Tropical Plant Research
An International Journal
© Society for Tropical Plant Research

ISSN (E): 2349 – 1183
ISSN (P): 2349 – 9265
2(2): 85–89, 2015

Research article

The effect of sodium silicate and silica nanoparticles on seed germination and growth in the *Vicia faba* L.

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Abstract: Silicon is the second most common element in soil that has beneficial effects on living and non-living increase stress tolerance in plants. It can lead to increased production and product quality, reduce evaporation of perspiration, increased stimulation of some antioxidant enzymes and decreased sensitivity to some of the fungus. The effects of silicon on seed germination and growth of the bean (*Vicia faba* L.) were investigated. The seeds of plant were treated by 0 (as control), 1.5 and 3 mM of sodium silicate and silica nanoparticles. There were three repeats for all treatments. The test results showed that seeds treated with sodium silicate concentration of 3 mM significant difference in the percentage of germination than the control no significant difference in the rate of germination of seeds treated compared to control was observed. Hypocotyl length and the flowering of all treated plants were significantly different compared to control. The highest flowering in plants treated silica nanoparticles was observed at a concentration of 1.5 mM. Only plants treated silica nanoparticles with a concentration of 3 mM significant difference in diameter than the control plants. According to the test results can be deduced the effect of silicon nanoparticles in the form of sodium silicate and silica increases the percentage of germination and growth of broad bean.

Keywords: Nano silica - Sodium silicate - Growth - Seed germination - *Vicia faba*.

[**Cite as:** Roohizadeh G, Majd A & Arbabian S (2015) The effect of sodium silicate and silica nanoparticles on seed germination and some of growth indices in the *Vicia faba* L. *Tropical Plant Research* 2(2): 85–89]

INTRODUCTION

Vicia faba L. is an annual plant of family *Fabaceae* with 80–110 cm height. The flowers of broad bean are white with black or purple spots. The seeds are sheathed and the fruits, seeds and flowers have medical usages. *Vicia faba* L.is hetero fertilized with 2n=12. Because of possessing of high percentage of proteins (30−34%) it is an important crop. After oxygen, silica is the second structural element in the earth which is non-mobile in the plants. Although silica is not necessary for plants, higher plants need it to have optimum growth (Richmond & Sussman 2003, Ma *et al*. 2004, Currie & Perry 2007). The most effect of silica on plants, is related to the resistance against biotic and abiotic stress (Ma & Yamaji 2006, Liang *et al*. 2007). As the cell wall of plants prevents the entrance of elements into cells, the Nano particles which have less diameter than the pores of cell wall, therefore can easily cross the pores. Nano particles in the leaves's surface enter the plants through the stomata and or base of hairs and is then transported to the different organs (Nair *et al*. 2010). Silica plays important role in the tolerance against salt stress (Zhu *et al*. 2003), manganese toxicity (Shi *et al*. 2005), boron toxicity (Gunes *et al*. 2007) and cadmium toxicity (Vaculik *et al*. 2009, Shi *et al*. 2010) via changing the activity of antioxidant enzymes. This study the effect of sodium silicate and silica nanoparticles on seed germination, hypocotyle length, stem diameter, and amount flowering of the broad bean is done.

MATERIALS AND METHODS

In order to assess ment the effects of silica nano particles and sodium silicate, on seed germination of broad bean (*Vicia faba* L.), the samples were grown in greenhouse. Before cultivation, the impact seeds were sterilized in 5% hypochlorite sodium solution. The seed then were washed up by deionised water. In each pot 2 seeds were cultivated. Solution containing 0 (as control), 1.5 and 3 mM of nano particle of silica and sodium silicate,

Received: 10 March 2015 Published online: 30 June 2015

were used in the experiment. The temperature of greenhouse was adjusted to 22±2 °C (at night) and 25±2 °C (at day). The relative humidity was 44%. The samples were treated for 65 days. SPSS Ver.16 was used for comparing of the means using Duncan test at P<0/05, level of significance. The diagrams were plotted using Excel software.

RESULTS

Percentage of seed germination

The results showed that the changes in Vicia faba seed germination, seed germination, but at a concentration of 3 mM sodium silicate plants treated with control plants showed no significant difference. The germination of seeds of plants treated silica nanoparticles with a significant difference in the concentration of 3 mM sodium silicate treated plants (Fig. 1A).

Germination rate

The results showed that the changes in germination rate of seeds germination rate in all treated plants compared to control plants was reduced, but the reduction in the level of P <0/05 was not significa. The lowest rate of germination of seeds treated with sodium silicate concentration of 3 mM, respectively (Fig. 1B).

