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The Effect of N-Si on Tomato Seed Germination under Salinity Levels

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ABSTRACT

A study was conducted to evaluate the effects of Nano-Silicon (N-Si) for ameliorating negative effects of salinity on germination and growth of tomato seeds. N-Si at 2 concentrations (1 and 2 mM) and NaCl (1 and 2 mM) was studied on tomato seed germination. Germination characteristics such as germination percentage (GP), germination rate (GR), shoot and root of seedling length, fresh and dry weight of seedlings and mean germination time (MGT) were measured. Results showed the great effects of N-Si to improve salinity stress on tomato seed germination. One mM N-Si under 25 mM showed the great enhancement on germination characteristics such as germination rate, root length and dry weight. On the other hand, 2mM N-Si under 50 mM NaCl, results showed reduction on germination properties.

Key Words: Germination rate, nanotechnology, mean germination time.

INTRODUCTION

Nanotechnology is a science that nowadays has widely application in almost all the technology field like chemical, manufacturing, medical, agricultural sector (Manchikanti and Bandopadhyay, 2010). Nanomaterials because of their tiny size show unique characteristics. They can change physic–chemical properties compared to their bulk materials, they have a great surface area than bulk materials. Because of these larger surface areas, their solubility and surface reactivity was higher (Monica Castiglione and Cermonini, 2009). By manufacturing the preparation ways of nanomaterials can change their characteristics, for example, the addition of nanoparticles in liquid changes their chemical, physiological and transport characteristics compared to their base fluids such as enhancement of thermal conductivity (Ashok *et al.*, 2008).

There is some group of nano materials that used common, carbon based nanomaterials like carbon nanotubes and metal based nano materials like metal oxides. There are some researches on the effects and application of these nanomaterials on plant species. For examples, single-walled carbon nanotubes could penetrate cell walls and acted as a transporter (Liu *et al*., 2009); N-Tio_2 could increase the water uptake and fertilizers due to increase nitrate reductase activity and also protected chloroplast from aging (Lee *et al.* 2009, Lu CM *et al.* 2002; Lu *et al*., 2002). In other studies carbon nanotubes (CNTs) penetrated tomato seeds and increased drastically their germination and growth rates due to support water uptake inside seeds (Khodakovskaya *et al*., 2009).

Nowadays, salinity is became one of the most serious environmental problems that caused great reduction on growth and development of plant species. On the other hand, silicon is one the beneficial element on plant growth under biotic and abiotic stresses. Some authors reported that Si could ameliorate salt stress depression on plant species (Adatia *et al*., 1986; Wang *et al*., 2010; Wang *et al*., 2011; Zuccarini, 2008). Although there are a lot of references regarding interaction between salinity and silicon in higher plants, but there is currently no information available about the possible beneficial effects of N-Si application to reduce salt stress damages. Thus, the objective of the present study was to examine the effects of N-Si application on germination and growth responses of tomato seeds under two salinity levels.

MATERIALS AND METHODS

The effects of N-Si on seed germination and seedling growth of tomato (*Lycopersicum esculentum*) under two NaCl concentrations was tested. The experiment was conducted at laboratory and arranged on base on completely randomized design (CRD) with 4 replications including 100 seeds in each replicates. In this research, N-Si characteristics were according to Table 1.

Table 1. Characterization of nanoparticles doped carbon nanostructures.

Nanostructures	Thermogravimetric Analysis (TGA)	Inductively Coupling Plasma (ICP)
Nano-Si	5.0±0.02	4.9±0.09

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Seeds were sterilized by keeping them in a commercial 50 % (v/v) sodium hypochlorite solution for 10 minutes, before transferring them to Petri dishes or pots and then were rinsed with distilled water. 100 seeds were placed over filter paper inside the 6 cm Petri dishes. N-Si at 2 concentrations (1 and 2 mM) and NaCl (1 and 2 mM) was added to Petri dishes. Petri dishes were placed in 25±2 ºC and 16/8 light/dark condition. Distilled water was applied to Petri dishes to prevent seed dryness. Germinated seeds counted daily for 10 days in lab and germination percentage (GP) were calculated in the last day. Seeds with 2 mm radical length considered as germinated seeds. Mean germination time (MGT) was calculated based on following formula:

$$\mathbf{MGT = \sum ni.ti/T}$$

Where n_i is the number of seeds germinating on the t_i^{th} day of germination testing T is the total number of seeds germinating during the experiment (Hartman et al., 2002). In the end of experiment, radical and plumule length and fresh weight measured. Plants were placed in oven at 70 ºC for 48h and weighted with sensitive scale.

RESULTS AND DISCUSSION

The results revealed that the germination of tomato was strongly affected by both salt treatments. Increased salt concentration caused a decrease in germination (Table 1). Strong reduction was observed mainly at the higher level of salt concentration compared to control (Table 2). 1 mM N-Si under 25 mM NaCl showed positive effects and increased seed germination about 6% (Tables 4). At 50 mM NaCl there was 17% reductions at seed germination, as long as 1 mM N-Si decreased this reduction to 10 % (Tables 4). Germination rate was significantly affected by salinity and N-Si, increasing salinity decreased GR, while N-Si increased it about 20 % (Table 3). Under 25 mM NaCl and 1 mM N-Si, results showed the least reduction on germination rate.

