



## The Study of Potassium Silicate effects on Qualitative and Quantitative Performance of Potato (*Solanum tuberosum* L.)

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(Received 28 September, 2015, Accepted 19 December, 2015)

(Published by Research Trend, Website: [www.researchtrend.net](http://www.researchtrend.net))

**ABSTRACT:** Potato is a plant with high nutritional value that is at fifth place after wheat, corn, rice and barley in terms of production and consumption in world. Its production is increased due to high productivity and compatibility with a wide range of climates and as a nutritional source. In this study, silicon effect as a useful element on quantitative and qualitative performance of potato crop was evaluated in form potassium silicate. The experiments were performed in completely randomized block design with 3 replicates and in field conditions. For review was used of the concentration 0, 5mM of potassium silicate in solution and spray forms. The results of comparing mean traits showed significant differences between treatment groups in chlorophyll b, soluble sugars of leaves and carotenoids. Although, it was not observed significant differences between treatment groups in terms of chlorophyll a amount, leaves insoluble sugars and protein, but spraying 5mM potassium silicate showed significant increase in Chlorophyll b amount and soluble sugars.

**Keywords:** potassium silicate, sugar, protein, Chlorophyll, *Solanum tuberosum* L.

### INTRODUCTION

Silicon is the second most abundant element in the earth's surface and is one of the important elements that form clay minerals structure in soils and is known as a useful element for plants (Epstein, 1999). The amount of silicon uptake and collection by plants is variable between 0.1 to 10 percent of dry weight. Today, silicon is not classified as an essential element for plants but its beneficial effects has been observed in a wide range of plant species (Epstein, 1994 & Ma and Yamaji, 2006).

Silicon plays role in growth improvement, photosynthesis increase, efficiency of transpiration and evaporation, increasing the strength of leaves, chlorophyll concentration per leaf area and product quality (Hwang *et al.*, 2005). It seems that precipitated silica on cell wall increases strength and reinforces walls (Inanaga and Okasaka, 1995). Potassium silicate is one of the silicon fertilizers which contain 27% of silicon oxide (Reezi *et al.*, 2009). Silicon is usually absorbed by plant in the form of mono Silicic ( $H_4SiO_4$ ) or acid anion ( $Si(OH)_3$ ) (Lewin, 1953). After silicon absorption, the element transportation in plants is done through vessel element and transpiration flow from roots to shoots (Ma and Takahashi, 2002).

Among absorbed nutrient elements, potatoes absorb potassium more than any other elements and obviously, more harvested potato tubers amount is, the amount of harvested nutrients from soil will be more. Despite plenty of potassium in country soil, the need for

studying soils in which potassium consumption is less than critical level is felt due to need for improved genotypes, potassium depletion from soil and low buffering capacity of soils to supply this element (Nori, 2001). Potassium is involved in almost all metabolic processes of plants. Also, it plays an important role in photosynthesis and production of carbohydrates, restoring nitrate and assist in consuming ammonium ions in manufacturing amino acids and protein synthesis. Also, it is effective on nutrients balance, increased tubers and increased absorption of nitrogen and phosphorus in plants (Khan *et al.*, 1994).

Soil native potassium amount in line with supplying nutrients from fertilizers for demanding crops (requiring more water) is not sufficient for plant's optimal physiological need and requires potassium fertilizer. The role of potassium and its consumption by fertilizers have been approved by countless researchers in many crops. Mangal and Kirkby research results showed that potash fertilizer consumption increases the photosynthesis efficiency, increases tuber size and tuber dry weight (Mengel and Kirkby, 1987).

McDole and Robert confirmed potassium consumption effect on increased root growth at early stages (Roberts and McDole, 1985). Kraus showed that increased potash fertilizer increases tuber dry matter (Krauss, 1999). Hoseinpur proved that potash fertilizer consumption in potatoes enhances performance as well as improves its quality (Hoseinpur, 1993).