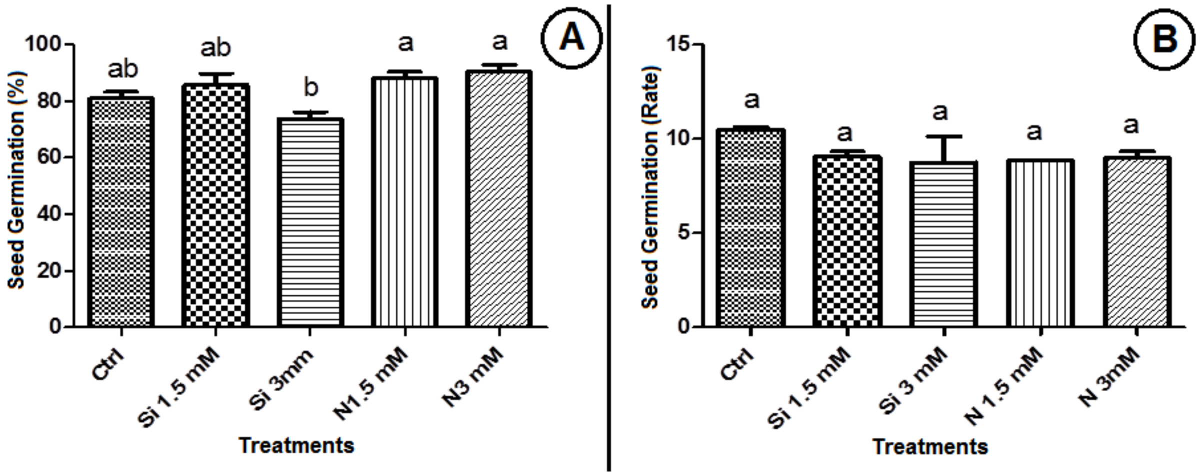

Figure 1. The effect of sodium silicate and silica nanoparticles on germination: **A**, Percentage of germination; **B**, Seed germination rate. (Means ± SE and P< 0.05)

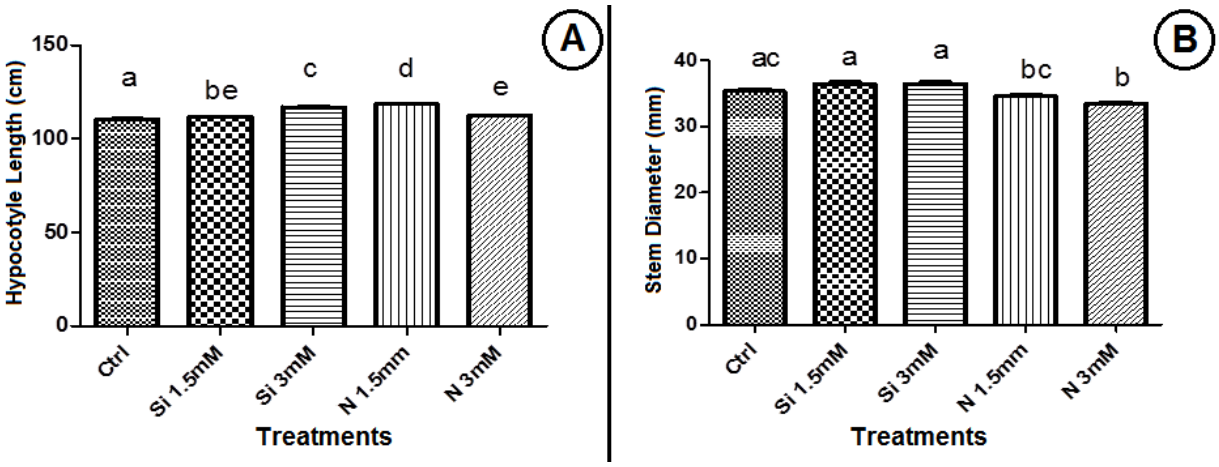

Figure 2. The effect of sodium silicate and silica nanoparticles on hypocotyl: **A**, Hypocotyl length; **B**, Stem diameter. (Means ± SE and P < 0.05)

Hypocotyl length

The results showed that the hypocotyls hypocotyls axis length changes in the concentration of silicon and silica nanoparticles was significantly different from controls and the concentration of silicon and silica nanoparticles were significantly increased during the hypocotyls. The most length of the hypocotyls of plants treated with a concentration of 1.5 mM silica nanoparticles as compared to the control. Between plants trated with different concentrations of silicon 1.5 mM silica nanoparticles with a concentration of 3 mM, no significant differences were observed (Fig. 2A).

