



Effect of Nano ZnO on Growth and Yield of Wheat under Salt Affected Soils

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ABSTRACT

Background: Nano zinc is important tool in agriculture for improving crop growth, yield and quality characteristics while increasing nutrient usage efficiency, reducing fertiliser waste and lowering cultivation costs. About 7.0 million ha of agricultural land is affected by varying degrees of salt problems in the country. The magnitude of yield reduction depends on the crop, soil type and management. The reduction in yield normally ranges from 10% to 90% for wheat, 30% to 50% for rice, 50% to 75% for cotton and 30% to 90% for sugarcane. High concentration of salts in the soils is one of the important factors associated with the low productivity of wheat. Due to high concentration of salts the germination of the seeds is affected which results in to low plant stand and ultimately low productivity. Zn is considered to have seed priming effect and increase the germination and helps to maintain the plant stand. Zn deficiency is the most damaging micronutrient to crop growth and output of all cereal crops, including wheat. Zn deficiency in Indian and global soils is a well-documented constraint in crop production and it is now regarded as the fourth most yield-limiting nutrient in India.

Methods: A pot culture study was conducted during Rabi 2022-2023 at Dept. of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experimental saline soil was collected from saline tract of purna valley, medium in organic carbon, moderately calcareous in nature, low in available N, medium in available P, very high in available K, marginal in available S and sufficient in micronutrients but deficient in Zn. The experiment was laid out in Completely Randomized Design with nine treatments replicated thrice.

Result: Significantly higher germination percentage (85%), number of tillers per plant (6.80), plant height (50.03 cm) was recorded under T₄: RDF+ seed treatment with nano ZnO 1000 ppm @ 8 ml per kg of seed. Maximum spike length (9.29 cm) was recorded in RDF+ foliar spray with of nano ZnO 1000 ppm @ 2 ml per liter. In case of chemical properties of soil i.e., pHs, ECe, organic carbon and available N, P, K, S and Zn content, non-significant changes were observed with the application of nano ZnO.

Key words: Germination, Nano zno, Salt affected soils, Wheat.

INTRODUCTION

Wheat is the most common staple food crop cultivated across the globe and it stands next to rice and contributes to the extent of 25 per cent of total food grain production of the country. Wheat is known as "king of cereals."

India is the second largest producer of wheat after China. It has good nutritional profile with 12.1% protein, 1.8% lipids, 1.8% ash, 2.0% reducing sugar, 6.7 pentose, 59.2% starch good sources of vitamins and minerals and nicotinic acid.

Among the micronutrients, Zn deficiency is the most detrimental to crop growth and yield of all the cereal crops including wheat (Alloway, 2008) The deficiency of Zn in Indian as well as world soils is very well documented constraint in crop production and it is considered to be the 4th most yield limiting nutrient after N, P and K, respectively in India (Shukla *et al.*, 2014).

The pH ranging from 6.5 to 7.5 is most favourable for availability of zinc. Primary minerals formed during weathering, Salt affected soils are mostly formed in arid and semi-arid climate where low rainfall and high evaporation prevails. The low rainfall in these regions is not sufficient to leach out the soluble weathered products and hence the salt accumulates in the soils. The ocean

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may be the source of salts as in soils where the parent materials consist of marine deposits that were laid down during earlier geological periods. Simultaneously, low permeability causing poor drainage and ground water containing high amount of soluble salts are also responsible for formation of salt affected soils. High concentration of salts in the soils is one of the important factors associated with the low productivity of wheat. Due to high concentration of salts the germination of the seeds

is affected which results in to low plant stand and ultimately low productivity. Zn is considered to have seed priming effect and increase the germination and helps to maintain the plant stand.

Farmers are using Zinc sulphate monohydrate, Zinc sulphate heptahydrate, Zinc oxide and Chelated Zinc as a source of zinc for soil application. Nano-Zinc is an important tool in agriculture for improving crop growth, yield and quality characteristics while increasing nutrient use efficiency, reducing fertiliser waste and lowering cultivation costs. The fundamental reason for the increased interest in nano-zinc is their great penetration ability, small size and extremely large surface area, which differs from the identical substance found in bulk form. Nano fertilizers are synthesized or modified forms of traditional fertilizers, fertilizers bulk materials or extracted from different vegetative or reproductive parts of the plant by different physical, chemical, or biological methods with the help of nanotechnology used to improve soil fertility, productivity and quality of agriculture produce. Sheoran *et al.*, (2024), evaluated the impact of foliar application of nano-nitrogen, potassium and zinc fertilizers on the growth and yield of wheat (*Triticum aestivum*). The results indicate that nano-fertilizer application significantly enhances various growth parameters and yield components compared to conventional fertilizers. Dayal *et al.*, (2022) tested 5 treatment combinations among which treatment 50% farmer fertilizer practices plus 1 spray of Nano-N, 1 spray of Nano-Zn and 1 spray of Nano-Cu give higher return than all there treatments in all crops. It is concluded that application of nano-fertilizers significantly increase crop yield over control or without application of nanofertilizer it is mainly because of increasing growth of plant parts and metabolic process such as photosynthesis leads to higher photosynthates accumulation and translocation to the economic parts of the plant. Foliar application of nano particles as fertilizer significantly increases in yield of the crop. Pooled result of the experiment on Lentil revealed that foliar spray of nano Zn @ 20 ppm at 30 and 50 DAS (T5) resulted significantly higher plant height, LAI, dry matter accumulation, 1000 seed weight, number and dry weight of nodules plant⁻¹, uptake of Zn, economics. This treatment produced 29.34% and 30.33% more seed and stover respectively than without Zn application (Saha *et al.*, 2024).

