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# Impact of Silicon on Decreasing of Salinity Stress in Greenhouse Cucumber (*Cucumis sativus* L.) in Soilless Culture

**Zahra Amirossadat[1*], Ahmad Mohammadi Ghehsareh[1] and Amin Mojiri[2]**
[1] Department of Soil Science, College of Agriculture, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, IRAN
[2] Young Researchers Club, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, IRAN

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## ABSTRACT

**Salinity is one of the environmental threats to agriculture. A study was carried out to investigate impact of silicon on decreasing of salinity stress in greenhouse cucumber (*Cucumis sativus* L.) in soilless culture. Seeds of cucumber were sown in polystyrene boxes with a substrate composed of 50% peat and 50% perlite. After 40 days (after germination), seedlings were transferred to plastic containers with 17 liter volumes. Five levels of silicon by sodium silicate ($NaSiO_3$) were considered including 0, 25, 50, 75 and 100 $mg.L^{-1}$ using sodium silicate in nutrient solution. Salinity levels in the final nutrient solution were considered including 2.5, 3.5 and 4.5 ($dS.m^{-1}$) using sodium chloride. After five weeks, samples were taken for testing. Maximum plant height, wet weight, dry weight (cm) and total chlorophyll (mg/g fresh weight) equal to 82.6, 333.4, 44.7 and 14.700 were recorded in No. 3 (EC=2.5 $dS.m^{-1}$ and Si= 50 $mg.L^{-1}$), 1 (EC= 2.5 $dS.m^{-1}$ and Si=0 $mg.L^{-1}$), 5 (EC=2.5 $dS.m^{-1}$ and Si= 100 $mg.L^{-1}$) and 2 (EC=2.5 $dS.m^{-1}$ and Si= 25 $mg.L^{-1}$), respectively. Minimum plant height, wet weight, dry weight (cm) and total chlorophyll (mg/g fresh weight) equal to 62.3, 281.7, 26.2 and 8.22 were recorded in No. 7 (EC=3.5 $dS.m^{-1}$ and Si= 25 $mg.L^{-1}$), 8 (EC=3.5 $dS.m^{-1}$ and Si= 50 $mg.L^{-1}$), 12 (EC=4.5 $dS.m^{-1}$ and Si= 25 $mg.L^{-1}$) and 7, respectively. The evidences provided by this experiment indicated that silicate has increased resistance of plant against salinity. Silicate caused an increase of chlorophyll content but it caused a decrease of plant height.**

**Key Words: Cucumber, Salinity stress, Silicon, Soilless culture**

## INTRODUCTION

Salinity affects about 7% of the world's land, and is one of the major environmental threats to agriculture (Fahmi *et al*. 2011). Many crop plants such as barley, maize and rice, are often expose to salinity stress (Joseph and Jini, 2011). Excessive uptake of $Cl^-$ and $Na^+$ are major constraints for plant growth and productivity (Ahmed et al., 2008). Salinity seems to effect on two processes of plant, including water relations and ionic relations (Amirjani 2011). Salt stress (NaCl) has both osmotic (cell hydration) and toxic (ion accumulation) impact on plants (Nivas *et al*. 2011). It also has reported that salinity changes plant morphological traits (Bybordi and Ebrahimian, 2011). The cucumber (*Cucumis sativus*) is a widely cultivated plant in the gourd family Cucurbitaceae and grown in most temperate countries (Moradi and Jafarpour 2011). Cucumber (*Cucmus sativus* L.) is one of the vegetable crops which are often grown under covers (Al-Hamzawi 2010). It is the main greenhouse vegetable species cultivated in Iran.

Silicon (Si) is the second most abundant element on the surface of the earth, yet its role in plant biology has been poorly understood and it is not considered an essential element, but Si can reach levels in plants similar to those of macronutrients (Reezi *et al*. 2009). Wattanapayapkul *et al* (2011) reported silicon fertilizer has numerous positive effects on plants. To reduce the hazard impacts of different stresses counting salt stress, metal toxicity, drought stress, radiation damage, various pests and diseases, nutrients imbalance, high temperature and freezing, silicon was reported (Ahmed *et al*., 2008).

