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Effect of Silicon on vegetative and generative performance of Broad Bean (*Vicia faba* L.)

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ABSTRACT: Broad Bean (*Vicia faba* L.) belongs to Leguminosae family. Its center of origin is west southern of Asia and as a winter crop is growing in wide level from tropical regions having moderate winter to high elevations (higher than 1200 m from sea level). In order to evaluate the effect of Silicon (Si) element on growth and development of Broad bean in a calcareous soil was conducted an experiment in completely randomized design by 4 treatments and 3 replications. The evaluated treatments were consisting: 0, 5, 10 and 15 mg Si Kg^{-1} soil as Sodium Silicate. After operating the treatments, were measured the characteristics such as day to flowering, flower number, pod weight, seed number, plant fresh weight, plant dry weight and chlorophyll index. The best results were observed in application of 15 mg Si.

***Keywords*:** Broad bean, Silicon, Calcareous soil.

INTRODUCTION

Broad bean is a cross pollination plant, which has about 30-45% cross pollination and the insects play main role in its pollination (Sarparast, 2006). This plant in Middle East, China and even regions of Europe and Australia has special place in feeding of human and animals as a protein source. Area under cultivation of Broad bean in Iran is about 30,000 ha, which the main regions of its production are Golestan, Khuzestan, Mazandaran and Guilan provinces and regards to population enhancement and reduction of availability to other protein sources, demand for this plant is increasing (Majnoon-Hosseini, 1993). Golestan province with more than 35% area under cultivation and 10308 $kgha^{-1}$ green pod in irrigation system is counted the largest Broad bean producer in Iran (Sabbaghpour, 2004). Broad bean with itself alternative influence lead to encourage and chemical and biological fertility of soil and in this regard is a suitable plant. Also, regards to its growing in winter, there is possibility using of precipitations. This plant has high nutritive value and can be used in human food ration and compensates deficiency of animal proteins. Furthermore, there is its export possibility to the margin Persian Golf countries and external markets due to its proper storage property (Mivechi-Langroodi *et al*., 2000). To achieve Broad bean to maximum yield, existence the required and the balanced nutrient elements is necessary in root dispersion environment (Kazemi *et al*., 2007). In Broad bean culturing, chemical fertilizers are added to the field before planting stage and complete chemical fertilizers containing equal N-P-K are suitable for it (Daneshvar, 2006). Silicon (Si) is an element that is sited in fourth group and third period of Mendeleev's table. It has been known as the reducer of toxic effects of some heavy elements and is causing to mobility of phosphorous in soil and has positive influence on plant photosynthesis. Although Si is not a necessary element in plant nutrition but have been reported many its useful effects in the plants. Si can be play effective role in increasing yield and improvement quality of different crops. Si is fourteenth element of Mendeleev's table and after oxygen is the most abundant element in earth's crust. Availability of Si for the plants is depending to rate of aerating minerals. In the minerals like quartz that are very resistant to aerating, Silicon is completely non-absorbable. There is Silicon in soil solution as Silicic acid molecule (H_4SiO_4) in pH<9 and in the higher pHs find as Silicate ion. Silicic acid concentration in soil solution is controlling via surface absorption reactions by iron and aluminum oxides, which is depending to soil pH. In acidic soils Si concentration in soil solution is higher and by application of lime is usually reducing Si uptake in the plant. There is Si in soil at three forms: 1) Si in the solid phase that is in the structure of clay minerals and amorphous silicates, 2) the surface absorbed Si, and 3) Si in the soil solution that is as Silicic acid. The surface absorbed Si is the quickest soluble Si provider source. Formless Silicates are the most important primary source to provide the required Si for plant (Saleh and Najafi, 2011). Investigations have been showed that Si has important role in enhancement of plant tolerance against salinity (Marschner, 1995). Si protects plant tissues against saline toxicity by increasing the anti-oxidant enzymes and by chlorophyll enhancement increases leaf area, photosynthesis, growth and yield of the plant in the saline conditions (kaya *et al*., 2006). Si increases water use efficiency (Gao *et al*., 2004).Si accumulates in epidermis cell wall in both leaf surfaces and consequently reduces loss of water from cuticle. Also it prevents from vessels collapsing when transpiration is high. In addition, Si reduces plant transpiration intensity (Gao *et al*., 2006). On of the usefulness of Si application is increasing tolerance of some plant species against toxicity of heavy metals (Savanat *et al*., 1997). Si settles into endoderm and occasions reduction transferring Cadmium via apoplast or free space between cell (Liang and Rohmeld, 2005). In an experiment on yield of different Broad bean cultivars was demonstrated that the cultivars of 'Zohre' with 1797 $kgha^{-1}$, 'Dashtestan' with 1718 $kgha^{-1}$, 'Barekat' with 1473 $kgha^{-1}$, Algerian with 1412 $kgha^{-1}$ and 'Shami' with 1407 $kgha^{-1}$ had the highest yield respectively in Boushehr township but they had no significant difference to control cultivar (Dashtestan) (Mivechi-Langroodi, 1994). In the other study, was evaluated the effect of Si and salinity on yield and yield components of purslane (*Portulaca oleracea* L.) seed. The results showed that application of Si had significant positive influence on total seed weight, branches and total seed yield but had no significant influence on dry weight of leaf and stem. Also was explained that could be use Si as a useful element for increasing the yield of agronomic plants and their resistance to environmental stresses (Rahimi *et al*., 2010). Mohaghegh *et al*. (2010) in evaluation the effect of Si on growth and yield of cucumber found that application of Si caused to increasing the concentration of Si in root and shoot. Also root and shoot dry weight, root length and plant height in the treated plants by Si significantly ($p<0.05$) increased comparison with the untreated plants.

