soil. In view of the above facts the present study entitled Effect of nano ZnO particle on growth and Yield of Finger Millet (*Eleusine coracana* (L.) Garten.)

RESOURCES AND METHODS

The present investigation was carried out at Zonal Agriculture and Horticultural Research Station, University of Agricultural and Horticultural Sciences (UAHS), Navile, Shivamogga to study the effect of Nano Zinc particle on growth and yield of finger millet in a pot culture experiment. The details regarding the collection of soil sample, methodology followed in the pot culture experiment and analytical methods employed during the course study for soil and plant analysis as per the standard procedure. Bulk soil samples collected from micro watershed in different land use system in kadur taluk of chikkamagalur district were categorized as low to medium with respect to native soil fertility status zinc

nutrients. Surface soil samples to a depth of 30cm were collected for the pot culture experimentation. The collected samples were characterized for various physical and chemical properties. Same sample used for pot culture experiment to study the growth and yield of finger millet. The experiment was laid out in a Complete Randomized design. With ten treatments involving various concentrations of nano ZnO and three replication with two sources used in these experiment one is Zinc oxide (ZnO) nano particle which is having particle size of 50 nm and ZnSO₄.7H₂O were used in the study. ZnO nanoparticles of mean size of 50 nm diameter were used in the study. Chelated bulk ZnSO₄.7H₂O was used as a reference Zn source. Because bulk ZnO will not dissolve in water and plants cannot absorb it, farmers are widely using chelated ZnSO₄.7H₂O. The materials were suspended directly in deionized water and dispersed by ultrasonic vibration (100 W, 40 KHz) for 30 min. Magnetic bars were placed in the suspensions for stirring before use to avoid aggregation of the particles. The soil sample was thoroughly mixed with FYM and filled in pots of 20 kg capacity having hole on the corner of the bottom of the container. Nitrogen, Phosphorus and potash were added to each pot at the rate of 50, 40, 25 kg ha⁻¹, respectively using urea, SSP and MOP. Zinc was applied in the form of ZnSO₄.7H₂O to treatments T₃ and T₅ for soil and foliar for T₄ and T₅ application, respectively. Whereas, foliar application of nano zinc oxide was done in T₆ to T₁₀ applied at time (30 DAT and 60 DAT) as per treatment details T₁: Absolute control, T₂: RPP, T₃: Soil application of ZnSO₄.7H₂O @ 10 kg ha⁻¹ at sowing, T₄: Foliar ZnSO₄.7H₂O @ 0.5 % ha⁻¹ at 30 and 60 DAT, T₅: Both soil and Foliar application ZnSO₄.7H₂O @ 0.5 % ha⁻¹ at 30 DAS, T₆: Foliar Nano ZnO @ 100 ppm ha⁻¹, T₇: Foliar Nano ZnO @ 500 ppm ha⁻¹, T₈: Foliar Nano ZnO @ 750 ppm ha⁻¹, T₉:Foliar Nano ZnO @ 1000 ppm ha⁻¹, T₁₀:Foliar Nano ZnO @ 1250 ppm ha⁻¹.Periodical observations (30, 60 at harvest DAT) on growth and yield parameters.

OBSERVATIONS AND ANALYSIS

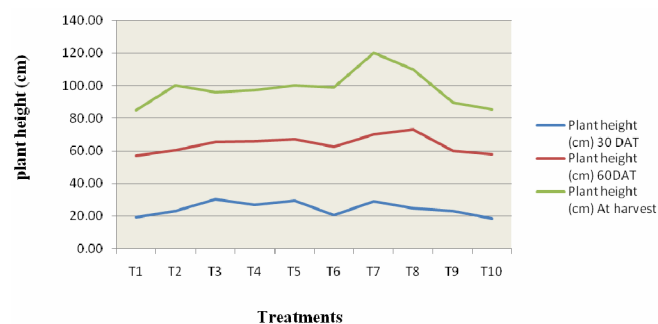
The results obtained from the present study as well as discussions have been summarized under following heads :

Growth parameter:

In this study, results showed that the different forms

of zinc sources they are $ZnSO_4 \cdot 7H_2O$ as conventional fertilizers and nano ZnO significantly influenced the plant growth attributes of finger millet. Among the various treatments, application of NPK+FYM+ Soil and Foliar application $ZnSO_4 \cdot 7H_2O @ 0.5 \% ha^{-1}$ (T_5) recorded maximum plant height of 30.47 cm and minimum plant height of 18.50 cm were observed in control treatment (T_1) at tillering stage. At harvest stage the highest plant height was recorded in the treatment (T_7) 120.50 cm with the foliar application of nano ZnO @ 500 ppm and control (T_1) treatment was recorded 85.00 cm in (Table 1 and figure 1). This might be due to profound influence of Zinc fertilizers on height of plant as increased metabolic process in plant which has promoted meristamatic activities causing higher apical growth and photosynthetic area. The results are in agreement with the finding of (Dekhane et al, 2011). Number of leaves in finger millet also differed significantly at all the growth stages. However, there is an increase in number of leaves to foliar application of nano ZnO at harvest Treatment receiving foliar spray of nano ZnO @ 500 ppm (T_7) recorded the highest number of leaves 42 and in control (T_1) 25.00, respectively (Table 1). Whereas, higher concentrations @ 1250 and 1000 ppm exhibited detrimental effects on growth of finger millet. (Prasad et al, 2012) observed that nano ZnO promoted seed germination, seedling vigor, early flowering and higher chlorophyll content in leaf. They also observed beneficial effects of NPs in enhancing plant growth, development and yield in peanut at lower doses, but at higher

concentrations ZnO NPs were detrimental just as the bulk nutrients. Number of earheads of finger millet, the finger length and test weight were significantly high in treatment receiving fertilizer and FYM along with nano ZnO foliar spray @ 500 ppm, which was superior over all other treatments. The significant increase in test weight may be attributed to better grain filling due to improved nutrient supply (Table 2).



T_1 : Absolute control	T_6 : Foliar Nano ZnO @ 100 ppm ha^{-1} at 30 and 60 DAT
T_2 : RPP (Recc NPK +FYM)	T_7 : Foliar Nano ZnO @ 500 ppm ha^{-1} 30 and 60 DAT
T_3 : Soil application $ZnSO_4 \cdot 7H_2O @ 10 kg/ha$ at sowing	T_8 : Foliar Nano ZnO @ 750 ppm ha^{-1} at 30 and 60 DAT
T_4 : Foliar $ZnSO_4 \cdot 7H_2O @ 0.5 \%$ at 30 and 60 DAT	T_9 : Foliar Nano ZnO @ 1000 ppm ha^{-1} at 30 and 60 DAT
T_5 : Soil and Foliar application $ZnSO_4 \cdot 7H_2O @ 0.5 \%$	T_{10} : Foliar Nano ZnO @ 1250 ppm ha^{-1} at 30 and 60 DAT

Fig. 1 : Plant height as influenced by different foliar application of $ZnSO_4 \cdot 7H_2O$ and nano ZnO formulation at different growth stages of finger millet

Table 1: Effect of different levels of foliar application of $ZnSO_4 \cdot 7H_2O$ and nano ZnO formulation at different growth stages on growth parameters of finger millet

Treat. No	Treatment	Plant height (cm)			Number of leaves hill ⁻¹	
		Tillering stage	Ear head stage	Harvest stage	Tillering stage	Harvest stage
T_1	Absolute control	18.50	57.00	85.00	18.00	25.00
T_2	RPP (Recc NPK +FYM)	23.00	60.50	100.00	20.00	28.00
T_3	NPK+FYM +Soil application $ZnSO_4 \cdot 7H_2O @ 10 kg ha^{-1}$ at sowing	27.00	65.42	96.00	29.00	30.00
T_4	NPK+FYM+ Foliar $ZnSO_4 \cdot 7H_2O @ 0.5 \% ha^{-1}$ at 30and 60 DAT	25.00	66.00	97.43	25.00	32.00
T_5	NPK+FYM+ Soil and Foliar application $ZnSO_4 \cdot 7H_2O @ 0.5 \% ha^{-1}$	30.47	67.00	110.00	30.00	38.00
T_6	NPK + FYM +Foliar Nano ZnO @ 100 ppm ha^{-1} at 30 and 60 DAT	20.60	62.55	99.00	25.00	29.00
T_7	NPK +FYM +Foliar Nano ZnO @ 500 ppm ha^{-1} 30 and 60 DAT	26.00	70.00	120.50	28.00	42.00
T_8	NPK+ FYM+ Foliar Nano ZnO @ 750 ppm ha^{-1} at 30 and 60 DAT	25.00	69.00	105.00	28.00	41.00
T_9	NPK+ FYM + Foliar Nano ZnO @ 1000 ppm ha^{-1} at 30 and 60 DAT	23.00	60.00	89.56	27.00	39.00
T_{10}	NPK + FYM + Foliar Nano ZnO @ 1250 ppm ha^{-1} at 30 and 60 DAT	19.00	58.00	85.56	25.00	35.00
	S.E.±	0.61	0.66	1.13	0.58	0.65
	C.D. (P=0.01)	2.41	2.65	4.53	2.32	2.61
	CV	4.35	1.77	1.96	3.46	2.73

