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EFFECT OF NANO ZINC OXIDE ON THE GERMINATION PARAMETERS OF SOYBEAN SEEDS UNDER DROUGHT STRESS

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ABSTRACT
In order to study the effect of nano zinc oxide on germination parameters of soybeans seeds under drought stress conditions applied by poly ethylene glycol (PEG), a factorial experiment conducted based on completely randomized design with three replications. Treatments were drought stress (0, -0.5, -1 MPa) and concentrations of nano zinc oxide (0, 0.5, 1 g lit^{-1}). Results showed that the effect of different concentrations of PEG and nano zinc oxide on germination rate and germination percentage, root length, root fresh and dry weight, seed residual fresh and dry weight were significant. Nano zinc oxide increased germination percentage and rate over control. Length and fresh weight of radicle was greater in stressed seedlings. Application of nano zinc oxide and stress occurrence caused to decrease in seed residual fresh and dry weight which indicates that treatments were effective for using of seed reservoirs to seedling growth.
KEY WORDS: *Polyethylene glycol, nano zinc oxide, soybean, drought stress, germination.*

INTRODUCTION

Drought is the most important abiotic stress limiting the growth and yield of plants (Cheong *et al*, 2003). Low and irregular participation always cause to drought stress during crop growth season (Sarmadnia & Kucheki, 1992). Drought stress occurs when soil water amount decreases to a level that leads to plant injury (Rad & Kar, 1995). Nutrient transfer mechanisms like mass flow, diffusion and osmosis related transfer totally are the function of soil and root water content and it water become in limit, concentrations of nutrient molecules can be changed (Taiz & Zaiger, 1998). Germination of seeds is related to available water and with decrease in osmosis and matric potentials, availability of water also decreases (Rahimian-Mashhadi *et al*, 1991). Germination is the first stage of plant encounters with drought. Germination also is important for determining the final plant density if planted seeds germinate completely and vigorously (Baalbaki *et al*, 1990). Fluctuations in the germinations related to environmental factors, are important in the view of ecology and crop management. Interaction between environmental factors and internal mechanisms of seeds, determines the germination under specific conditions (Bradford *et al*, 1992). Germination and emergence of soybean seed is very susceptible to water limitation (Khajepour, 1999). Dornbas *et al* (1989) reported that drought stress decreased soybean seed germination percentage significantly. De and Kar (1995) suggested that in legumes germination percentage is related to slow diffusion in testa. Dehghanian and Madandust (2008) reported that crop nutrients specially zinc can improve the plant tolerance to drought stress. Zinc contains in the structure of 200 enzymes and transcriptional factors which have important roles in protein and carbohydrate synthesis and regulation of metabolism in saccharides, nucleic acids and lipids. Zn also influence on chlorophyll biosynthesis (Kabata – Pendias & Pendias, 1999). Cakmak *et al* (1996) reported that zinc deficiency occurs in arid and semi – arid soils with dry surfaces.

Micronutrient fertilizers can increase the tolerance of plants to environmental stresses like drought and salinity (Baybordi, 2005). Ferrous and zinc prepare the plants to tolerate drought stress (Cakmak, 2008). Tatis *et al* (2004) demonstrated that under drought stress, germination percentage of soybean seeds decrease significantly. Abedi – Baba Arabi (2008) reported the decrease in germination traits of safflower under drought stress. Zn increases the radical growth in germinated seeds (Cakmak *et al* 1996). Cakmak (2008) also reported that high Zn content in grains can increase the seed viability and establishment especially in Zn – deficient areas. Reduction in the plumule dry weight under drought stress can be related to decrease in remobilization of nutrients from reserves to embryo and reduction in plumule length. In the presence of Zn, there is an increase in the biosynthesis of auxin and gibberellins (Cakmak, 2008). This increase in the endogenous auxin levels can lead to plumule growth and increase of its dry weight.