MATERIALS AND METHODS

In order to evaluate the effect of Silicon element on growth, development and yield of Broad bean (Vicia faba L.), was performed an experiment in Borazjan township, Boushehr province, Iran in winter of 2012. Duration of this study was 130 days and was done in completely randomized design by four treatments and three replications. At first, were selected twelve 5-kg pots and the pots filled by the soils that had been measured its physical and chemical properties and were sown two seeds in each pot. To provide N-P-K were added 80 mg P and K Kg^{-1} soil from fertilizers of potassium sulfate and triple super phosphate respectively and 100 mg N Kg^{-1} as urea, equal to the pots. Then the treatments were added to the pots consist 0, 5, 10 and 15 mg Si Kg^{-1} soil from sodium silicate. Finally, the traits of day to flowering, number of flower, average of pod weight and seed number were measured. In the end of the experiment, the obtained data was analyzed by SPSS software and the means were compared by Duncan's multiple range test (DMRT) and the most suitable treatment was distinguished for growth and development of Broad bean plant.

RESULTS AND DISCUSSION

Results

Day to flowering (DTF)

Based on the results of table 1, influence of Si element was not significant on the number of day to flowering. However, the concentration of 10 mg Si Kg^{-1} with 95 day had the highest DTF than control treatment and other levels of Si.

Number of flower

Different levels of Si had significant effect on the number of flower so that by increasing Si level from Si_0 to Si_{15}, the number of flower increased. Flower number in control treatment (57.3 flowers) reached to 128.0 flowers in Si_{15}. In Si_{15} was observed significant enhancement in the number of flowers than other concentrations.

Table 1. Effect of different concentrations of Silicon on the generative properties of Broad bean

Silicon	Si0	Si5	Si10	Si15
traits	$mgKg^{-1}$ soil			
Day to flowering	†88.3^{a}	88.7^{a}	95.0^{a}	84.0^{a}
Flower number	57.3^{c}	88.7^{b}	92.3^{b}	128.0^{a}
Average pod weight (g)	5.83^{b}	12.00^{a}	14.33^{a}	11.33^{ab}
Average seed number	1.3^{b}	2.7^{a}	2.3^{ab}	2.3^{ab}

† Means in each row with same letter are not significant ($p<0.05$) different according to DMRT.

Average pod weight

There was significant different between various concentrations of Silicon in relation to pod weight so that by increasing Si level from Si_0 to Si_{10}, the weight of pod significantly increased. Pod weight in control treatment (5.83 g) increased to 14.33 g in Si_{10}. Although Si_{15} reduced the weight of pod but this enhancement was not significant.

Average seed number

According to the results of table 1, was observed significant different between various levels of Si in relation to seed number. The number of seed significantly increased by enhancement Si level from Si_0 to Si_5. Seed number in control treatment (1.3 seeds) increased to 2.7 seeds in Si_5. The number of seed non-significantly decreased in concentrations of Si_{10} and Si_{15}.