Reezi *et al* found that adding 50 mg per liter potassium silicate to Hot Lady nutrients will increase number of flowers (Reezi *et al.*, 2009). According to Moyer *et al* reported that using silicon does not effect on Gerbera flowers increase (Moyer *et al.*, 2010).

According to reports on beneficial effects of silica compounds on improved quality of various plants and nutritional, economic and health importance of potatoes plant, this study was conducted in order to evaluate the effect of potassium silicates on review the plant performance and quality.

## MATERIALS AND METHODS

This study aimed to investigate the effects of potassium silicates on qualitative and quantitative performance of potato in spring of 2014 on a farm in Tabriz city and in a completely randomized block design with three replications. In this study, healthy tubers of Granola potato were used. Tubers were immersed in a solution of 5% sodium hypochlorite disinfectant for 4 minutes when they were washed with tap water and then they were washed with sterile distilled water. Potassium silicate was prepared from Iran Silica Company. Potassium silicate treatments were used in both forms with concentrations of (0 and 5mM) in order to measure photosynthetic pigments, soluble and insoluble sugars of leaves and protein.

### A. Photosynthetic pigments measurement

Measurement of photosynthetic pigments such as chlorophyll a, b and carotenoids was performed using Lichtenthaler method. 0.1g of fresh leaves was gradually rubbed with 80% acetone and the extract was centrifuged for 10 minutes at 10000g round using centrifuges and then, optical absorption of zinc solution was measured using a spectrophotometer at wavelengths of 646, 663 and 470 nm. Chlorophyll content was calculated in milligrams per gram fresh weight using formula (Lichtenthaler and Wellburn, 1983).

Chl. a =  $(12.21 (A_{663}) - 2.81 (A_{646})) \times \text{volume of supernatant (ml)} / 1000 \times \text{sample weight (g)}$ .

Chl. b =  $(20.13 (A_{646}) - 5.03 (A_{663})) \times \text{volume of supernatant (ml)} / 1000 \times \text{sample weight (g)}$ .

Car =  $[(1000A_{470} (1000A_{470} - 3.27[\text{chl a}] - 104[\text{chl b}]) / 227] \times \text{volume of supernatant (ml)} / 1000 \times \text{sample weight (g)}$ .

### B. Soluble and insoluble sugars of leaves measurement

0.1 g of plant dried materials (leaves) was added to 10 ml of Ethanol 70% and was held for a week in refrigerator. Then, 5.0 ml of supernatant samples was taken and was reached to volume of 2 ml and then 1 ml of phenol 5% and 5 mL of concentrated sulfuric acid was added to it. The yellow color was obtained and it was red after half an hour using a spectrophotometer device at a wavelength of 485 nm and sugar sample quantities were measured using standard curves based on mg/ g dry weight.

Remained plant from filtering ethanol solution was dried for 15 minutes at 100°C in oven in order to measure the dissolved sugars, then it was boiled in Erlenmeyer containing distilled water (15 minutes) and its volume became 25 ml using distilled water and finally, 2 ml of this solution was removed and dissolved sugars were determined by phenol-sulfuric acid (Helluburst and Craigie, 1978).

### C. Proteins measurement

0.5 g of leaves was rubbed in 5 ml extraction buffer of Tris glycine (PH = 8.3) in order to achieve homogenous solution. Extract was transferred to centrifuge tube and was centrifuged at 12000g at 4°C for 10 minutes. Concentrations of solved proteins were measured according to Bradford method. Different concentrations of bovine serum albumin protein (BSA) were used in order to draw standard curve of (Bradford, 1976.).

### D. Statistical Analysis

SPSS software was used for data analysis and statistical analysis and Duncan's Multiple Rangetest was used for comparison of data mean in different treatments. Calculating the probability of significant differences was done at P <0.05 level. Diagrams were drawn using Excel software.