1 mM N-Si under 50 mM NaCl increased root length about 9 %, however interaction with 1 mM N-Si and 25 mM NaCl and 1 and 2 mM N-Si just could slow the reduction rate. There were no significant effects on shoot length of tomato seedlings. Salinity interaction with N-Si showed negative effects on fresh weight and decreased it greatly. Root length of tomato seedling enhanced as a result of 1mM N-Si application under 25 mM NaCl, although in other treatments no significant effect was observed. MGT had low reduction under 25 and 50 mM NaCl by 1 and 2 mM N-Si application. Germination improvement as a result of N-Si application demonstrated that the effects of this nanomaterial look like its bulk size. Similar resulted were reported by other researchers that confirm the positive effects of silicon at salinity stress (Lee *et al*., 2010; Sun *et al.* 2010; Wang *et al.*, 2010; Wang *et al*., 2011; Zuccarini, 2008). They observed that silicon application could ameliorate salinity damages on plant species. Zuccarini (2008) observed that Si application leaded to balance growth reduction of *Phaseolus vulgaris* L. caused by salinity like decrease stomatal conductance, drop of leaf RWC, decrease K^+ tissues content and etc. In other study, it was found that applying Si at plants under salt stress could increase antioxidative enzymes activity like SOD, POD and CAT which played great role to counterbalance salinity damages (Wang *et al*., 2011). In other hand, there is little study on the effects of N-Si on plant species. Bao-shan *et al.* (2004) tested TMS (nanostructured silicon dioxide) on growth of Changbai larch (*Larix olgensis*) seedlings. They observed that *Larix* seedlings growth and quality which treated with TMS was promoted. 500 $\mu L.L^{-1}$ TMS showed the highest amount of mean height, root collar diameter, main root length and the number of lateral roots of seedlings. In other study, it was found that N-SiO_2 could enhance the growth of soybean. They observed that soybean seeds which treated by a mixture of N-SiO2 and N-TiO2 had more germination and the activity of nitrate reductase, superoxide dismutase, catalase and peroxidase of germinating seeds were increased significantly (Lu *et al*., 2002). At interaction of both salinity and N-Si the rate of GR reduction was high (Table 4). It was indicated that N-Si might have toxic effects or it can be stronger salinity effects (Table 5). Although there was a report on toxicity of N-SiO_2 on *Arabidopsis thaliana*, but these toxicity was not stronger as other nanoparticles such as N-ZnO and N-Fe_3O_4 (Lee *et al.*, 2010).

CONCLUSIONS

According our results, N-Si showed great effects to ameliorate salinity damages. But our experiment was the first work at N-Si and salinity. There was some strange reduction at higher concentration of salinity and N-Si but it is not clear that this reduction is due to high salinity or higher concentration of N-Si. We suggest to other researcher to work on this field to clarify the pure effects of N-Si on growth stage of plant species.

Table 2. The effect of Salinity on germination characteristics of tomato.

Salinity	GP	GR	Shoot length (cm)	Root length (cm)	Dry weight of shoot (g)	Fresh weight of shoot (g)	MGT	seedling vigor index
0	94.000A	5.0829A	6.3429A	3.7800A	0.6225A	0.0492A	0.2033A	36.209 A
25	7.000AB	3.6437B	4.6020B	3.1908A	0.3350B	0.0350A	0.1457B	45.226 A
50	79.667 B	3.1108B	5.3614AB	3.2134A	0.2200C	0.0383A	0.1244B	25.545 B

Within a column means followed by the same letter are not significantly different at P<5% according to least significant different test.

Table 3. The effect of N-Si on germination characteristics of tomato.

N-Si	GP	GR	Shoot length (cm)	Root length (cm)	Dry weigh of shoot (g)	Fresh weight of shoot (g)	MGT	seedling vigor index
0	91.66A	3.68B	4.69A	3.39A	0.437A	0.049A	0.14B	56.204 A
1mM	87.0A	3.80AB	5.89A	3.48A	0.467A	0.042A	0.15AB	28.863 B
2mM	82.0A	4.34A	5.71A	3.30A	0.272B	0.030A	0.17A	21.914 B

Within a column means followed by the same letter are not significantly different at P<5% according to least significant different test.

Table 4. The interaction effect of salinity and N-Si on GP, GR and MGT.

		GP	
	0	25 mM	50 mM
0	91.0ab	80.0ab	75.0b
1mM	93.0ab	99.0a	83.0ab
2mM	98.0ab	82.0ab	81.0ab
		GR	
	0	25 mM	50 mM
0	4.72b	3.55cd	2.78d
1mM	4.02bc	3.89bc	3.48cd
2mM	6.50a	3.48cd	3.06cd
		MGT	
	0	25 mM	50 mM
0	0.26a	0.15bc	0.13cd
1mM	0.18b	0.14cd	0.12cd
2mM	0.16bc	0.13cd	0.11d
		Seedling vigor index	
	0	25 mM	50 mM
0	57.617 ab	34.820 cd	16.190 e
1mM	66.124 a	39.860 bc	29.696 cde
2mM	44.870 bc	11.909 e	19.856 de

The means followed by the same letter are not significantly different at P<5% according to least significant different test.

