J. Bangladesh Acad. Sci. 45(2); 251-253: December 2021 DOI: 10.3329/jbas.v45i2.57213

Journal of Bangladesh Academy of Sciences

Journal homepage: http://www.bas.org.bd/publications/jbas.html

Short Communication

Improvement of growth of maize by application of silicon through its suppressing effect on sodium uptake under salt stress condition

Najira Akter, Mohammad Asadul Haque* and Md Fazlul Hoque

Department of Soil Science, Patuakhali Science and Technology University, Patuakhali, Bangladesh

ARTICLE INFO

Article History

Received: 14 September 2021
Revised: 12 November 2021
Accepted: 23 November 2021

Keywords: Germination, Maize, Salinity level, Salt tolerances, Silicon.

ABSTRACT

An experiment was conducted with three levels of salinity (0, 60, and 120 mM NaCl) and four levels of silicon (0, 5, 10, and 20 mM) in petridish. All the growth parameters were decreased gradually with increasing salt concentration, whereas increasing silicon concentration progressively increased the parameters up to 10 mM Si across all the salt concentrations. The beneficial role of Si was noticed both in saline and non-saline conditions. Silicon application in the growth medium dramatically reduced shoot Na content, making plants tolerant to salt stress.

Introduction

Salinity stress is one of the most devastating stressful environments for plant growth and production (Haque et al., 2018). One viable strategy of overcoming the salinity-induced injurious effect on plant growth is the exogenous application of silicon (Si). The addition of Si has been considered beneficial for improving crop tolerance to both biotic and abiotic stresses (Sirisuntornlak et al., 2021). However, how the application of Si improves crop tolerance to salt stress is not well understood. Although the application of silicate alleviates the negative effects of stress, the higher dose may have an adverse effect on crops (Sacała, 2017). Therefore, finding out an optimum rate of Si is a prerequisite for harvesting maximum benefit from adding Si.

Maize is one of the most important food grains, could be cultivated in the coastal saline region with appropriate amelioration techniques. Salt tolerance at the germination stage is an important factor, where soil salinity is mostly dominated by the surface layer. As Si has been identified as a beneficial nutrient to overcome biotic and abiotic stresses, it could be helpful to increase germination and early seedling growth of maize. Therefore, an experiment is undertaken to investigate how the exogenous application of Si helps plants be tolerant to salt stress conditions and find out an optimum rate of Si in salt stress conditions.

The experiment was conducted at the Department of Soil Science, Patuakhali Science and Technology University, Bangladesh, during the winter season of 2019. There were twelve treatment combinations consisting of three levels of salinity viz. 0, 60 and 120 mM NaCl, and four levels of silicon viz. 0, 5, 10, and 20 mM as silicic acid. The experiment was carried out in Petri dishes of 12 cm diameter. A thin layer of cotton was set at the bottom of the Petri dishes. Twenty-five maize seeds were placed on a cotton bed in a circle pattern. Ten milliliters of treatment solutions of different salinity and silicon concentrations were poured in each Petri dish to immerse the seeds partially for ensuring proper aeration. The seeds were allowed to germinate at room temperature (25±2°C). Required amount of distilled water was added to each Petri dish every day to

*Corresponding author: <masadulh@yahoo.com; masadulh@pstu.ac.bd>

maintain the same water level as on the initial date. Data were recorded following standard procedure and statistically analysed using STAR software.

Results revealed that the single effect of sodium chloride and silicon and their interactions significantly influenced the germination percentage of maize (Table 1). Increasing sodium chloride concentration drastically reduced germination percentage. Over the salinity concentrations increasing the silicon rate progressively increase the germination percentage of maize. However, 20 mM silicon had harmed the plant; in which drastically fell the germination percentage. The germination percentage in 0, 5, 10 and 20 mM silicon solution was 81.3, 88.0, 89.3 and 66.2%, respectively. Looking interaction effect in all the salt concentrations 10 mM Si had the highest germination percentage (Table 1).

Table 1. Effect of silicon on germination percentage of maize under different salinity stress conditions.

Silicon conc.	NaCl concentration			Si mean
	0 mM	60 mM	120 mM	
Si 0 mM	93.3	84.0	66.7	**81.3B**
Si 5 mM	96.0	90.7	77.3	**88.0A**
Si 10 mM	98.7	85.3	84.0	**89.3A**
Si 20 mM	92.0	64.0	42.7	**66.2C**
NaCl mean	**95.0a**	**81.0b**	**67.7c**	

Significance level: NaCl-***, Silicon-***, Interaction-***; %CV: 4.87

Similar capital letter in a column or similar small letter in a row is not significantly different

***- Significant at 0.1% level; CV-Coefficient of variation.

Seedling height was significantly influenced by different salinity levels, silicon and their interactions (Table 2). With the increase of NaCl concentration, seedling height was drastically decreased. Considering the single effect of silicon, increasing silicon rate consistently increase maize's seedling height.

Table 2. Effect of silicon on seedling height of maize under different salinity stress conditions

Silicon conc.	NaCl concentration			Si mean
	0 mM	60 mM	120 mM	
Si 0 mM	14.1	9.6	4.6	**9.4C**
Si 5 mM	17.9	12.7	4.7	**11.8B**
Si 10 mM	21.6	13.9	7.0	**14.2A**
Si 20 mM	7.0	2.5	1.9	**3.8D**
NaCl means	**15.2a**	**9.7b**	**4.6c**	

Significance level: Sodium-***, Silicon-***, Interaction-***; %CV: 7.07

The increases were maximum at 10 mM silicon concentration. When silicon concentration was increased to 20 mM, the seedling height fell drastically. The results evidenced that silicon not only reduced the harmful effect of salt. Instead, it acts as a plant nutrient.

