Research Journal of Biological Science

MEDWELL PUBLICATIONS

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

[1]Shiva Talebi, [1]Ahmad Majd, [1]Masoumeh Mirzai, [1]Sayeh Jafari and [2]Masoumeh Abedini

[1]Department of Biology, Faculty of Biological Sciences, North-Tehran Branch, Islamic Azad University, Tehran, Iran

[2]Department of Biology, Faculty of Biological Sciences, Tabriz Branch, Payame Noor University, Tabriz, Iran

Key words: Potassium silicate, sugar, protein, chlorophyll, *Solanum tuberosum* L.

Corresponding Author:
Shiva Talebi
Department of Biology, Faculty of Biological Sciences, North-Tehran Branch, Islamic Azad University, Tehran, Iran

Page No.: 64-68
Volume: 15, Issue 3, 2020
ISSN: 1815-8846
Research Journal of Biological Sciences

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 0.5 mM 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 5 mM potassium silicate showed significant increase in chlorophyll b amount and soluble sugars.

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[1]. The amount of silicon uptake and collection by plants is variable between 0.1-10% 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[2, 3].

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[4]. It seems that precipitated silica on cell wall increases strength and reinforces walls[5]. Potassium silicate is one of the silicon fertilizers which contain 27% of silicon oxide[6]. Silicon is usually absorbed by plant in the form of mono Silicic (H_4SiO_4) or acid anion ($Si\ (OH)_3$)[7]. After silicon absorption, the element transportation in plants is done through vessel element and transpiration flow from roots to shoots[8].

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[9]. 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[10]. 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[11] research results showed that potash fertilizer consumption increases the photosynthesis efficiency, increases tuber size and tuber dry weight.

Robert and McDole[12] confirmed potassium consumption effect on increased root growth at early stages. Kraus showed that increased potash fertilizer increases tuber dry matter. Hoseinpur[13] proved that potash fertilizer consumption in potatoes enhances performance as well as improves its quality. Reezi *et al*.[6] found that adding 50 mg per liter potassium silicate to Hot Lady nutrients will increase number of flowers. According to Moyer *et al*.[14] reported that using silicon does not effect on Gerbera flowers increase.

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 nano-silica and 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 min 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 5 mM) in order to measure photosynthetic pigments, soluble and insoluble sugars of leaves and protein.

Photosynthetic pigments measurement: Measurement of photosynthetic pigments such as chlorophyll a, b and carotenoids was performed using Lichtenthaler method. 0.1 g of fresh leaves was gradually rubbed with 80% acetone and the extract was centrifuged for 10 min at 10000 g 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[15]:

Chl. a = (12.21 (A663)-2.81 (A646))×volume of supernatant (mL)/1000×sample weight (g)
Chl. b = (20.13 (A646)-5.03 (A663))×volume of supernatant (mL)/1000×sample weight (g)
Car = [(1000A470 (1000A470-3.27[chl a]-104[chl b])/ 227]×volume of supernatant (mL)/1000×sample weight (g)

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 min at 100°C in oven in order to measure the dissolved sugars, then it was boiled in Erlenmeyer containing distilled water (15 min) 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[16].

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 12000 g at 4°C for 10 min. 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[17].

Statistical analysis: SPSS Software was used for data analysis and statistical analysis and Duncan's Multiple Range test 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 AND DISCUSSION

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

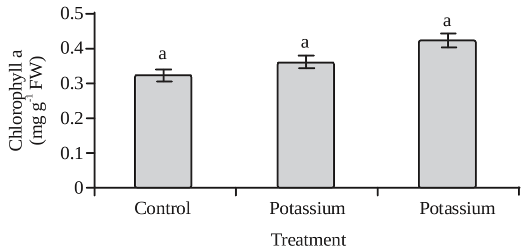

Fig. 1: Average of effects potassium silicate on chlorophyll a. The columns which have joint letters have not a significant difference in level of 5%; (Means±SE)

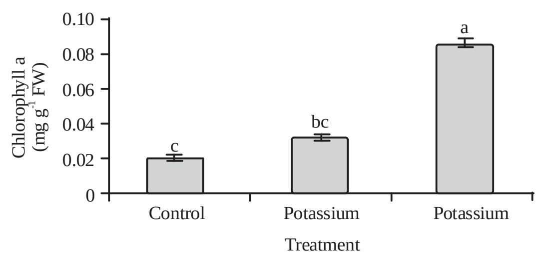

Fig. 2: Average of effects potassium silicate on chlorophyll b. The columns which have joint letters have not a significant difference in level of 5%; (Means±SE)

