Journal of Medicinal Plants Research Vol. 6(10), pp. 1896-1901, 16 March, 2012
Available online at http://www.academicjournals.org/JMPR
DOI: 10.5897/JMPR11.1307
ISSN 1996-0875 ©2012 Academic Journals

Full Length Research Paper

Effect of exogenous silicon on germination and seedling establishment in *Borago officinalis* L.

Firoozeh Torabi[1], Ahmad Majd[1] and Shekoofeh Enteshari[2]*

[1]Department of Biology, Faculty of Science, Tarbiat Moalem University, Tehran, Iran.
[2]Department of Biology, Payame Noor University, 19395-4697-Tehran, I. R. of Iran.

Accepted 16 January, 2012

Borage (*Borago officinalis L.*) is a valuable medicinal plant with a high content of gamma linolenic acid. Seed germination and early seedling growth are critical stages for plant establishment and production. One of the major problems in the field of plant cultivation and production of this plant is low and uniform seed germination. Thus in this experiment, the influences of exogenous silicon concentration during germination and early seedling growth was evaluated. Treatments were 7 levels of silicon (0, 0.2, 0.5, 0.7, 1, 1.5, 2 mM Na_2Sio_3) in 4 replicates. The results showed that different treatments of silicon had considerable effect on the germination rate (GR), germination index (GI) and seedling growth of borage. The highest germination percentage was obtained at 1.5 mM silicon and the total dry and fresh weight of seedling was increased. Result of this experiment is consistent with the hypothesis that silicon has a priming effect and can prepare a suitable metabolic reaction in seeds and improve seed germination performance and seedling establishment.

Key word: *Boragoofficinalis* L., seed germination and seedling growth.

INTRODUCTION

Borage (*Borago officinalis* L.) is an annual herbaceous plant and native to Europe, North Africa, and Asia Minor. It is an important vegetable crop which cultivated in some countries including Iran. Borage has been the subject of increasing agricultural interest because of the potential market for the gamma linolenic acid (GLA), an unusual, valuable fatty acid extracted from the seed. The oil content of the seed is 30 to/40% by weight, of which 20 to/30% is GLA. Borage oil with GLA levels greater than 20% commands a premium price (Gupta and singh, 2010).

One of the most important problems in the field of cultivation and production of this plant are little and non-uniform germination (Gupta and singh, 2010). Another problem in developing countries is the heterogeneity and lack of suitable conditions in soil that causes decrease in germination percentage, heterogeneous emergence, unbalanced seedling growth and competition for environmental resources, such as light, nutrients and water. Subsequently, this makes difference in biomass and plant species performance (Sedghi et al., 2010).

One of the methods that can overcome to this problem is seed preplanting treatments called priming that include water absorption at enough level to begin germination events that is accomplished by the subsequent drying. The purpose of priming is increasing germination percentage, decreasing mean of germination time and improving growth and vigor of seedling at very wide favor and unfavored environmental conditions. This method is successful in small seed plants and the most medicinal plants that have great economic value with quick and uniform emergence requirement (Sedghi et al., 2010).

Silicon is the second most abundant element in soil, it is not considered to be an essential element for higher plants. However, there is increasing evidence that it has a number of beneficial effects on plant growth under biotic and abiotic stress (Epstein, 1994). However, little research had been devoted to the role of exogenous silicon on seed germination.

The aim of this study was to evaluate different concentrations of Si, for beneficial (or detrimental) effects to seed germination of borage.

*Corresponding author. E-mail: sh_enteshari@yahoo.com.

Table 1. Effects of exogenous silicon on germination percentage, germination rate, germination index and vitality in *B. officinalis* L.