Yield parameter :

The results of the study revealed that application of nano ZnO as foliar spray has recorded highest grain yield ($9.60 \text{ gm plant}^{-1}$) and least in control without application of fertilizers ($7.00 \text{ gm plant}^{-1}$) in Table 2. Nano particles (NPs) with small size and large surface area are expected to be the ideal material for use as a Zn fertilizer in plants. It is because of that when materials are transformed to a nano scale, they change their physical, chemical and biological characteristics as well as catalytic properties and even more increase the chemical and biological activities (Mazaherinia *et al.*, 2010). Prasad *et al.*, (2012) studied the effect of nanoscale zinc oxide on the germination, growth and yield of peanut and observed significantly more growth and yield. Reynolds (2002) demonstrated that micronutrients in the form of NPs can be used in crop production to increase yield.

There was a promontory effect on dry matter production with the application of nano ZnO with @ 500 ppm. There after inhibitory effect was noticed. Based on the results, the highest ($15.87 \text{ gm plant}^{-1}$) dry matter weight was recorded in the treatment (T_7) receiving nano ZnO @ 500 ppm and lowest were in control ($11.25 \text{ gm plant}^{-1}$). Improvement in growth parameters like plant height, number of leaves and leaf area per plant due to foliar application of nano ZnO resulted in increased dry matter accumulation (Table 2). Total biomass or crop dry weight (CDW) is the result of these two processes.

Harvest index (HI) is the ratio of grain yield to biological yield, *i.e.*, a measure of the efficiency of the plant when accumulating assimilates in the organs of economic significance (Moragues *et al.*, 2006). Significant relationships between yield and biomass at anthesis or during grain filling have been reported in bread wheat (Turner, 1997) and durum wheat (Ramdani, 2004).

Conclusion :

Application of nanotechnology in agriculture is still in its budding stage. However, it has the potential to revolutionize agricultural systems particularly where the issues on fertilizer applications are concerned. Nano fertilizer application promoted the growth, development, and has the potential to improve crop production and plant nutrition with greater effectiveness and agronomic efficiency compared to traditional sources of fertilizers. A new class of nano ZnO fertilizers to enhance the growth and yield of finger millet through pot culture test in an inert growing medium showed that application of nano ZnO by foliar application with lower dose as zinc sources promoted higher finger millet growth rate than regular $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ fertilizer treatment. This research indicated that nano ZnO in enhancing grain yield and biomass production. The outcome of this research would be beneficial for other studies involving the application of nanotechnology in the field of agriculture.

Table 2: Effect of different levels of foliar application of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and nano ZnO formulation at different growth stages on grain and straw yield of finger millet

Treat. No	Treatment	Grain yield	Straw yield
		gm pot ⁻¹	
T ₁	Absolute control	7.00	11.25
T ₂	RPP (Recc NPK + FYM)	7.60	12.10
T ₃	Soil application $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ @ 0.5 % at sowing ha ⁻¹	7.85	12.63
T ₄	Foliar $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ @ 0.5 % ha ⁻¹ at 30 and 60 DAT	7.84	12.87
T ₅	Soil and Foliar application $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ @ 0.5 % ha ⁻¹	8.40	14.77
T ₆	Foliar Nano ZnO @ 100 ppm ha ⁻¹ at 30 and 60 DAT	7.35	12.16
T ₇	Foliar Nano ZnO @ 500 ppm ha ⁻¹ at 30 and 60 DAT	9.60	15.87
T ₈	Foliar Nano ZnO @ 750 ppm ha ⁻¹ at 30 and 60 DAT	9.30	15.40
T ₉	Foliar Nano ZnO @ 1000 ppm ha ⁻¹ at 30 and 60 DAT	7.60	11.53
T ₁₀	Foliar Nano ZnO @ 1250 ppm ha ⁻¹ at 30 and 60 DAT	7.40	11.04
	S.E.±	0.34	0.41
	C.D. (P=0.01)	1.36	1.65
	CV	7.78	5.43

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