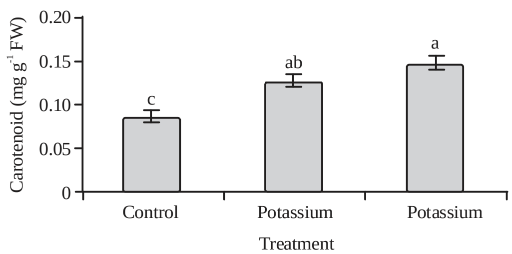

Fig. 3: Average of effects potassium silicate oncarotenoids. The columns which have joint letters have not a significant difference in level of 5%; (Means±SE)

difference between treatments was significant at probability level of ($p<0.05$). Potassium silicate spray 5 mM 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 5 mM 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 5 mM spray. The control group had the least amount of carotenoids and this difference was significant compared to potassium silicates 5 mM spray (Fig. 3).

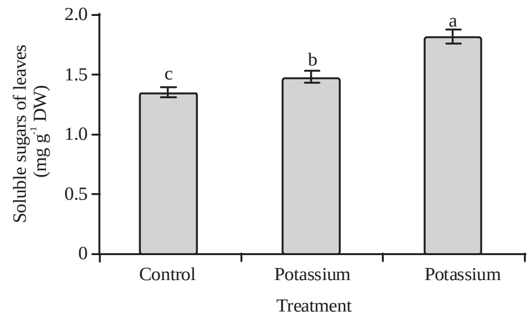

Fig. 4: Average of effects potassium silicate insoluble sugars. The columns which have joint letters have not a significant difference in level of 5%; (Means±SE)

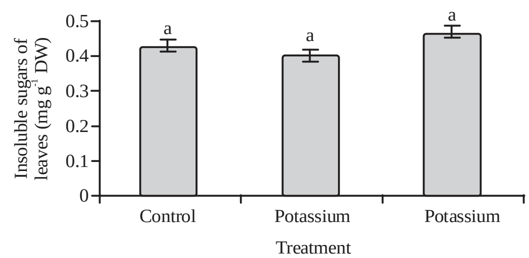

Fig. 5: Average of effects potassium silicate on insoluble sugars. The columns which have joint letters have not a significant difference in level of 5%; (Means±SE)

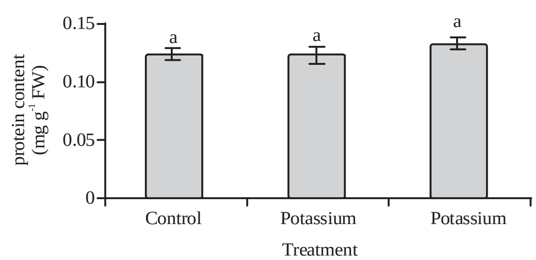

Fig. 6: Average of effects potassium silicate on protein. The columns which have joint letters have not a significant difference in level of 5%; (Means±SE)

Soluble and insoluble sugars of leaves: Potassium silicates 5 mM 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 5 mM 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 and 6).

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).

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[18].

Potassium silicates 5 mM sprayed treatment showed the highest chlorophyll amount compared to potassium silicates 5 mM 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[19].

One of the main reasons for chlorophyll decline is its destruction by reactive oxygen species. The reduced activity of photo system II and Robisko decreased enzyme activity and ATP inhibition increases the formation of free oxygen species in chloroplasts[20]. 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[21].

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[22].

The highest chlorophyll b amount, soluble sugars and carotenoids are related to potassium silicate 5 mM sprayed treatment and the least are related to control group. No significant difference was observed between potassium silicate 5 mM solution treatment and control in terms of chlorophyll b amount. No significant difference was observed between potassium silicate 5 mM solution treatment and potassium silicate 5 mM sprayed treatments in terms of measuring carotenoids. The maximum amount of soluble sugars is related to potassium silicate 5 mM sprayed treatment. The amount of plants chlorophyll is an important factor in maintaining photosynthetic capacity[23]. The results consistent with Mirabbasi *et al*.[24] results who stated that the highest chlorophyll amount is related to potassium silicate spray.

