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RESEARCH ARTICLE

Response of two sorghum genotypes to foliar spray by different zinc oxide nanoparticles concentrations

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Abstract

A field experiment was carried out during 2017 and 2018 summer seasons at Arab El-Awamer Station, Assiut, Egypt to study the response of two sorghum cultivars to foliar spray by different zinc oxide nanoparticles concentrations. The field experiment was carried out in a randomized complete block design using a strip plot arrangement with three replications. Zinc oxide nanoparticles (ZnO NPs) concentrations (control, 50, 100, 150 ppm) were allotted horizontally, while two genotypes of sorghum (Giza 15 and Dorado) were assigned vertically. The obtained results showed that plant height, panicle length, panicle width, 1000 kernel weight and grain yield / plant were affected highly significant or significant by different zinc oxide nanoparticles in the two growing seasons, except 50% flowering was insignificant in both seasons. Grain sorghum plants which were sprayed by 1٠٠ ppm ZnO NPs gave the highest mean values of grain yield /plant over both cultivars (44.87 and 44.90 g), as against (40.10 and 39.92 g) in control plants for the first and the second season, respectively. The same trend was observed for 1000-kernel weight, since the highest mean values of two cultivars obtained from plants which sprayed by 100 ppm ZnO Nps (32.23 and 32.55 g) with compared to control plants (28.25 and 28.45 g) for both seasons, respectively. The interaction between ZnO NPs concentrations and genotypes had a non significant effect on the all studied traits in the first season, while in the second season the interaction between ZnO NPs concentrations and genotypes had significant effects on plant height , panicle length, grain yield / plant and 100٠ kernel weight.

Keywords : Grain sorghum ; Zinc Oxide Nanoparticles.

1. Introduction

Grain sorghum (*Sorghum bicolor L. Moench*) can grow as fodder and for human consumption in areas relay under water stress. Sorghum has a high concentration of potassium and starch, it is less acidifying and is easily absorbed and tolerated by the sick and diabetics, adults and even children. Sorghum is a substitute for wheat and is great for those requiring a gluten-free diet. Sorghum is naturally high in fiber and iron, with a high protein level as well (Pontieri *et al.*, 2010). Dy Kes and Rooney (2006) reported that sorghum is rich in antioxidants, which are believed to help lower the risk of cancer, diabetes, heart disease and some neurological diseases. Sorghum produces much more forage than maize. Zinc (Zn) is an essential nutrient required by all living organisms and represents the nanoparticles (NPs) with very small particles and large surface area are expected to be the ideal material for use as a Zn fertilizer in plants. Currently use of nanomaterial's has been expanded in every fields of science including agriculture. It has been stated that application of micronutrient fertilizers in the form of NPs is an important route to release required nutrients gradually and in a controlled way, which is essential to mitigate the problems of fertilizer

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pollutions Naderi and Abedi, 2012). It is because of that when materials are transformed to a nanoscale, 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). Reynolds, (2002) demonstrated that micronutrients in the form of NPs can be used in crop production to increase yield. Currently 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. Sustainable agriculture mainly aims to reduce application of chemical fertilizer and minimize nutrient losses in fertilization and increase yields through optimized nutrient management. Recently, nanotechnology is coming into focus because nano particles (NPs) are small in size (<100 nm) having high surface area and reactivity. Recent studies revealed that powder or nano sized particles are found to be effective in absorption and translocation. However, physiological aspects of nano zinc application and its accumulation in grains crops are meager. Decreased particle size increased number of particles per unit weight of applied Zn, also, increases the specific surface area of a fertilizer, which should increase the dissolution rate of fertilizers with low solubility in water such as zinc oxide (Mortvedt, 1992). Hence, the present study was carried out to investigate the effects of various concentrations of Zinc Oxide (ZnO) NPs on yield attributes in grain sorghum.