Treatment	Germination percentage	Germination rate	Germination index	Vitality index
S0=Si (0 mM)	31.25[cd]	1.0298[cd]	1.9375[bc]	12.6594[d]
S1=Si (0.2 mM)	40[c]	1.2658[bcd]	2.675 b[c]	23.2656[bcd]
S2=Si (0.5 mM)	32.5[cd]	0.9577[d]	2.35[bc]	24.125[bc]
S3=Si (0.7 mM)	41.25[c]	1.652[bc]	2.3875[bc]	24.45[bc]
S4=Si (1 mM)	52.5[b]	2.4125[a]	2.9625[b]	27.8812[b]
S5=Si(1.5 mM)	62.5[a]	1.9305[ab]	4.1625[a]	49.0062[a]
S6=Si (2 mM)	26.25[d]	0.8675[d]	1.675[c]	15.5438[cd]

The lower case alphabet means significant difference at 0.05 levels.

MATERIALS AND METHODS

Seeds of borage were obtained from the Pakan-bazr Company in Iran. In this experiment *B. officinalis* L. seeds were used to study the germination characteristics. Seeds with uniform size were surface sterilized with 5% (w/v) sodium hypochlorite for 15 min, and rinsed four times thoroughly with distilled water. The seeds were placed in 9 cmglass petri dishes on a layer of filter paper (Whatman # 41). Twenty five seeds were placed in each petri dish. The petri dishes were irrigated with seven different silicon solutions consisted of 0 (control), 0.2, 0.5, 0.7, 1, 1.5 and 2 mM of Na_2Sio_3 (Sigma).

The Petri dishes were placed in a germinator at 27 ± 1°C. The experiment was designed by using a randomized complete block design with four replicates. Seed germination was recorded daily up to day 14 after the start of the experiment. A seed was considered germinated when radicle emerged by about 2 mm in length. Thelength of radicle, the length ofhypocotyl was determined after culturing for 14 day. At the same time, the fresh weight wasdetermined. To determine the seedling dry weight, seedlings that produced in each petri dish were driedatoven in 70°C to a constant weight and then weighed.

From the germination data collected, we calculated the following variables:

1. Germination percentage (%) = (number of germinated seeds/number of seeds per sample) × 100.
2. Germination index (GI) = ∑ (Gt/Dt), where Gt is the number of germination at time tand Dt represents the corresponding day of germination.
3. Vitality index (VI) = S × GI, where S is the length of seedlings.
4. Germinationrate (GR) = X1/Y1 + (X2 - X1)/Y2+…+ $(X_n - X_{n-1})/Y_n$, where X_n is the number of germination on the nth day and Y_n is the number of day from first day experiment.

RESULTS

Seed germination at different concentrations of silicon solution

Different Si concentration was evaluated to determine which one was beneficial effect on germination. As shown in Table 1, germination rate (GR), germination index (GI) and vitality index (VI) in the addition of different Si concentrations treatments has a significant difference with control. GI and VI are two important parameters that reflect the seed quality and the datas were shown in Table 1. When comparing the germination percentages in different Si concentration, the differences were significant at three concentrations of si (1, 1.5, 2 mM si) In the 1 and 1.5 mM concentrations of Si, a significant increase and at 2 mM concentration significant decrease in germination percentages were observed compared to control (Table 1) and the optimal concentration was 1.5 mM Si (Figure 1).

In comparison to control in the 1 and 1.5 mM concentrations a significant increase in germination rate was observed (Figure 2). When comparing the germination index, only at 1.5 mM Si, there was a significant increase in germination index (Figure 3).

There were significant differences in vitality index of borage seed. Significant increases in the four concentrations of Si (0.5, 0.7, 1 and 1.5 Mm) in vitality index were observed compared to control (Figure 4).

With the increasing exogenous silicon treatment concentration, those above indexes started to increase except in S6 treatment (Table 1). These indicated that exogenous silicon could improve the germination characteristics of borage seeds and S5 was the better treatment concentration.

Effects of exogenous silicon on seedling growth

The lengths of radicle, length of hypocotyl and plants fresh and dry weight are also important reference indexes for judging the growth status of plants. So the above morphological indices of plants under different treatments were determined and the datas were shown in Table 2.