## RESULTS

### A. Photosynthetic pigments

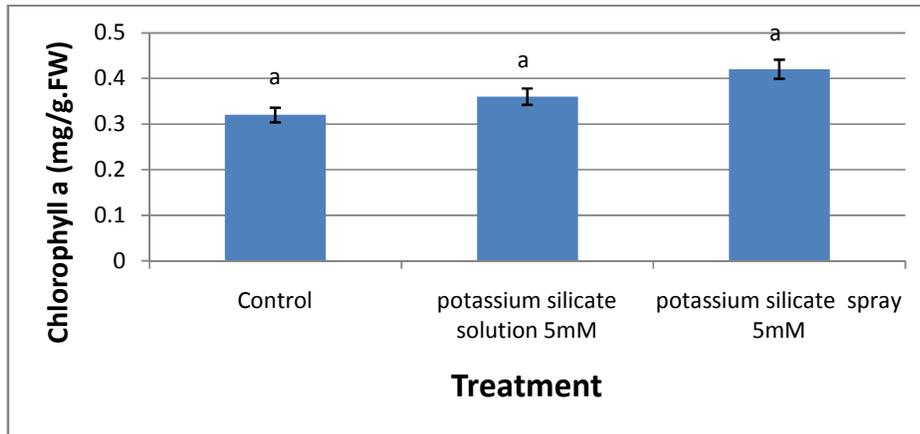
Chlorophyll a index of potassium silicate solution and spray was increased compared to control group but this difference was not statistically significant (Fig. 1).

Chlorophyll b amount difference between treatments was significant at probability level of (P<0.05). Potassium silicate spray 5mM has the highest chlorophyll b. The lowest level of chlorophyll b is related to control group that is not statistically and significantly different from potassium silicate 5mM solution treatment (Fig. 2).

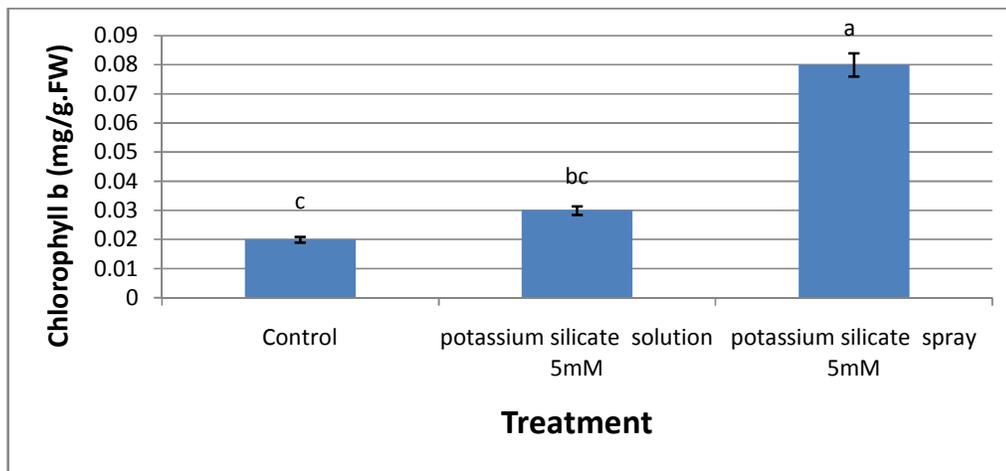
The results showed that potassium silicates statistically has significant effect on carotenoids at probability level of (P <0.05). The highest level of carotenoids was observed in potassium silicates 5mM spray. The control group had the least amount of carotenoids and this difference was significant compared to potassium silicates 5mM spray (Fig. 3).