2. Materials and Methods

This study was carried out during 2017 and 2018 summer seasons at newly reclaimed soil in the Agricultural Research Centre, the Arab El-Awamer Station, Assiut, Egypt to study the effect of foliar spray by different zinc oxide nanoparticles concentrations on grain yield and its components on two grain sorghum cultivars (Dorado and Giza -15) after 45 days from sowing. Chemical analyses of the experimental soil are presented in Table 1.

Table 1. Some physical and chemical properties of experimental sites.

Properties	Arab El Awamer	
	2017	2018
Mechanical analysis:		
Sand (%)	85.40	87.20
Silt (%)	8.70	7.20
Clay (%)	5.90	5.60
Texture	Sandy	
Chemical analysis:		
EC (1:1 extract) (dsm-1)	0.59	0.77
pH (1:1 suspension)	8.21	8.43
Available		
Total nitrogen (%)	0.06	0.04
NaHCO3-extractable P (ppm)	5.14	4.88
NaOAC-extractable K (ppm)	0.14	0.12
Total CaCO3 % (ppm)	27.33	32.15
Organic matter (%)	0.82	0.76

2.1. Experimental treatments and design

The experiment was laid out in randomized complete block design (RCBD) using strip split plot arrangement with three replications. Zinc dioxide nanoparticles size (control, 50, 100, 150 ppm) were allocated horizontally, while genotypes of sorghum (Dorado, Giza -15) were arranged vertically in sub plots.

2.2. Cultural practices

Grain sorghum seeds were hand sown on rows of 3 m long and 60 cm apart with 25 cm between hills on 2nd, 23rd of June in the first and second seasons, respectively. Control plants were treated with water (without ZnO NPs) while the others were sprayed by the certain concentration of ZnO NPs. All sprayed treatments were done at 45 days after sowing. All other recommended cultural practices for grain sorghum crop were done in both seasons.

2.3. Statistical analysis

All collected data were subjected to the analysis of variance (ANOVA)**,** procedures (Gomez and Gomez; 1984)**,** using the SAS Statistical Software Package v.9.2 (SAS, 2008). Differences between means were compared by revised least significant difference (LSD) at 5 % level of significant (El-Rawi and Khalafalla, 198

Table 2. Effect of zinc oxide nanoparticles concentrations, grain sorghum cultivars and their interaction on plant height/plant.

Seasons	2017			2018		
Zinc oxide \ Cultivars	Giza 15	Dorado	Mean	Giza 15	Dorado	Mean
control	250.53	122.33	186.43	250.73	124.93	187.83
50 ppm	254.60	126.57	190.58	256.27	126.60	191.43
100 ppm	266.00	125.83	195.92	265.90	126.77	196.33
150 ppm	258.73	124.13	191.43	259.10	124.77	191.93
Mean	257.47	124.72	-	258.00	125.77	-

	F test	LSD 0.05	F test	LSD 0.05
ZnONPs	**	2.75	**	0.94
Cultivars	**	3.89	**	1.34
Interaction	*	5.50	**	1.89

*and ** mean significant 5 and 1% at level of probability, respectively.

3. Results and Discussion

3.1. Growth and Yield components traits

The presented data in Tables (2- 6) reveal that the studied zinc oxide nanoparticles (ZnO NPs) concentrations had a significant or highly significant ($P\leq0.05$ or $P\leq0.01$) effect on all studied traits in the two growing seasons except 50% flowering was no significant in both seasons. The interaction between ZnO NPs concentrations and grain sorghum cultivars had a significant or highly significant effect on plant height in the first and second season, respectively. Thus, the highest mean values of plant height (195.92 and 196.33cm in the two respective seasons), as against (186.43 and 187.83 cm in control plants), were obtained from grain sorghum plants which were sprayed by