Introduction of new technologies in crop production and studying of their capabilities to overcome the stresses can provide us a new horizon to increasing plant production. Therefore, the objective of this study was to determine the potential of new produced nano – zinc oxide particles for improving soybean seed germination under drought stress.

MATERIALS AND METHODS

In order to evaluate the effects of Nano – zinc oxide particles on the germination traits of soybean seed under drought stress, a factorial experiment conducted based on completely randomized design with three replications. Treatments were drought stress severity including 0, -0.5 and -1 MPa and nano zinc oxide concentrations as 0, 0.5 and 1 g lit^{-1}. Seeds were surface sterilized with 10% sodium hypochlorite for 3 min and rinsed three times. Then seeds planted on Watt man paper in petridishes and drought stress applied using poly ethylene glycol (PEG 6000) at the -0.5 and -1 MPa potential. Nano – zinc oxide powder at mentioned concentrations added to deionized water and placed on ultra sonic equipment (100 w and 40 kHz) on a shaker for better solution. Then, prepared solutions were added to each petridish. Pure water used for control treatment.

Germination seeds were counted based on 2 mm radical emergence (Kafi *et al*, 2005) and 24h after planting counting was continued until the number of germinated of seeds were constant in last three days of experiment. Radicle length was measured using millimeter paper. In each plat 10 seedlings were selected randomly for measuring dry and fresh weight of radical and residual deeds in an oven at 70^0C for 24h.

Germination rate (GR) was calculated according to formula by Ellis and Roberts (1981):

$$GR = \sum \frac{n}{dn}$$

which n is the number of germinated seeds and is the counting day. Statistical analysis on data was performed after normality test using SAS 9.1 software and comparison of means executed by Duncan's multiple range test at %5 probability level.

RESULT AND DISCUSSION

Simple effects of drought and nano – zinc oxide were significant decrease in GP (table 1). There was a significant decrease in GF and GR with increasing drought severity and GP decreased from %97 in control to %78 in -1 MPa (table 2). Rade and Kar (1995) reported that all traits of mungbean germination have decreased under drought stress. However, Perisco *et al* (1992) showed a decrease in GP by increasing in drought stress severity.

Reduction in GP attributed to decrease in imbibitions of seeds and water uptake under stress conditions (Turk *et al*, 2004), or could be related to metabolic disorders such as reservoirs hydrolyzed nutrient for embryo development (Gul & Allen, 1979). Therefor it can be resulted that enzymatic activities decrease under drought and reduction in osmotic potential can be occurred.

Nano – zinc oxide caused an increase in GP and GR (table 2) and the highest values achieved by applying 1 g lit^{-1} of nano – zinc oxide about %89.5 and 6.88, respectively. Zn acts as e co- factor for enzyme activation of enzymes.

Effect of nano – zinc oxide and drought was significant on radical length, but only the simple effect of drought and nano – zinc oxide were significant on fresh and dry weight of radicle (table 1).

Drought and nano – zinc oxide increased the radical length and the highest length (4.45 cm) observed in sever tress and applying 1 g lit^{-1} (fig 1). The highest fresh and dry weight of radical was related to 1 g lit^{-1} Nano – zinc oxide with 0.07 and 0.02 g, respectively (table 2). The highest values for these traits also observed in -1 MPa drought stress as 0.07 and 0.0198 g respectively (table 2). Zn has the main role in seed germination (Cakmak *et al*, 1996).

Zn probably can be used for membrane activity and cell elongation under stress conditions (Cakmak, 2000), and causes to membrane stability and increase cell elongation. So, increasing in radicle growth leads to an increase in fresh and dry weight.