Table 5. The interaction effect of salinity and N-Si on fresh and dry weight.

	Fresh weight of root		
	0	25 mM	50 mM
0	3.984a	3.572ab	2.632b
1mM	3.479ab	3.142ab	3.838a
2mM	3.876a	2.857ab	3.169ab
	Fresh weight of shoot		
	0	25 mM	50 mM
0	0.652a	0.437b	0.222d
1mM	0.757a	0.405bc	0.240cd
2mM	0.457b	0.162d	0.197d
	Dry weight of shoot		
	0	25 mM	50 mM
0	0.072a	0.035ab	0.040ab
1mM	0.037ab	0.052ab	0.037ab
2mM	0.037ab	0.0175b	0.037ab

The means followed by the same letter are not significantly different at P<5% according to least significant different test.

REFERENCES

Adatia, M.H. and Besford, R.T. 1986. The effects of silicon on cucumber plants grown in recirculating nutrient solution. Ann. Bot. 58:343-351.

Ashok K. S. and V. S. Raykar. 2008. Microwave synthesis of silver nanofluids with polyvinylpyrolidine (PVP) and their transport properties. Colloid Polym Sci, 286:1667-1673.

Bao-shan L., D.Shao-qi, L. Chun-hui, F. Li-jun, Q. Shu-chun and Y. Min. 2004. Effects of TMS (nanostructured silicon dioxide) on growth of Changbai larch seedlings. Journal of Forestry research, 15:138-140.

Castiglione Monica, R. and R. Cremonini. 2009. Nanoparticles and higher plants. Caryologia, 62: 161-165.

Hartman, H. T. , D. , Kester, F. T. , Davies and R. L. , Geneve. 2002. Plant propagation principles and practices. Pearson Education. 7th edition. 880p.

Huang L. S., S. G. Yang, T. Li, B. X. Gu, Y. W. Du, Y.N. Lu and S. Z. Shi. Preparation of large-scale cupric oxide nanowires by thermal evaporation method. Journal of Crystal Growth, 260:130-135.

Khodakovskaya, M., Dervishi, E., Mahmood, M., Xu, Y., Li, Z., Watanabe, F. and Biris, A.S. 2009 Carbon nanotubes are able to penetrate plant seed coat and dramatically affect seed germination and plant growth. ACS Nano 3:3221–3227.

Lee S. K., E. Y. Sohn, M. Hamayun, L. Y. Yoon and I. J. Lee. 2010. Effects of silicon on growth and salinity stress of soybean plant grown under hydroponic system. Agroforest Syst, 80:333-430.

Lee, C.W. , S. Mahendra, K. Zodrow, D. Li, Y. Tsai, J. Braam and P. J. J. Alvarez. 2010. Developmental phytotoxicity of metal oxide nanoparticles to *Arabodopsis thaliana*. Environ. Toxicol. Chem. 29:669-675.

Lin, C., Fugetsu, B., Su, Y. and Watari, F. 2009. Studies on toxicity of multi-walled carbon nanotubes on *Arabidopsis* T87 suspension cells. J. Hazard. Mater.170:578–583.

Liu C., F. Li, C. Luo, X. Liu, S. Wang, T. Liu and X. Li. 2009. Foliar application of two silica sols reduced cadmium accumulation in race grains. Journal of Hazardous Material, 161:1466-1472.

Liu, Q., Chen, B., Wang, Q., Shi, X., Xiao, Z., Lin, J. and Fang, X. 2009. Carbon nanotubes as molecular transporters for walled plant cells. Nano Lett. 9:1007–1010.

Lu C. M., C. Y. Zhang, J. Q. Wen, and G. R. Wu, Effects of nano material on germination and growth of soybean, Soybean Sci. 21(3), 168–171 (2002) (in Chinese).

Lu, C. M., Zhang C. Y., Wen J. Q., Wu G. R. and Tao M. X. 2002. Research of the effect of nanometer materials on germination and growth enhancement of Glycine max and its mechanism. Soybean Science, 21:168–172.

Manchikanti P. and T. K. Bandopadhyay. 2010. Nanomaterials and effects on biological systems: development of effective regulatory norm. Nanoethics, 4:77-83.

Wang X. D., C. Ou-yang, Z. Fan, S. Gao. F. Chen and L. Tang. 2010. Effects of exogenous silicon on seed germination and antioxidant enzyme activities of *Momordica charantia* under salt stress. Journal of Animal & Plant Science, 6:700-708.

Wang X., Z. Wei, D. Liu and G. Zhao. 2011. Effects of NaCl and silicon on activities of antioxidative enzymes in roots, shoots and leaves of alfalfa. African Journal of Biotechnology, 10:545-549.

Zuccarini P. 2008. Effects of silicon on photosynthesis, water relations and nutrient uptake of *Phaseolus vulgaris* under NaCl stress. Biologia Plantarum, 52:157-160.