ZnO NPs concentration at 100 ppm Table2. The plants treated at the concentration of 100 ppm ZnO NPs initiated flowering after (80.50 and 79.67 day) in the two respective seasons, as against (82.33 day in both seasons in control plants), no significant for the interaction between ZnO NPs concentrations and grain sorghum cultivars in both seasons on 50% flowering (Table 3). Concerning the interaction effect on panicle length trait, the exhibited data in Table 4 reveal that the interaction between ZnO NPs concentrations and grain sorghum cultivars had a significant effect in this respect during the second season only. The highest mean values of panicle length (22.27 and 22.35 cm) in the two respective seasons, as against (20.10 and 20.17 cm in control plants) in the two respective seasons. Also, the recorded data in Table 5 denote that the tested grain sorghum cultivars had no significant influence on panicle width in the two seasons, respectively. The highest mean values of panicle width (8.90 and 9.00 cm in the two respective seasons, as against (8.03 and 8.12 cm) in control plants. Here too, the exhibited data in Tables 6, 7 denote that the interaction between ZnO NPs concentrations and grain sorghum cultivars had a significant effect on grain yield and 1000 kernel weight in the second season. The highest mean values of grain yield (44.87 and 44.90 g) in the two respective seasons, as against (40.10 and 39.92 g) in control plants. While, for 1000 kernel weight the highest mean values (32.23 and 32.55 g) in the two seasons respectively, as against (28.25 and 28.45 g) in control plant

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150 ppm	258.73	124.13	191.43	259.10	124.77	191.93
Mean	257.47	124.72	-	258.00	125.77	-
	F test	LSD 0.05		F test	LSD 0.05	
ZnONPs	**	2.75		**	0.94	
Cultivars	**	3.89		**	1.34	
Interaction	*	5.50		**	1.89	

*and ** mean significant 5 and 1% at level of probability, respectively.

The study shows that, by using a very less quantity of fertilizers may reduce the application doses of fertilizers, wastage of fertilizers, environmental hazards and increase nutrient use efficiency. There is need to study the effects of nano zinc oxide particles on soil beneficial microorganisms and different beneficial process like nitrification, nitrogen fixation, decomposition of organic material, mineralization, and immobilization. There is also need to standardize the nano fertilizers doses for different crop and optimum stage of crop for to achieve better crop production and also need to know the intra and extra cellular mechanisms involved in uptake and translocation of nanoparticles. In conclusion, foliar fertilization of 100 ppm ZnO was found more effective than other concentrations (50 and 150 ppm ZnO). It is worth mentioning that higher/toxic doses of ZnO NPs i.e. >1000 ppm caused significant reduction in grain yield of sorghum (Poornima and Koti (2019), so it clearly indicates that nano particles are efficient and helps in increasing yield at much lower concentrations itself as compared to bulk forms of zinc and the results were in accordance with the reports on radish, rape, corn, lettuce and cucumber by Lin and Xing, (2007).

Table 3. Effect of zinc oxide nanoparticles concentrations, grain sorghum cultivars and their interaction on %50 flowering.

Seasons	2017			2018		
Zinc oxide \ Cultivars	Giza 15	Dorado	Mean	Giza 15	Dorado	Mean
control	81.33	83.33	82.33	82.00	82.67	82.33
50 ppm	81.00	83.67	82.33	81.33	81.67	81.50
100 ppm	80.00	81.00	80.50	79.67	79.67	79.67
150 ppm	84.33	83.67	84.00	84.67	83.00	83.83
Mean	81.67	82.92	-	81.92	81.75	-
	F test		LSD 0.05	F test		LSD 0.05
ZnONPs	ns		-	*		0.99
Cultivars	*		2.01	ns		-
Interaction	ns		Ns	ns		ns

*and ** mean significant 5 and 1% at level of probability, respectively.

Table 4. Effect of zinc oxide nanoparticles concentrations, grain sorghum cultivars and their interaction on panicle length/ plant.