Mean of hypocotyl length varied between 6.3125 and 11.75 cm at various silicon concentrations. The longest hypocotyl length was observed in the 1.5 mM Si. There was significant increase in hypocotyl length in comparison to control (Figure 5).

When comparing the length of radicle, only at 1.5 mM Si, a significant increase was observed compared to control (Figure 6).

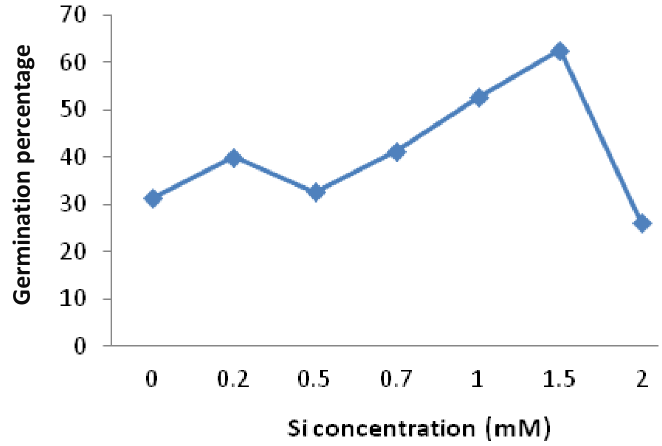

Figure 1. The effect of different silicon levels on germination percentage of seeds of borage.

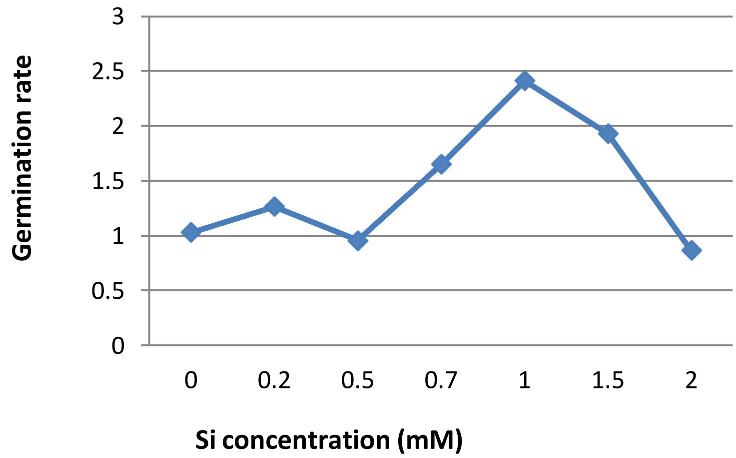

Figure 2. The effect of different silicon levels on germination rate of seeds of borage.

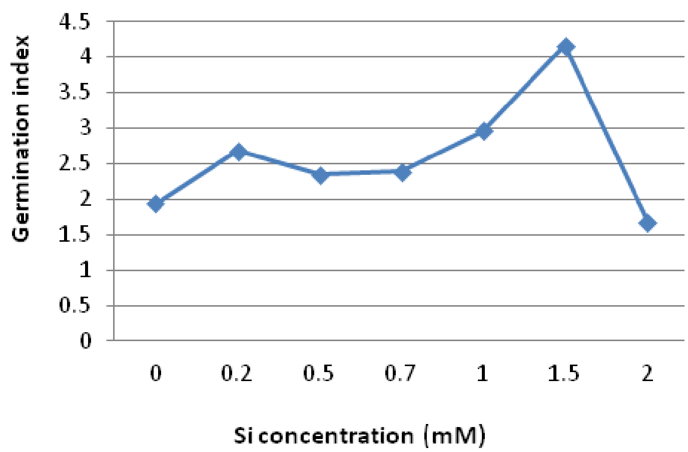

Figure 3. The effect of different silicon levels on germination index of seeds of borage.