### B. Soluble and insoluble sugars of leaves

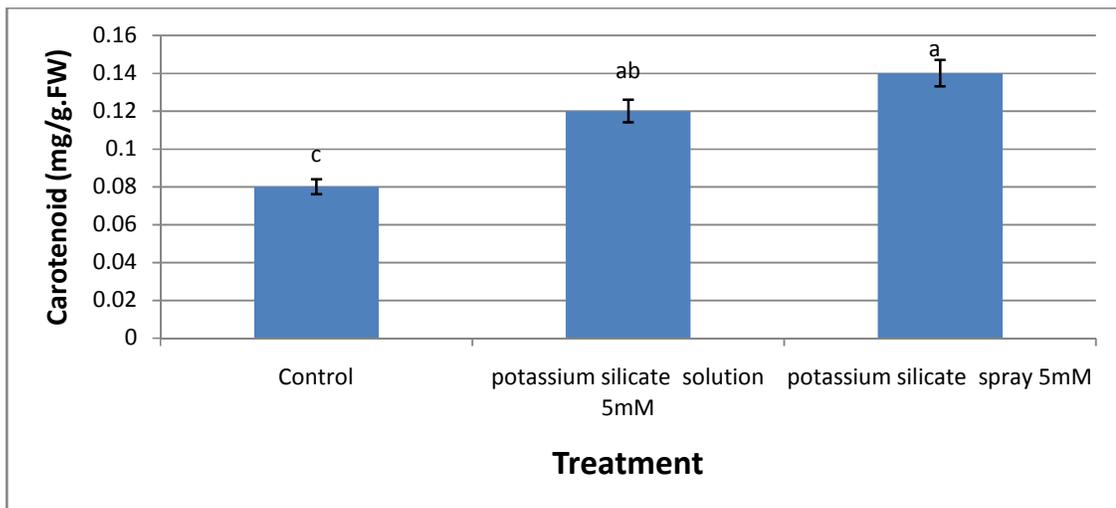
Potassium silicates 5mM solution and spray on soluble sugars showed significant differences at probability level of (P <0.05). So that the maximum amount of soluble sugars was related to potassium silicates 5mM spray treatment, that have significantly different with control group that had the least amount of soluble sugars (Fig. 4). Since the maximum amount of insoluble sugars in leaves was related to potassium silicate spray treatment but it was not significantly different with potassium silicate solution treatment and control groups (Fig. 5).



**Fig. 1.** Average of effects potassium silicate on Chlorophyll *a*. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).



**Fig. 2.** Average of effects potassium silicate on Chlorophyll *b*. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).



**Fig. 3.** Average of effects potassium silicate on carotenoids. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

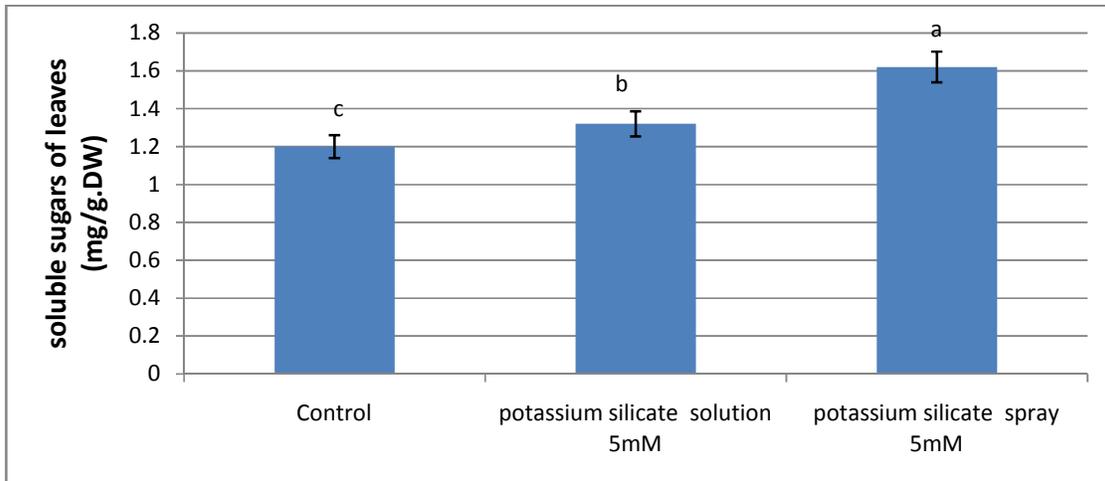


Fig. 4. Average of effects potassium silicate on soluble sugars. The columns which have joint letters have not a significant difference in level of 5%. (Means $\pm$ SE).