Seasons	2017			2018		
Zinc oxide \ Cultivars	Giza 15	Dorado	Mean	Giza 15	Dorado	Mean
control	8.63	7.43	8.03	8.73	7.50	8.12
50 ppm	8.80	7.73	8.27	9.30	7.93	8.62
100 ppm	9.17	8.63	8.90	9.33	8.67	9.00
150 ppm	8.80	7.93	8.37	9.03	7.43	8.23
Mean	8.85	7.93	-	9.10	7.88	-
	F test		LSD 0.05	F test		LSD 0.05
ZnONPs	*		0.26	**		0.42
Cultivars	**		-	**		-
Interaction	ns		Ns	ns		Ns

*and ** mean significant 5 and 1% at level of probability, respectively.

Table 5. Effect of zinc oxide nanoparticles concentrations, grain sorghum cultivars and their interaction on panicle width. *and

Seasons	2017			2018		
Zinc oxide \ Cultivars	Giza 15	Dorado	Mean	Giza 15	Dorado	Mean
control	18.40	21.80	20.10	18.47	21.87	20.17
50 ppm	19.70	23.10	21.40	19.20	23.00	21.10
100 ppm	20.73	23.80	22.27	21.47	23.23	22.35
150 ppm	20.77	22.43	21.60	20.63	22.57	21.60
Mean	19.90	22.78	-	19.94	22.67	-
	F test		LSD 0.05	F test		LSD 0.05
ZnONPs	*		0.98	**		1.23
Cultivars	**		-	*		-
Interaction	ns		Ns	*		1.03

*and** mean significant 5 and 1% at level of probability, respectively.

Table 6. Effect of zinc oxide nanoparticles concentrations, grain sorghum cultivars and their interaction on grain yield / plant.

Seasons	2017			2018		
Zinc oxide \ Cultivars	Giza 15	Dorado	Mean	Giza 15	Dorado	Mean
control	44.70	35.50	40.10	43.90	35.93	39.92
50 ppm	44.67	38.23	41.45	44.33	39.43	41.88
100 ppm	48.63	41.10	44.87	49.73	40.07	44.90
150 ppm	47.43	38.73	43.08	46.47	39.30	42.88
Mean	46.36	38.39	-	46.11	38.68	-
	F test		LSD 0.05	F test		LSD 0.05
ZnONPs	**		1.15	**		1.68
Cultivars	**		-	**		-
Interaction	ns		Ns	*		2.26

*and ** mean significant 5 and 1% at level of probability, respectively.

Table 7. Effect of zinc oxide nanoparticles concentrations, grain sorghum cultivars and their interaction on 1000 kernel weight.

Seasons	2017			2018		
Zinc oxide \ Cultivars	Giza 15	Dorado	Mean	Giza 15	Dorado	Mean
control	32.87	23.63	28.25	32.43	24.47	28.45
50 ppm	34.47	24.70	29.58	34.63	25.67	30.15
100 ppm	37.63	26.83	32.23	38.33	26.77	32.55
150 ppm	34.47	25.03	29.75	34.50	24.97	29.73
Mean	34.86	25.05	-	34.97	25.47	-
	F test		LSD 0.05	F test		LSD 0.05
ZnONPs	*		0.87	*		0.62
Cultivars	**		-	**		-
Interaction	ns		Ns	*		1.78

*and ** mean significant 5 and 1% at level of probability, respectively.

Lower doses of nano ZnO is sufficient to achieve positive response and higher doses showed growth retardation. Results depicted clearly indicate that ZnO NPs at 100 ppm significantly induced early flowering and seed yield in treated grain sorghum plants. The increase in vegetative growth in other crops (Onion) might be due to fundamental role of Zn in protecting and maintaining structural stability of cell membranes (Welch *et al.*, 1982) and use in protein synthesis, membrane function, cell elongation as well as tolerance to environmental stresses (Cakmak, 2000). Also, **(** Poornima and Koti, 2019**)** shows that application of nano ZnO recorded more yield and growth of sorghum as compare to bulk ZnSO4. In Egypt Mourad and El-Menshawi (2005), reported that grain weight per head , number of kernel per head and grain yield increased significantly by raising zinc level up to 0.5 gm / L whereas the same characters decreased significantly by spraying one grain zinc per liter.