Different levels of salinity, silicon and their interaction significantly influenced maize's root and shoot growth (Table 3). With the increase of the salt concentration, root dry weight drastically reduced. Silicon addition positively effected on root dry weight, having 0.178, 0.187, and 0.205 g 5^{-1} plant root dry weight in 0, 5, and 10 mM Si, respectively. Regarding interaction effect, 10 mM Si recorded maximum root dry weight, across all the salt concentrations.

Regarding shoot dry weight the Si addition increases the shoot dry weight having highest of 0.375 g 5^{-1} plant in 10 mM Si concentration, which was 15% higher than the 0 mM Si concentration. Table 3 shows that at 0, 60 and 120 mM NaCl concentration the root: shoot ratio was 0.579, 0.582 and 0.606, respectively. Thus it indicates that increasing salt concentration increased the root:shoot ratio, which evidenced that higher salt concentration favors more root production. Regarding the single effect of silicon, the lowest root:shoot ratio of 0.555 was found in 10 mM, Si concentration, which otherwise indicates that root and shoot production was relatively closer in this treatment.

Table 3. Effect of silicon on root and shoot production of maize under different salinity stress conditions.

Silicon conc.	NaCl concentration			Silicon mean
	0 mM	60 mM	120 mM	
Root dry wt. (g 5^{-1} plant)				
Si 0 mM	0.204	0.183	0.145	**0.178B**
Si 5 mM	0.206	0.205	0.150	**0.187AB**
Si 10 mM	0.216	0.217	0.183	**0.205A**
Si 20 mM	0.183	0.054	0.043	**0.093C**
NaCl mean	**0.202a**	**0.165b**	**0.130c**	
Significance level: NaCl-***, Silicon-***, Interaction-***; %CV: 7.64				
Shoot dry wt. (g 5^{-1} plant)				
Si 0 mM	0.385	0.358	0.232	**0.325B**
Si 5 mM	0.407	0.357	0.236	**0.333AB**
Si 10 mM	0.450	0.361	0.314	**0.375A**
Si 20 mM	0.233	0.086	0.078	**0.132C**
NaCl mean	**0.369a**	**0.290b**	**0.215c**	
Significance level: NaCl-***, Silicon-***, Interaction-*; %CV: 11.66				
Root:shoot ratio				
Si 0 mM	0.531	0.512	0.630	**0.558**
Si 5 mM	0.506	0.584	0.652	**0.581**
Si 10 mM	0.479	0.602	0.582	**0.555**
Si 20 mM	0.801	0.631	0.561	**0.665**
NaCl mean	**0.579**	**0.582**	**0.606**	
Significance level: NaCl-NS, Silicon-NS, Interaction-NS; %CV: 15.09				

* and ***- Significant at 5 and 0.1% level, respectively; NS- Not significant

Over the Si concentrations increase of salt concentration progressively increased the Na content of shoot (Fig. 1). Interestingly the silicon effect of reducing the Na content of shoot was very promising. When no salt was added, all the Si concentrations, including Si control, gave similar Na content. But when 60 mM NaCl was added the 0, 5, 10 and 20 mM Si concentration recorded shoot Na content of 1.17, 0.53, 0.43 and 0.42 (%), respectively. A similar trend was also found in 120 mM NaCl concentration. The results evidenced that silicon makes a barrier to uptake of Na, and plants get tolerant to salt stress.

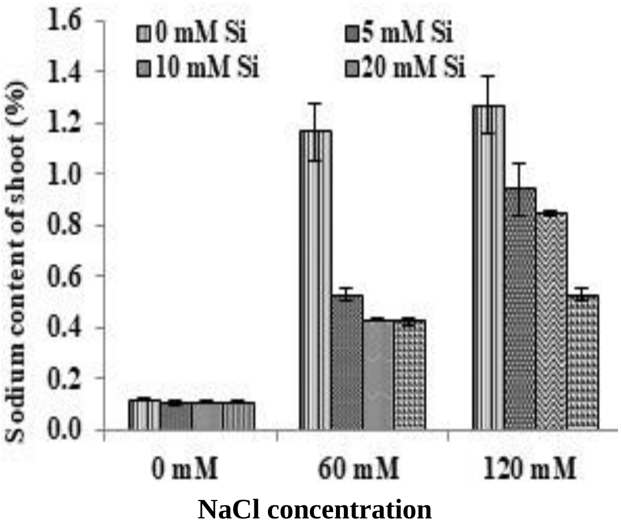

Fig. 1. Sodium content of maize seedling (Vertical bars indicate standard deviation of means).

In conclusion it can be told that silicon potentially save maize seedling against the detrimental effect of salinity. Silicon prohibits the uptake of Na by plant under saline condition.

The authors acknowledges the financial support of "Nutrient Management for diversified Cropping in Bangladesh" project Co-funded by ACIAR Australia (LWR/2016/136) and KGF Bangladesh (ICP-II) to conduct the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

References

Haque MA, Jahiruddin M and Clarke D. Effect of plastic mulch on crop yield and land degradation in south coastal saline soils of Bangladesh. *Int. Soil Water Conserv. Res.* 2018; 6(4): 317-324.

Sacała E. The influence of increasing doses of silicon on maize seedlings grown under salt stress. *J. Plant Nutri.* 2017; 40(6): 819-827.

Sirisuntornlak N, Ullah H, Sonjaroon W, Arirob W, Anusontpornperm S and Datta A. Effect of seed priming with silicon on growth, yield and nutrient uptake of maize under water-deficit stress. *J. Plant Nutri.* 2021; 44(13): 1869-1885.