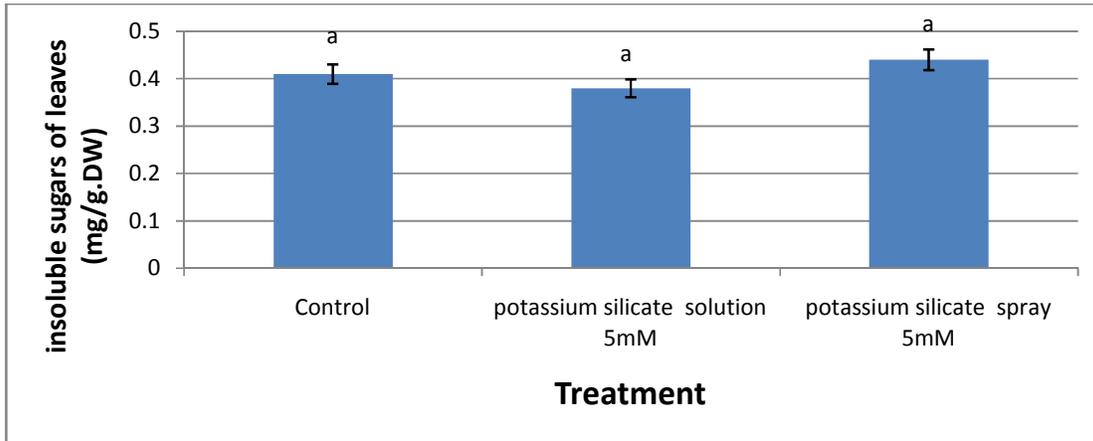


Fig. 5. Average of effects potassium silicate on insoluble sugars. The columns which have joint letters have not a significant difference in level of 5%. (Means $\pm$ SE).

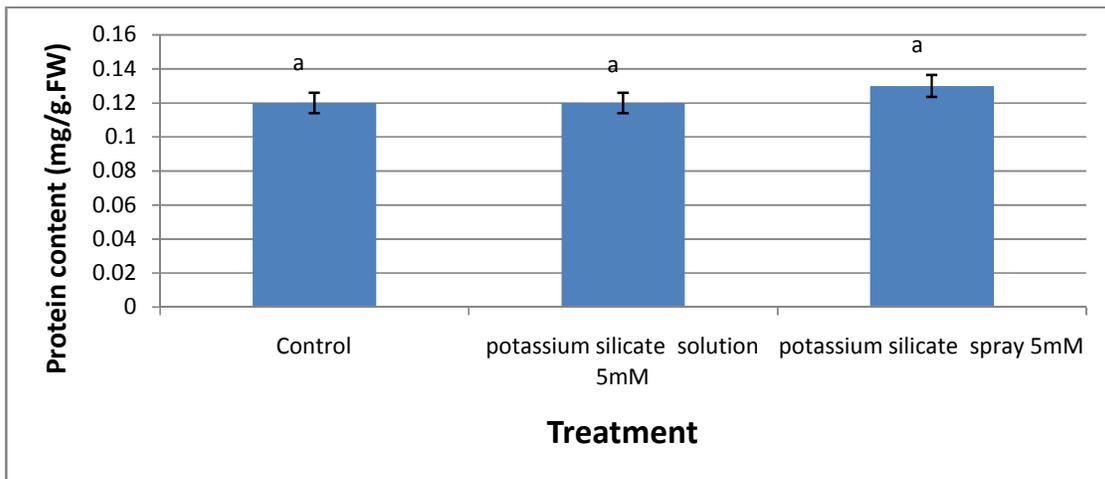


Fig. 6. Average of effects potassium silicate on Protein. The columns which have joint letters have not a significant difference in level of 5%. (Means $\pm$ SE).

### C. Protein

According to findings, potassium silicates effects on protein levels of treatment and control groups was not statistically significant at level of ( $P < 0.05$ ) (Fig. 6).