MATERIALS AND METHODS

The present pot culture experiment was conducted at Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *rabi* season 2022-23. Akola is situated in subtropical zone and located at the latitude of 20°70'02" North and longitude of 77°00'81" East, at the altitude of 307.42 m above mean sea level (MSL). The climate is hot and slightly moist. The soil was collected from the farmer's fields near purna valley of Amravati district. The experimental soil was slightly alkaline in reaction (pHs 8.33), saline in nature, medium

in organic carbon (0.48 kg ha⁻¹), ECs 0.41 dS m⁻¹, low in available nitrogen (200.2 kg ha⁻¹), medium in available phosphorous (11.15 kg ha⁻¹), very high in available potassium (320.1 kg ha⁻¹), marginal in available S (10.19 mg ha⁻¹) and sufficient in micronutrients but deficient in zinc (0.48 mg kg⁻¹). The experiment was laid out to study the Effect of nano zinc oxide on growth, yield and fertility status of soil after harvest of wheat (Variety: AKAW-4627) with completely randomize block design which was replicated thrice. The different treatments are as: T₁: Control (soil only), T₂: 100% RDF, T₃: T₂ + soil application of ZnSO₄ as per Soil Test Value (STV) (Deficient: 25 kg/ha, Medium: 10 kg/ ha). Seed treatments were applied according to the treatments such as T₄: T₂ + seed treatment with 1000 ppm nano Zn particles @ 8 ml per kg of seed, T₅: T₂ + seed treatment with 1000 ppm nano Zn particles @ 10 ml per kg of seed, T₆: T₂ + seed treatment with 1000 ppm nano Zn particles @ 12 ml per kg of seed. Foliar treatments were applied according to the treatments such as first spray at crown root initiation at 21 DAS and second spray at 45 days after sowing *i.e.*, T₇: T₂ + foliar spray with 1000 ppm nano Zn particles @ 2 ml per liter was applied, T₈: T₂ + foliar spray with 1000 ppm nano Zn particles @ 4 ml per liter was applied, T₉: T₂ + foliar spray with 1000 ppm nano Zn particles @ 6 ml per liter was applied. Basal dose of nitrogen, phosphorous and potassium was applied through urea, single super phosphate and Murate of potash. The various biometric observations were recorded treatment wise on randomly selected five wheat plants from each pot for recording yield parameter during the course of investigation *i.e.* plant height per pot, number of tillers plant⁻¹, spike length plant⁻¹, seed yield kg ha⁻¹, straw yield kg ha⁻¹ were recorded from these randomly selected plants. A composite sample was prepared and sieved through 2 mm sieve and analysed for the estimation of pHs, ECe, organic carbon content, available nitrogen, phosphorus, potassium, sulphur and zinc content of the soil.

RESULTS AND DISCUSSION

Growth attributes

From data recorded on germination it is clearly evident that here was significant increase in germination (%) in wheat seed treated with nano ZnO. RDF and seed treatment with nano ZnO 1000 ppm @ 8 ml per kg of seed (T₄) recorded higher germination (85 %) (Table 1). Among the different treatments maximum plant height at harvest (50.03 cm) was recorded in treatment - RDF and seed treatment with nano ZnO 1000 ppm @ 8 ml per kg of seed (T₄). The seed priming effect of nano zinc reduces the adverse effects of high salt concentration and might have increased the germination of the seed. The synergistic effect of zinc with availability of other nutrients might supply good amount of nutrients to the seedlings which could be responsible for higher plant height. Similar findings were reported by Prasad *et al.* (2012) and Ranjbar and Bahamian (2007), respectively.

Table 1: Effect of nano ZnO on germination and plant height of wheat.