Stem diameter

Study results showed that Stem diameter silica nanoparticles stabilization period, hearts treated plants only 3 mM significant difference in Stem diameter than the control. The plants treated with concentrations of 1.5 and 3 mM sodium silicate significant difference from plants treated silica nanoparticles with a Stem diameter of 1.5 and 3 mM showed Highest and lowest Stem diameter of the treated plants at a concentration of 3 mM sodium silicate and silica nanoparticles with a concentration of 3 mM compared to control plants (Fig. 2 B).

The amount of Bolting

The results are significant differences in the rate of flowering in plants treated with concentrations of 1.5 and 3 mM sodium silicate and silica nanoparticles as compared to the control the amount flowering in all treatments was higher than control. The increasing concentration of 1.5 mM or nanosilica flowering of treatment (Fig. 3).

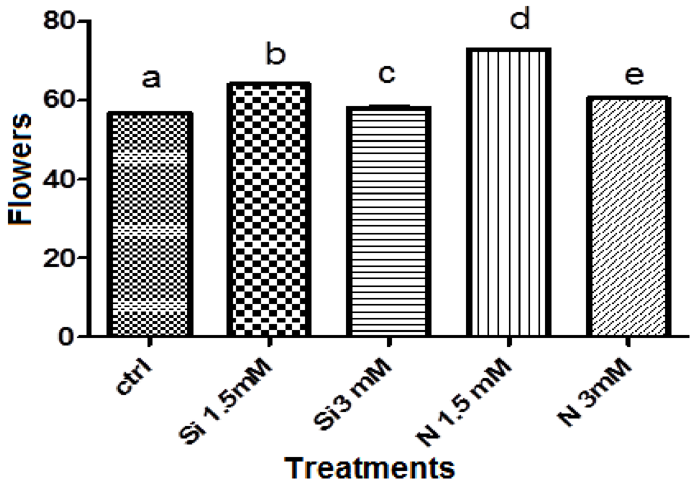

Figure 3. The effect of sodium silicate and silica nanoparticles the amount of Bolting. (Means ± SE and $P < 0.05$)

DISCUSSIONS

Germination and seedling establishment of the most critical stages in the life cycle of the plant is The most important stages of germination, including water absorption, enzymatic activity, the growth of the embryo, seed coat and tears seedling emergence is the results of the experiments, the researchers suggest that chemical treatments can stimulate seed germination in many species of plants. Zhu *et al*. (2010) reported calcium, gibberellic acid, ascorbic acid, ethanol to speed up germination and Mohammadi *et al*. (2009) described the effect of salysyk acid and gibberellic acid on seed germination rate of lentil. The positive effects silicon attributes tomato plant germination (Haghighi *et al*. 2012) and soybean (Li *et al*. 2004) have also been reported. Mozaffarian *et al*. (2011) & Manzer *et al*. (2013) demonstrated that silica nanoparticles improve seed germination in tomato plants. Increased percentage of soybean germination by combining nanoparticles of silicon and titanium has also been observed (Lu *et al*. 2002) this study, the addition of silicon to form sodium silicate and silica nanoparticles become improves seed germination.

Effects of sodium silicate and silica nanoparticles on growth indices

The present study, reported that the use of silicon improves the growth of root, stem and leaves plant. This effect may be due to the prominent role of silicon in improving plant water status (Romero-Aranda *et al*. 2006). The benefits of using silicon indirect effects such as increased capacity and efficiency of photosynthesis, transpiration and thus reduce shoot growth related (Liang 2003). Samuels *et al*. (1993) showed that in the presence of silicon increases plant growth by improving the mechanical strength of stems and leaves on light absorption and photosynthetic capacity of the plant is increased. Kamindiou *et al*. (2010) observed the effects of silicon on morphological characteristics and growth of gerbera flowers in the greenhouse cultivation, and the positive effects of the use of silicon as the medium Na2Sio3 the plant height, the thickness of the shoot the size flowers flowering reported. Reezi *et al*. (2009) found that adding 50 mg^{-1} potassium silicate or nutrient Hot Lady

Rose cut increases the number of flowers. The results of our study showed that the use of sodium silicate and silica nanoparticles increases the length of the hypocotyl, stem diameter and the amount of Bolting of the *Vicia faba*.

CONCLUSION

The results of this study, sodium silicate and silica nanoparticles can affect the germination of seeds. Thus, in cases such as seeds that grow with the problem of different concentrations of these substances can be used to facilitate and accelerate the germination of seeds and increase the efficiency of their applications. It can also be used these to help plant growth and ultimately better performance.

ACKNOWLEDGEMENTS

The authors are thankful of all laboratories personnel Mahmoodieh Islamic University Tehran North Iran, who contributed to this research.

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