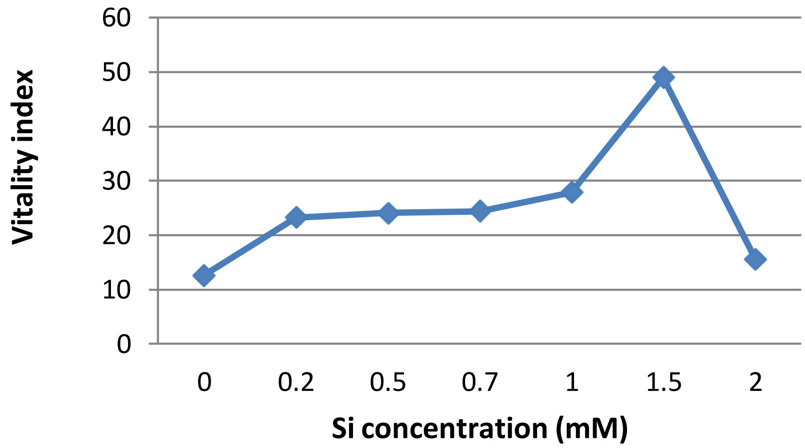

Figure 4. The effect of different silicon levels on vitality index of seeds of borage.

Table 2. Effects of exogenous silicon on fresh weight, dry weight, hypocotyl and radicle length in *B. officinalis* L.

Treatment	Fresh weight(g)	Dry weight (g)	The length of hypocotyl (cm)	The length of radicle (cm)
S0=Si (0 mM)	0.1558[d]	0.0028[de]	6.3125[c]	4.625[b]
S1=Si (0.2 mM)	0.241[bc]	0.0055[bc]	8.6875[b]	6.687[b]
S2=Si (0.5 mM)	0.2925[ab]	0.0039[cd]	10[ab]	7.25[b]
S3=Si (0.7 mM)	0.286[b]	0.007[ab]	10.5[ab]	7.125[b]
S4=Si (1 mM)	0.298[ab]	0.0065[ab]	9.5[b]	5.875[b]
S5=Si (1.5 mM)	0.3572[a]	0.0081[a]	11.75[a]	11.125[a]
S6=Si (2 mM)	0.2142[cd]	0.0011[e]	9.5[b]	5.25[b]

The lower case alphabet means significant difference at 0.05 levels.

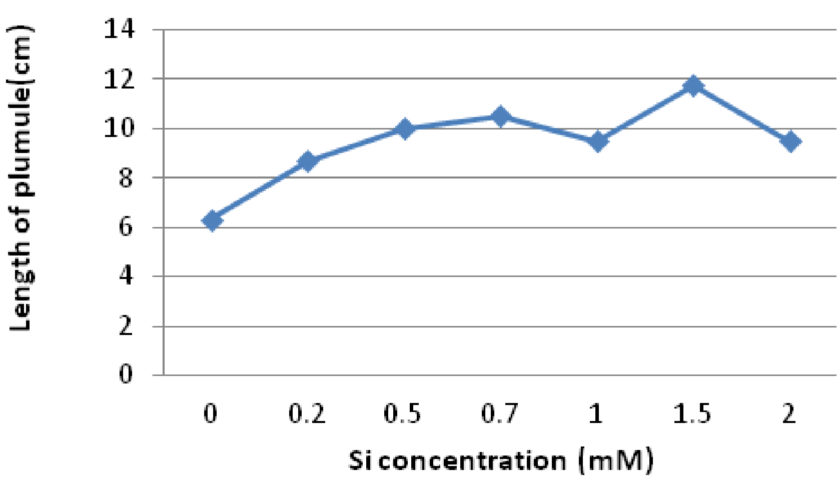

Figure 5. The effect of different silicon levels on the length of plumule of borage.