According to findings, it seems that in increase amount of chlorophyll b, soluble sugars and carotenoids, potassium silicate 5 mM 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

01. Epstein, E., 1999. Silicon. Annu. Rev. Plant Biol., 50: 641-664.
02. Epstein, E., 1994. The anomaly of silicon in plant biology. Proc. Nat. Acad. Sci. USA, 91: 11-17.
03. Ma, J.F. and N. Yamaji, 2006. Silicon uptake and accumulation in higher plants. Trends Plant Sci., 11: 392-397.
04. Hwang, S.J., H.M. Park and B.R. Jeong, 2005. Effects of potassium silicate on the growth of miniature rose Pinocchio grown on rockwool and its cut flower quality. J. Japan Soc. Horticul. Sci., 74: 242-247.
05. Inanaga, S. and A. Okasaka, 1995. Calcium and silicon binding compounds in cell walls of rice shoots. Soil Sci. Plant Nutr., 41: 103-110.
06. Reezi, S., M. Babalar and S. Kalantari, 2009. Silicon alleviates salt stress, decreases malondialdehyde content and affects petal color of salt stressed cut rose (*Rosa xhybrida* L.) Hot Lady. Afr. J. Biotechnol., 8: 1502-1508.
07. Lewin, J., 1953. Silicon metabolisms in diatoms. J. General Physiol., 3268: 589-601.
08. Ma, J.F. and E. Takahashi, 2002. Soil, Fertilizer and Plant Silicon Research in Japan. 1st Edn., Elsevier Science, Amsterdam, Netherlands, ISBN-13: 9780080525761, Pages: 294.
09. 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, Iran.
10. Khan, H.R., S.F. Elahi, M.S. Hussain and T. Adachi, 1994. Soil characteristics and behavior of potassium under various moisture regimes. Soil Sci. Plant Nutr., 40: 243-254.
11. Mengel, K. and E.A. Kirkby, 1987. Principles of Plant Nutrition. 4th Edn., International Potash Institute, Berne, Switzerland.
12. Roberts, S. and R.E. McDole, 1985. Potassium Nutrition of Potatoes. In: Potassium in Agriculture, Munson, R.S. (Ed.). ASA Publisher, Madison, Wisconsin, pp: 800-818.

13. Hoseinpour, K., 1993. Effect of potassium on the quantity and quality of potatoes in four regions Iran. M.Sc. Thesis, Tarbiat Modarres University, Tehran, Iran.
14. Moyer, C., N.A. Peres, L.E. Datnoff, E.H. Simonne and Z. Deng, 2008. Evaluation of silicon for managing powdery mildew on gerbera daisy. J. Plant Nutr., 31: 2131-2144.
15. Lichtenthaler, H.K. and R.R. Wellburn, 1983. Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem. Soc. Trans., 11: 591-592.
16. Hellubust, J.A. and J.S. Craigie, 1978. Handbook of Physiological and Biochemical Methods. Cambridge University Press, Cambridge.
17. Bradford, M.M., 1976. A rapid sensitive method for the quantitation of microgram quantities of protein utilising the principle of protein-dye binding. Anal Biochem., 72: 248-254.
18. Lee, J., J. Park and K. Han, 2000. Effects of potassium silicate on growth, photosynthesis and inorganic ion absorption in cucumber hydroponics. J. Korean Soc. Hortic. Sci., 41: 480-484.
19. Agarie, S., W. Agata, H. Uchida, F. Kubota and P.B. Kaufman, 1996. Function of silica bodies in the epidermal system of rice (*Oryza sativa* L.): Testing the window hypothesis. J. Exp. Bot., 47: 655-660.
20. Lawlor, D.W. and G. Cornic, 2002. Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants. Plant Cell Environ., 25: 275-294.
21. Quanzhi, Z. and G. Erming, 1998. Effects of silocate fertilization on rice in the rice areas along Yellow river. Acta Agric. Univ. Henanensis, 32: 308-313.
22. Shinya, Y. and H. Yoshihiro, 2000. Some effect of potassium silicate application on photosynthesis of sugarcane. J. Agric. Sci., 40: 115-121.
23. Jiang, Y. and B. Huang, 2001. Drought and heat stress injury to two cool-season turfgrasses in relation to antioxidant metabolism and lipid peroxidation. Crop Sci., 41: 436-442.
24. Mirabbasi, N., A. Nikbakht, N. Etemadi and M.R. Sabzalian, 2013. Effect of different concentrations of potassium silicate, nano-silicon and calcium chloride on concentration of potassium, calcium and magnesium, chlorophyll content and number of florets of Asiatic lily cv. Brunello. J. Sci. Technol. Greenhouse Culture, 4: 41-50.