Plant fresh weight (PFW)

As has been showed in the table 2, different concentrations of Si had significant different influence on plant PFW so that PFW significantly decreased by enhancement Si level from Si_0 to Si_5. PFW in control treatment (172.33 g) reached to 75.33 g in Si_5 and again PFW significantly increased in Si_{10} and Si_{15} and reached to 121.66 and 130.00 g in Si_{10} and Si_{15}.

Plant dry weight (PDW)

The results of table 2 indicate that there was significant difference between different concentrations of Si in relation to PDW. Plant dry weight significantly decreased by enhancement Si level from Si_0 to Si_5. PDW in control treatment (102.33 g) reached to 35.33 g in Si_5 and again PDW significantly increased in Si_{10} and Si_{15} and reached to 43.33 and 50.33 g respectively.

Table 2. Effect of different concentrations of Silicon on the vegetative properties of Broad bean

Silicon	Si0	Si5	Si10	Si15
traits	$mgKg^{-1}$ soil			
Plant fresh weight (g)	$^{\dagger}172.33^{a}$	75.33^{c}	121.66^{b}	130.00^{b}
Plant dry weight (g)	102.33^{a}	35.33^{c}	44.33^{bc}	50.33^{b}
Chlorophyll index	27.5^{c}	33.7^{b}	37.8^{ab}	42.8^{a}

† Means in each row with same letter are not significant (p<0.05) different according to DMRT.

Chlorophyll index

Different concentrations of Si had significant influence on chlorophyll index so that chlorophyll index significantly risen by increasing Si level from Si_0 to Si_{15}. Chlorophyll index in control treatment (27.5) reached to 42.8 in Si_{15}. There was significant difference between Si_{15} to Si_0 and Si_5 but difference between Si_{15} and Si_{10} was not significant.

Discussion

Regards to the obtained results, the lowest day to flowering was observed in the concentration of Si_{15} (84.0 days). It seems application of 15 mg Si Kg^{-1} soil is the best treatment for early flowering of Broad bean plant. Rahimi *et al*, (2010) also reported that can be used Si as a useful element for increasing the yield of agronomic plants and their resistance to environmental stresses. In relation to the number of flower, the highest flower number obtained from the levels of 15 mg Si Kg^{-1} soil. The greatest weight of pod was observed in 10 mg Si Kg^{-1} soil. Sarparast, (2002) in evaluation the correlation of traits in 8 Broad bean cultivars realized that there was positive significant correlation between yield and seed number in the pod (0.4) and the correlation between 100-seeds weight and pod number was negative significant. In the other investigation, Sarparast, (2004) reported that Barekat cultivar with 19.8 cm and 136.0 g produced the highest pod length and 100-seeds weight respectively, whereas Dashtestan cultivar with 89.9 g and 17.7 cm had the least 100-seeds weight and pod length. In evaluation of characteristics correlation was observed negative highly significant correlation (-0.420 and -0.650) between pod number with seed numbers in pod and 100-seeds weight, so that correlation between sees number in pod and yield was positive significant (0.560).

The highest seed number in the pod was observed in 5 mg Si Kg^{-1} soil. It seems increasing the concentration of Silicon had been negative effect on seed number. However other researcher such as Saleh and Najafi (2011) and Savanat *et al*, (1997) reported that sufficient Silicon lead to increase of seed number in the agronomic plants. In fact, accumulation of Si in cell walls of xylems increases resistance of the plant against verse. Besides, Silicon accumulates in endodermic cells of the root and increases the resistance of the plant against diseases agent.

Plant fresh and dry weigh in control treatment (Si_0) was the greatest amount (172.33 and 102.33 g) and in 5 mg Si Kg^{-1} soil was the least amount (75.33 and 35.33). Enhancement Silicon concentration decreased fresh and dry weight of the plant. Saleh and Najafi (2011) on rice demonstrated that application of Si had the positive influence on photosynthesis rate and yield production. Mohaghegh *et al*. (2010) also reported that root and shoot dry weight, root length and shoot height of cucumber plant increased by application of Silicon element, which does not conform to the results of present study. Utilization of 15 mg Si Kg^{-1} soil increased chlorophyll index, which is according to the findings of Kaya *et al*. (2006). They explained that Si protects plant tissues against saline toxicity by increasing the anti-oxidant enzymes and by chlorophyll enhancement increases leaf area, photosynthesis, growth and yield of the plant in the saline conditions. Generally, regards to the obtained results in the present study can be concluded that the best results were observed in application of 15 mg Si Kg^{-1} soil.

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