Liang *et al*. (1996) reported that added Si decreased the permeability of plasma membrane of leaf cells and significantly improved the ultra-structure of chloroplasts which were badly damaged by the added NaCl.

Mohaghegh *et al*. (2011) investigated effect of silicon nutrition on oxidative stress induced by *Phytophthora melonis* infection in cucumber. Silicon nutrition at either concentration significantly reduced disease severity relative to the treatment that received no silicon. There was a significant negative correlation between the extent of root rot caused by *P. melonis* and the extent of electrolyte leakage of roots. Roots infected with *P. melonis* had greater root catalase (CAT) and ascorbate peroxidase (APX) activities. There was a positive correlation between silicon concentrations and CAT and APX activities in plants inoculated with *P. melonis*. Silicon improved activity of antioxidant enzymes, resulting in enhanced crop resistance to oxidative stress induced by *P. melonis* infection and improved cucumber growth.

The aim of the study was investigated impact of silicon on decreasing of salinity stress in greenhouse cucumber (*Cucumis sativus* L.) in soilless culture.

[*] Corresponding author: zahra.amirossadat@yahoo.com

## MATERIALS AND METHODS

### *Sample Preparation*

This study was carried out according to randomized complete block design at greenhouse in 2011. Seeds of cucumber were sown in polystyrene boxes with a substrate composed of 50% peat and 50% perlite. After ten days (after germination), seedlings were transferred to plastic containers with 17 liter volumes. Five levels of silicon by sodium silicate ($NaSiO_3$) were considered including 0, 25, 50, 75 and 100 mg.$L^{-1}$ using sodium silicate in nutrient solution (Table 1). Salinity levels in the final nutrient solution were considered including 2.5, 3.5 and 4.5 (dS.$m^{-1}$) using sodium chloride. After five weeks, samples were taken for testing. The plant tissues were prepared for laboratory analysis by Wet Digestion method (Campbell and Plank 1998).

**Table 1.** Nutrient solution.

| Mo (ppm) | B (ppm) | Cu (ppm) | Zn (ppm) | Mn (ppm) | Fe (ppm) | S (ppm) | Mg (ppm) | Ca (ppm) | K (ppm) | P (ppm) | N (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 0.7 | 0.07 | 0.14 | 1.97 | 6.85 | 77 | 46 | 116 | 239 | 43 | 247 |

### *Laboratory Analysis*

Plant physiological and morphological parameters, including, height, wet weight, and dry weight were measured. Total chlorophyll was measured (Lichtent and Welburn 1983).

### *Statistical Analysis*

Descriptive statistical analysis, including mean comparison using Duncan's Multiple Range Test (DMRT), was conducted using SPSS software.

## RESULTS AND DISCUSSION

Plant parameters in treatments are shown in Table 2. Base on Table 2, Maximum plant height, wet weight, dry weight (cm) and chlorophyll (mg/g fresh weight) equal to 82.6, 333.4, 44.7 and 14.700 were recorded in No. 3, 1, 5 and 2, respectively. Minimum plant height, wet weight, dry weight (cm) and chlorophyll (mg/g fresh weight) equal to 62.3, 281.7, 26.2 and 8.22 were recorded in No. 7, 8, 12 and 7, respectively.

Liang (1999) investigated Effects of silicon on enzyme activity and sodium, potassium and calcium concentration in barley under salt stress. This result showed that the addition of Si was also found to reduce sodium but increase potassium concentrations in shoots and roots of salt-stressed barley. Sodium uptake and transport into shoots from roots was greatly inhibited by added Si under salt stress conditions. However, Si addition exhibited a little effect on calcium concentrations in shoots of salt-stressed barley. Thus, Si-enhanced salt tolerance is attributed to be selective uptake and transport of potassium and sodium by plants.