Main effects of nano – zinc oxide and drought were significant on seed residual dry and fresh weight (table 1). Comparison of means showed that with increasing in nano – zinc oxide concentration, there was a reduction in the residual fresh and dry weight and the highest values (respectively 0.38 and 0.111 g) observed in control treatment (table 2). Drought stress also had similar trend and the highest residual fresh and dry weight (0.386 and 0.108 g respectively) observed in non – stress treatment (table 2). It seems that under control conditions, seed reservoirs were not consumed effectively, because the main portion or reservoirs was not used and increased the residual weight. While, in the presence of Zn biosynthesis of hormones especially auxin and gibberellins increased (Cakmak, 2008). Therefore, increase of endogen concentration of auxin and gibberelline causes to increase in radical and plumule growth under Zn presence and leads to increase in depletion of seed reserves and reduction of residual seed weight.

Table 1. Analysis of variance for the effect of nano zinc oxide on morphological and germination parameters of soybean seeds under drought stress caused by poly ethylene glycol.

			MS					
Zn	DF	GP	GR	RL	RFW	ReFW	RDW	ReDW
PEG	2	46*.63	0.45**	1.63**	0.0006**	0.001**	0.00005**	0.0008**
ZN*PEG	2	04**.832	5.11**	0.83**	0.001**	0.0009**	0.00008**	0.0003**
Error	4	ns41.7	ns0.008	0.022*	ns0.000003	ns0.000007	ns0.0000009	ns0.000004
CV (%)	18	79.15	0.015	0.006	0.000005	0.00004	0.000001	0.00002
Zn	DF	4.57	1.88	2.17	3.78	1.71	5.95	4.61

ns, *, **: Representing non-significant and significant effects at 5 and 1% probability level, respectively. GP (germination percent), GR (Germination rate), RL (radicle length), RFW (radicle fresh weight), ReFW (seed residual fresh weight), RDW (radicle dry weight) and ReDW (seed residual dry weight).

Table 2. Comparison of means for the interaction of drought and nano zinc oxide on the studied traits in soybean seeds.

				MS				
Treatment	concentration	GP (%)	GR (N/day)	RL (Cm)	RFW (g)	ReFW (g)	RDW (g)	ReDW (g)
	Control	b2.84	c43.6	c22.3	c054.0	a0.38	c0.015	a0.111
Zn (g lit^{-1})	0.5	ab83.86	b66.6	b76.3	b063.0	b0.37	b0.017	b0.1005
	1	a51.89	a88.6	a07.4	a07.0	c0.36	a0.02	c0.092
	Control	a12.97	a43.7	c4.3	c0.05	a0.386	b0.0141	a0.108
PEG (MPa)	-0.5	b35.85	b60.6	b65.3	b0.067	b0.372	a0.0191	b0.1004
	-1	c067.78	c93.5	a007.4	a0.07	b0.367	a0.0198	c0.095

In each column means with the same letter are not statistically different. GP (germination percent), GR (Germination rate), RL (radicle length), RFW (radicle fresh weight), ReFW (seed residual fresh weight), RDW (radicle dry weight) and ReDW (seed residual dry weight).

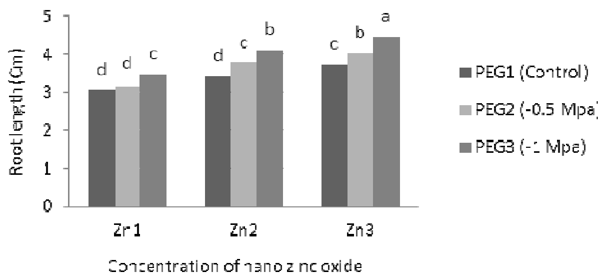

Fig1. Effect of nano zinc oxide and drought stress on radicle length of soybean seedlings.

CONCLUSION

Under drought conditions, all germination traits decreased except of radical dry and fresh weight. Nano – zinc oxide enhanced the germination parameters and caused to better drought tolerance. So, with applying 1 g lit^{-1} of nano – zinc oxide it can be practical to increase and improve soybean seed germination under drought stress. It is suggested to study the potential of nano – zinc oxide on the changes in the quality and quantity of soybean performance in field conditions.

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