In comparison to the control fresh weight of seedling were significantly promoted with the exogenous silicon treatment except at 2 mM concentration of Si. The maximum fresh weight of seedling was seen at 1.5 mM Si

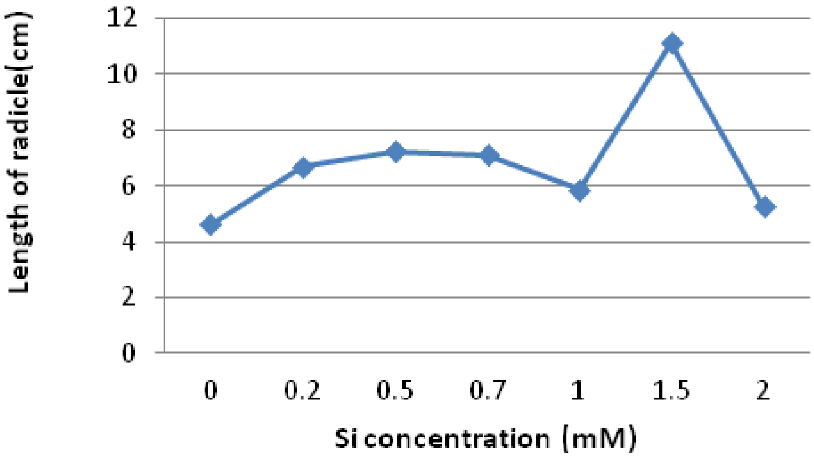

Figure 6. The effect of different silicon levels on the length of radicle of borage.

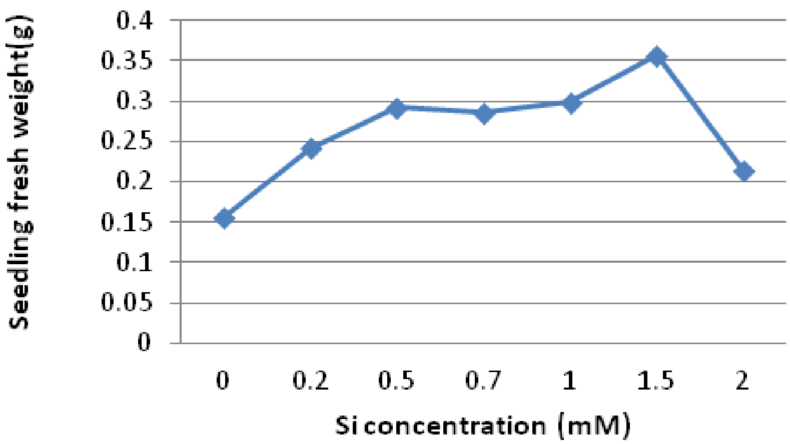

Figure 7. The effect of different silicon levels on seedling fresh weight of borage.

(Figure 7).

Also there were significant differences in dry weight of seedling. At four concentration (0.2, 0.7,1, 1.5 mM Si) significant increases were observed compared to control. The lowest seedling dry matter was observed at 2 mM Si (Figure 8).

DISCUSSION

Chemical treatments can stimulate seeds germination in many plant species. Ca, GA3, H_2O_2, ethanol and ascorbic acid had been reported to increase the seed germination rate. For example, ethanol increased the germination rate of *Crithmum maritimum* seeds by 30% compared to the control (Meot-Duros and Magne, 2008). Ascorbic acid of 40 and 60 mM improved the germination rate by 10 and 30% compared to the control (Meot-Duros and Magne, 2008). In our experiment, the right exogenous silicon treatment concentration had increased the germination rate, germination percentage, germination index, vitality index, the length of radicle and plumule of borage. Makkizadeh et al. (2008) reported that osmopriming of borage seeds by polyethilenglicole, increases the germination index and decreases germination time significantly. In previous reports have been suggested that Si has many positive effects on the growth and yield as well as physiology and metabolism in different plant species (Liang et al., 2003; Ma and Yamaji, 2008). These findings suggested that silicon may be involved directly or indirectly in both morphological changes and physiological processes in plants. Recently, the mitigating role of Si in salt stress has received worldwide attention. In addition, some earlier studies have shown that Si is effective in mitigating salinity in different plant species, such as barley (Liang et al., 2005), cucumber (Zhu et al., 2004), maize (Moussa, 2006), tomato (Romero-Aranda et al., 2006) and wheat (Tuna et al., 2008). There are some