Treatment	Germination (%)	Plant height (cm)		
		At 30 DAS	At 60 DAS	At harvest
T ₁ : Control (soil only)	60	14.60	32.06	46.36
T ₂ : 100% RDF	69	14.64	32.86	46.38
T ₃ : T ₂ + soil application of ZnSO ₄ as per soil test value	71	15.69	33.66	48.01
T ₄ : T ₂ + seed treatment with 1000 ppm nano Zn particles @ 8 ml per kg of seed	85	16.84	35.45	50.03
T ₅ : T ₂ + seed treatment with 1000 ppm nano Zn particles @ 10 ml per kg of seed	80	16.11	33.90	47.19
T ₆ : T ₂ + seed treatment with 1000 ppm nano Zn particles @ 12 ml per kg of seed	83	16.44	33.90	48.77
T ₇ : T ₂ + foliar spray with 1000 ppm nano Zn particles @ 2 ml per liter	80	16.65	35.01	49.61
T ₈ : T ₂ + foliar spray with 1000 ppm nano Zn particles @ 4 ml per liter was applied	76	16.16	34.08	48.27
T ₉ : T ₂ + foliar spray with 1000 ppm nano Zn particles @ 6 ml per liter	80	15.80	33.54	48.99
SEm±	3.01	0.46	0.54	0.76
CD (P≤0.1)	11.55*	NS	NS	NS

ZnO- Zinc oxide; DAS – Days after Sowing; *Significant at P≤0.1; NS- Non significant at P>0.1.

Table 2: Effect of nano ZnO on yield attributes and yield of wheat.

Treatments	Numbers of tillers per	Spike length plant (cm)	Seed yield (g pot ⁻¹)	Straw yield (g pot ⁻¹)
T ₁ : Control (soil only)	4.00	6.10	163.07	189.80
T ₂ : 100% RDF	4.83	7.10	166.40	204.60
T ₃ : T ₂ + soil application of ZnSO ₄ as per soil test value	6.53	7.77	184.80	206.40
T ₄ : T ₂ + seed treatment with 1000 ppm nano Zn particles @ 8 ml per kg of seed	6.80	7.33	196.01	238.40
T ₅ : T ₂ + seed treatment with 1000 ppm nano Zn particles @ 10 ml per kg of seed	6.73	8.13	192.40	234.60
T ₆ : T ₂ + seed treatment with 1000 ppm nano Zn particles @ 12 ml per kg of seed	6.47	8.43	191.00	232.00
T ₇ : T ₂ + foliar spray with 1000 ppm nano Zn particles @ 2 ml per liter	6.49	9.29	195.00	238.00
T ₈ : T ₂ + foliar spray with 1000 ppm nano Zn particles @ 4 ml per liter was applied	6.39	8.13	194.40	237.00
T ₉ : T ₂ + foliar spray with 1000 ppm nano Zn particles @ 6 ml per liter	6.67	8.33	192.20	235.60
SEm±	0.42	0.07	0.58	0.009
CD (P≤0.1)	1.62*	0.3*	2.23*	0.03*

ZnO- Zinc oxide; *Significant at P≤0.1.

Yield parameters

Data regarding number of tillers per plant as influenced by different treatments are presented in Table 2. Maximum number of tillers per plant (6.80) was recorded in treatment - RDF and seed treatment with nano ZnO 1000 ppm @ 8 ml per kg of seed (T₄) and was found to be statistically at par with treatments T₅ (6.73) and T₉ (6.67). Similar results were observed by Dhaliwal *et al.* (2012). Highest spike length (9.29 cm) was recorded in treatment-RDF + foliar spray with of nano ZnO 1000 ppm @ 2 ml per liter (T₇) and was found to be statistically at par with treatments T₆ (8.43 cm). Similar results were also reported by Bhutto *et al.* (2016). The data pertaining to seed yield per pot as influenced significantly by various treatments are presented in Table 2. Maximum seed yield pot⁻¹ (196.01 g pot⁻¹) was recorded in RDF and seed treatment with nano ZnO 1000 ppm @ 8 ml per kg of seed (T₄) and was found to be statistically at par with treatments T₇ (195 g pot⁻¹). The data presented in table 2 revealed that straw yield (g pot⁻¹) of wheat was influenced significantly due to different nutrient management treatments. Maximum straw yield (238.40 g pot⁻¹) was

recorded in treatment with RDF and seed treatment with nanoZnO 1000 ppm @ 8 ml per kg of seed (T₄) and was found to be statistically at par with treatments T₇ (238 g pot⁻¹). Similar results were also reported by Pandey *et al.*, 2010; Prasad *et al.*, 2012; Jayarambabu *et al.*, 2014; Yang *et al.*, 2015; Adhikari *et al.*, 2016).

CONCLUSION

In saline tract of purnavalley, along with recommended dose of fertilizers, application of nano Zinc as seed treatment with 1000 ppm nano ZnO particles @ 8 ml per kg of seed or foliar spray with nanoZnO 1000 ppm @ 2 ml per liter of water could be recommended in wheat for improved growth, yield attributes and yield.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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