4. Conclusion

Plant height, panicle length, panicle width, 1000 kernel weight and grain yield / plant were affected highly significant or significant by different zinc oxide nanoparticles in the two growing seasons, except 50% flowering was insignificant in both seasons. Grain sorghum plants which were sprayed by 1٠٠ ppm ZnO NPs gave the highest mean values of grain yield /plant over both cultivars. The same trend was observed for 1000-kernel weight, since the highest mean values of two cultivars obtained from plants which sprayed by 100 ppm ZnO Nps. The interaction between ZnO NPs concentrations and genotypes had a non significant effect on the all studied traits in the first season, while in the second season the interaction between ZnO NPs concentrations and genotypes had significant effects on plant height, panicle length, grain yield / plant and 100، kernel weight.

5. References

Cakmak, I. (2000) 'Role of zinc in protecting plant cells from reactive oxygen species' *New Phytologist*, pp. 146, 185 - 205.

Dy Kes and Lloyd, w. Rooney. (2006) 'Sorghum and millet phenols and antioxidants' *Journal of cereal science,* pp. 44 pages 236- 251.

El-Rawi, K. and A.M. Khalafalla, 1980. Design and analysis of agricultural experiments, El Mousel Univ., Iraq, 19.

Gomez, K.A. and Gomez, A.A. (1984) 'Statistical Procedures for Agricultural Research' *2nd Edn., John Wily and Sons, New York,* pp: 68.

Mazaherinia, S., Astaraei, A.R., Fotovat, A., Monshi, A. (2010) 'Nano iron oxide particles efficiency on Fe, Mn, Zn and Cu concentrations in wheat plant' *Word applied Science Journal*, pp.7(1):36-40.

Mortvedt, J.J. (1992) 'Crop response to level of water soluble zinc in granular zinc fertilizers' *Fertilizer Res*, pp. 33: 249–255.

Naderi, M.R. and Abedi, A. (2012) 'Application of nanotechnology in agriculture and refinement of environmental pollutants' *Journal of Nanotechnology*, pp. 11(1):18-26.

Mourad, A.C.A.A. and El-Menshawi, M.M. (2005) 'Effect of adding nitrogen, potassium and zinc on growth and yield on grain sorghum hybrid (Shandaweel 2) In sandy soils. Egypt' *J. of App. Sci.,* pp. 20 (8A): 127-138.

Poornima, R. and Koti, R.V. (2019) 'Effect of nano zinc oxide on growth, yield and grain zinc content of sorghum (Sorghum bicolor)' *Journal of Pharmacognosy and Phytochemistry,* pp. 8(4): 727-731.

Pontieri, P., Mario, A.Di., Tamburino, R., stelano, M. De., Tilley, M., Bean, S.R., Roemer, E., Vita, P.De., Vita, Alifano, P.S., Givdice, L. Del., and Massardo, D.R. (2010) 'Chemical composition of selected food – grads sorghum varieties'

Prasad, T.N.V.K.V., Sudhakar, P., Sreenivasulu, Y., Latha, P., Munaswamy, V., Raja Reddy, K., Sreeprasad, T. S., Sajanlal,P. R. and Pradeep, T. (2012) 'Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut' *Journal of Plant Nutrition,* pp. (35), 905-927.

Reynolds, G.H. (2002) 'Forward to the future nanotechnology and regulatory policy' *Pacific Research Institute,* pp. 24,1-23.

SAS institute (2008) 'The SAS System for Windows, release 9.2 ' Cary NC: SAS institute.

Welch, R.M., Webb, M.J. and Loneragan, J.F. (1982) 'Zinc in membrane function and its role in phosphorus toxicity ' *In: Proceedings of the Ninth Plant Nutrition Colloquium, ed. A. Scaife, pp710 -715. Wallingford, UK: CAB International.*