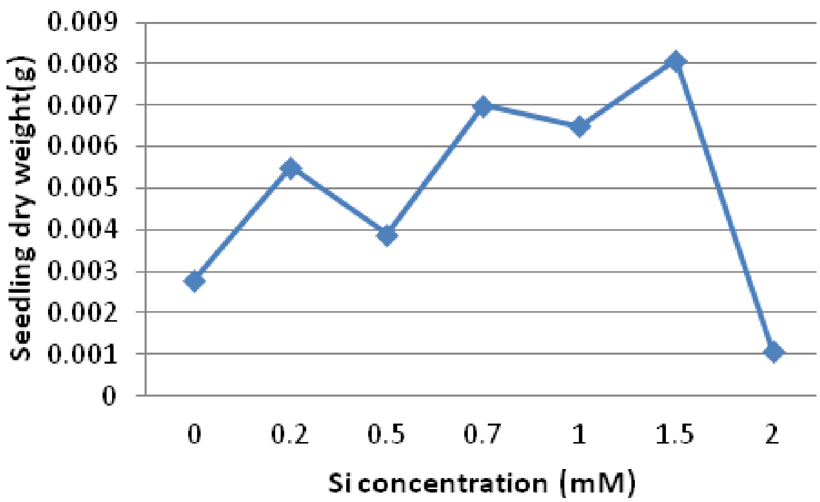

Figure 8. The effect of different silicon levels on seedling dry weight of borage.

reports about a protective role of silicon in seed germination of plant species to prevent them from being severely affected by salt stress (Sedghi et al., 2010) but very little information is available on the effects of silicon on the germination, that will, in some cases, be essential for germination and seedling establishment especially. In addition, more studies are needed to investigate the effects of silicon on seed germination and how they affect the species composition in soil seed banks.

REFERENCES

Epstein E (1994). The anomaly of silicon in plant biology. Proc. Nat. Acad. Sci. U.S.A., 91: 11-17.

Gupta M, Singh S (2010). *Borago officinalis* L. an important medicinal plant of Mediterranean region: A review. Int. J. Pharm. Sci., 5: 005.

Liang YC, Chen Q, Liu Q, Zhang W, Ding R (2003). Exogenous silicon (Si) increases antioxidant enzyme activity and reduces lipid peroxidation in roots of salt-stressed barley (*Hordeum vulgare* L.). J. Plant Physiol., 160: 1157-1164.

Ma JF, Yamaji N (2008). Functions and transport of silicon in plants. Cell Mol. Life Sci., 65: 3049-3057.

Makkizadeh TM, Tavakol-Afshari R, Majnoon- Hosseini N, Naghdi- Badi HA (2008). Evaluation of salinity tolerance and absorption of salt by Borage (*Borago officinalis* L.). Iran. J. Med. Arom. Plant, 24: 253-262.

Meot-Duros L, Mange C (2008). Effect of salinity and chemical factors on seed germination in the halophyte (*Crithmum maritimum* L.). Plant Soil, 313: 83-87.

Moussa HR (2006). Influence of exogenous application of silicon on physiological response of salt-stressed maize (*Zea mays* L.). Int. J. Agric. Biol., 8: 293-297.

Romero-Aranda MR, Jurado O, Cuartero J (2006). Silicon alleviates the deleterious salt effect on tomato plant growth by improving plant water status. J. Plant Physiol., 163: 847-855.

Sedghi M, Nemati A, Esmaielpour B (2010). Effect of seed priming on germination and seedling growth of two medicinal plants under salinity. Emir. J. Food Agric., 22(2): 130-139.

Tuna AL, Kaya C, Higgs D, Murillo-Amador B, Aydemir S, Girgin AR (2008). Silicon improves salinity tolerance in wheat plants. Environ. Exp. Bot., 62: 10-16.

Zhu ZJ, Wei GQ, Li T, Qian QQ, Yu JQ (2004). Silicon alleviates salt stress and increases antioxidant enzymes activity in leaves of salt-stressed cucumber (*Curcumas sativa* L.). Plant Sc., 167: 527-533.