### DISCUSSION AND CONCLUSION

According to results of present research, potassium silicate concentrations had statistically significant effect on the amount of chlorophyll b, carotenoids and soluble sugars at probability level of ( $P < 0.05$ ). Chlorophyll a amount, insoluble sugars of leaf and protein content did not show statistically significant difference of potassium silicates application.

The results of study using silicon in cucumbers bushes, increased chlorophyll and photosynthetic activity of leaves, reduced petiole length and increased weight gain are consistent with study results (Jung Sup *et al.*, 2000).

Potassium silicates 5mM sprayed treatment showed the highest chlorophyll amount compared to potassium silicates 5mM solution treatment and control groups, but this difference was not statistically significant.

The results of research was consistent with Agarie *et al* study results who showed that when silica is reduced, chlorophyll amount will be low as a result, plant photosynthesis will be reduced. They related the reason for this issue to silica role in photosynthesis chain and preventing chlorophyll degradation by silica (Agarie *et al.*, 1996).

One of the main reasons for chlorophyll decline is its destruction by reactive oxygen species. The reduced activity of photosystem II and Robisko decreased enzyme activity and ATP inhibition increases the formation of free oxygen species in chloroplasts (Lawlor and Cornic, 2002). Since silica plays an important role in leaves upright state and is able to provide more leaf area towards light, thereby increased the plant photosynthesis efficiency (Quanzhi and Erming, 1998).

It was observed in one study that using potassium silicate on sugar cane plant, chlorophyll content, leaf nitrogen and leaf wilt will be increased which correspond with our results (Shinya and Yoshihiro, 2000).

The highest chlorophyll b amount, soluble sugars and carotenoids are related to potassium silicate 5mM sprayed treatment and the least are related to control group. No significant difference was observed between potassium silicate 5mM solution treatment and control in terms of chlorophyll b amount. No significant difference was observed between potassium silicate 5mM solution treatment and potassium silicate 5mM sprayed treatments in terms of measuring carotenoids. The maximum amount of soluble sugars is related to potassium silicate 5mM sprayed treatment. The amount of plants chlorophyll is an important factor in maintaining photosynthetic capacity (Jiang and Haung, 2001).

The results consistent with Nikbakht *et al* results who stated that the highest chlorophyll amount is related to potassium silicate spray (Nikbakht *et al.*, 2013).

According to findings, it seems that in increase amount of chlorophyll b, soluble sugars and carotenoids, potassium silicate 5mM spray will be the best treatment.

Given the importance of potato plant, this study aimed to assess plant responses to potassium silicate effects on potatoes qualitative and quantitative performance.

### REFERENCES

- Agarie, S., (1996). Function of silica bodies in epidermal system of rice (*Oryza sativa* L.). *Journal of Experimental Botany*. **47**: 655-660.
- Bradford, M.M., (1976). A Rapid Sensitive Method for the Quantitation of Micro Program Quantities of Protein Utilizing the Principle of Protein-Dye Binding. *Analytical Biochemistry*. **72**: 248-254.
- Epstein, E., (1994). The anomaly of Silicon in Plant biology. *Proceeding of the National Academy of Sciences of the United State of America* **91**: 11-17.
- Epstein, E., (1999). Silicon. *Annual Review of Plant Physiology and Plant Molecular Biology*. **50**: 641-664.
- Helluburst, J.A., and Craigie, J.S., (1978). *Handbook of Physiological and Biochemical Method*, Cambridge Univ Press.
- Hoseinpour, K., (1993). Effect of potassium on the quantity and quality of potatoes in four regions Iran. M.Sc. Thesis, Faculty of Agriculture, Tarbiat Modarres University. Tehran.
- Hwang, S.J., Park, H.M., and Jeong, B.R., (2005). Effect of potassium silicate on the growth of miniature rose 'Pinocchio' grown on rock wool and its cut flower quality. *Journal of the Japanese Society for Horticultural Science*. **74**: 242-247.
- Inanaga, S., and Okasaka, A., (1995). Calcium and silicon binding compounds in cell walls of rice shoot. *Soil Science & Plant Nutrient* **41**: 103-110.
- Jiang, Y., and Haung, N., (2001). Drought and heat stress injury to two cool season turf grasses in relation to antioxidant metabolism and lipid peroxidase. *Crop Science*. **41**: 436-442.
- Jung Sup, L., Jong Han, P., and Kyeong Suk, H., (2000). Effects of potassium silicate on growth, photosynthesis, and inorganic ion absorption in cucumber hydroponics. *Korean Society for Horticultural Science*. **41**: 480-484.
- Khan, H.R., Elahi, S., Hussain, M.S., and Adachi, T., (1994). Soil characteristics and behavior of potassium under various moisture regimes. *Soil science and plant nutrition*. **40**(2): 234-254.
- Krauss, A., (1999). Quality, its what counts in the market place. International fertilizer Correspondent (IFC). No.5,1-3 Basel, Switzerland.
- Lawlor, D.W., and Cornic, G., (2002). Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants affected by N fertilization. *Agronomy Journal*. **73**: 583-587.