**Table 2.** Plant parameters in different treatments.

| No. | Treatments | | Plant Parameters | | | |
|---|---|---|---|---|---|---|
| | **EC (dS/m)** | **Si ($mg.L^{-1}$)** | **Height (cm)** | **Wet Weight (g)** | **Dry Weight (g)** | **Total Chlorophyll** (mg/g fresh weight) |
| 1 | 2.5 | 0.0 | 74.6ab | 333.4abc | 37.5b | 9.710bc |
| 2 | 2.5 | 25.0 | 73.6abc | 317.1abc | 34.7bc | 14.700a |
| 3 | 2.5 | 50.0 | 82.6a | 301.0abc | 31.7bcd | 11.252ab |
| 4 | 2.5 | 75.0 | 76.5abc | 317.0abc | 35.7bc | 9.216bc |
| 5 | 2.5 | 100.0 | 68.1cd | 313.3abc | 44.7a | 9.110bc |
| 6 | 3.5 | 0.0 | 77.3ab | 314.3abc | 32.3bcd | 8.273c |
| 7 | 3.5 | 25.0 | 62.3s | 321.3ab | 30.9bcd | 8.22c |
| 8 | 3.5 | 50.0 | 79.6a | 281.7c | 31.5bcd | 9.648c |
| 9 | 3.5 | 75.0 | 77.6ab | 315.0abc | 35.7cd | 12.630a |
| 10 | 3.5 | 100.0 | 74.5abc | 332.8a | 32.8bcd | 11.482ab |
| 11 | 4.5 | 0.0 | 70.3bcd | 311.3abc | 28.1cd | 8.535c |
| 12 | 4.5 | 25.0 | 72.0abc | 305.7abc | 26.2d | 9.696bc |
| 13 | 4.5 | 50.0 | 70.3bcd | 295.7abc | 29.2cd | 10.383abc |
| 14 | 4.5 | 75.0 | 71.6abc | 290.3bc | 33.9bcd | 10.336abc |
| 15 | 4.5 | 100.0 | 71.6abc | 294.3abc | 31.3bcd | 10.404abc |

+ Numbers followed by same letters in each column are not significantly ($P<0.05$) different according to the DMR test.

Savvas *et al*. (2009) investigated silicon supply in soilless cultivations of zucchini alleviates stress induced by salinity and powdery mildew infections. These results indicate that the supply of at least 1mM of Si via the nutrient solution is capable of enhancing both tolerance to salinity and resistance to powdery mildew in soilless cultivations of zucchini squash.

Based on Table 2, silicate has increased resistance of plant against salinity. Silicate has increased chlorophyll content comparison to without silicon treatments that the most increasing was in 25(ppm) of silicon and 3 (dS/m) of salinity. Silicon caused a decrease of plant height. This is in line with findings of Sopandie *et al.* (1995) and Kamenidou *et al*. (2010).

Silicon caused a decrease of plant height. The result of this study is not in line with findings of Liang (1999), Savvas *et al.* (2009) and Zhu *et al*. (2004). These studies were used potassium silicate ($KSiO_3$) but in this research was used sodium silicate ($NaSiO_3$).

Sopandie *et al.* (1995) investigated effect of silicate on the growth and ion uptake in NaCI-Stressed plants. The results revealed that Si had the protective effect on salt injury only for rice plants. This alleviating effect of Si appeared to be associated with the interference of Si on the upward Na transport by reducing the content of Na in the shoots and retaining it in the roots. Generally, addition of Si did not affect the content of K in all plants tested. Except for rice, Si had no or less effect on Ca and Mg uptake in bean and barley plants.

## CONCLUSIONS

One of the most damaging abiotic stress factors limiting crop productivity worldwide is salinity (Saleethong *et al*. 2011). The aim of the study was to investigate impact of silicon on decreasing of salinity stress in greenhouse cucumber (*Cucumis sativus* L.) in soilless culture. This result showed that silicate has increased resistance of plant against salinity. Silicate caused an increase of chlorophyll content. Silicon caused a decrease of plant height.

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