- Lewin, J., (1953). Silicon metabolisms in diatoms. *The Journal of General Physiology*. **32**: 589-601.
- Lichtenthaler, H.K., and Wellburn, A.R., (1983). Determinations of Total Carotenoids and Chlorophylls a and b of Leaf Extracts in Different Solvents. *Biochemical Society Transactions*. **11**: 591-592.
- Ma, J.F., and Takahashi, E., (2002). Soil, Fertilizer and Plant Silicon Research in Japan. *Elsevier Science*, Amsterdam, The Netherlands.
- Ma, J.F., and Yamaji, N., (2006). Silicon uptake and accumulation in higher Plants. *Trends in Plant Science* **11**: 392-397.
- Mengel, K., and Kirkby, E.A., (1987). Principles of Plant nutrition. 4<sup>th</sup> Edition International Potash Institute, Bern, Switzerland.
- Reezi, S., Babalar, M., and Kalantari, S., (2009). Silicon alleviates salt stress. Decrease malondialdehyde content and affects petal color of salt stressed cut rose (Rosaxhybridal.), Hot Lady,. *Afric. Journal of Biotechnology*. **8**: 1502-1508.
- Moyer, C., Peres, N.A., Datnoff, L.E., Simonne, E.H., and Deng, Z., (2010). Evaluation of silicon for managing powdery mildew on Gerbera Daisy. *Journal of Plant Nutrition*. **31**: 2131-2144.
- Nikbakht, A., et al., (2013). The effect of different concentrations of potassium silicate, nano silica and calcium chloride on concentrations of potassium, calcium and magnesium, chlorophyll content index and the number of Asian Lilium flower, Brunello,. Science and Technology of Green house Culture. No:14.
- Nori, A.A., (2001). Study of potassium sulfate and zinc sulfate to improve performance and reduce of cadmium and nitrate of potatoes in Zanjan.MS Thesis. Islamic Azad University, Science and Research Branch, Tehran.
- Quanzhi, Z., and Erming, G., (1998). Effect of silicon application on rice in a rice area along the yellow river. *Department of agronomy*, **32**: 308-313.
- Reezi, S., Babalar, M., and Kalantari, S., (2009). Silicon alleviates salt stress. Decrease malondialdehyde content and affects petal color of salt stressed cut rose (Rosaxhybridal.), Hot Lady,. *Afric. Journal of Biotechnology*. **8**: 1502-1508.
- Roberts, S., and McDole, R.E., (1985). Potassium nutrition of potatoes, In: Potassium in Agriculture (E.d:R.S. Munson). ASA-CSSA, Madison, WI.Pp.800-818.
- Shinya,Y., and Yoshihiro, H., (2000). Some effect of potassium silicate application on photosynthesis of sugarcane. *Journal of Agricultural Science*, Vol. **40**: No.2, p115-121.