Biological Forum – An International Journal **7**(2): 879-883(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

The Study of Nano-silica effects on qualitative and quantitative performance of potato (*Solanum tuberosum* L.)

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(Received 12 August, 2015, Accepted 09 November, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Nano-particles have entered widely into agriculture and biology world due to exclusive biological and Physico-chemical features. Plant interactions with nano-particles have been studied directly through many fertilizers, pesticides and herbicides based on nano-particles and indirectly through irrigation water contaminated with nano-particles. In this study, silicon effect as a useful element on quantitative and qualitative performance of potato crop was evaluated in form nano-silica. 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 nano-silica 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 nano-silica showed significant increase in Chlorophyll b amount and soluble sugars.

Key words: nano-silica, sugar, protein, Chlorophyll, *Solanum tuberosum* L.

INTRODUCTION

Nano-science technology of materials is at atomic and molecular level. The term is used for materials that their size is between 1 to 100 nm. Research in nanotechnology area has increased significantly in recent years. Although, exploitation of this technology potentials is ongoing in medical and pharmaceutical sciences, but using it in the protection of agricultural products has recently been considered. New tools for rapid molecular detection, cure diseases, enhance the ability of plants to absorb nutrients and special load transfer to a special site are examples of development in this new field of science (Alejandro *et al.,* 2009).The production of nano-scale fertilizers is one of the applications of this technology and has more easy absorption due to large surface area and high density of reactive surfaces and is more effective than conventional chemical fertilizers (Anonymous, 2009). Since the plant cell wall acts as a barrier to easy entry of foreign agents into plant cells, nano-particles that have smaller pore diameter compared to pore diameter of cell wall can easily pass through the pores of walls. Nano-particles on leaves surface enter into plant through pores or villus bases and then are transported to different tissues (Nair *et al.,* 2010).

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 (Currie & Perry 2007, Richmond & Sussman 2003).

The most effect of silica on plants is related to the resistance against biotic and abiotic stress (Liang *et al.,* 2007, 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 (Epstein, 1999, Inanaga and Okasaka 1995).

Potato with scientific name of *Solanum tuberosum* L. from Solanaceae family is one year plant with alternating and Pinnately compound leaves that consist of 2 to 6 pairs of leaflets and a terminal leaflets. Inflorescence of pistil is composed of 5 sepals and 5 petals and five flags that are fused at the base and surround ovary. Potato upper ovary is composed of carpel and a two branched stigma. Ripe fruit is berry that resembles a small tomato and is green (Rezai and Soltani 1996).

Strategic importance and nutritional value of potatoes for human nutrition and climatic variability in various regions of country requires regional research in order to achieve high performance per unit area (Zahedi).

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 minutes when they were washed with tap water and then they were washed with sterile distilled water. Nano- silica was prepared from Nano- unit Industry Company's. Nano- silica 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.

A. Photosynthetic pigments measurement

Measurement of photosynthetic pigments such as chlorophyll *a*, *b* and carotenoids was performed using Lichtenthaler (1987) method. 0.1gr 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 (18).

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).

B. Soluble and insoluble sugars of leaves measurement

0.1 gr 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 gr 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 (Bradford1979). Different concentrations of bovine serum albumin protein (BSA) were used in order to draw standard curve of (6).

D. 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

A. Photosynthetic pigments

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

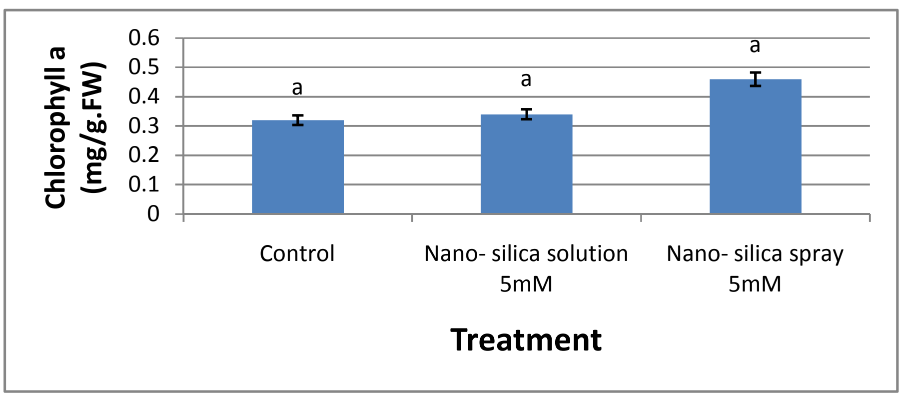

Fig. 1. Average of effects nano-silica on chlorophyll *a*. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

Chlorophyll *b* amount difference between treatments was significant at probability level of (P<0.05). Nano-silica 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 nano-silica 5mM solution treatment (Fig. 2). The results showed that nano-silica statistically has significant effect on carotenoids at probability level of (P <0.05). The highest level of carotenoids was observed in nano-silica 5mM spray. The control group had the least amount of carotenoids and this difference was significant compared to nan-silica 5mM spray (Fig. 3).

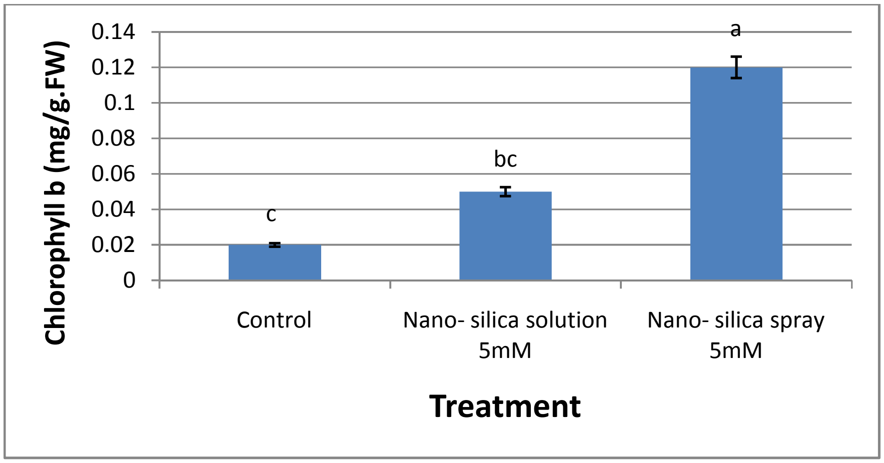

Fig. 2. Average of effects nano- silica on chlorophyll *b*. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

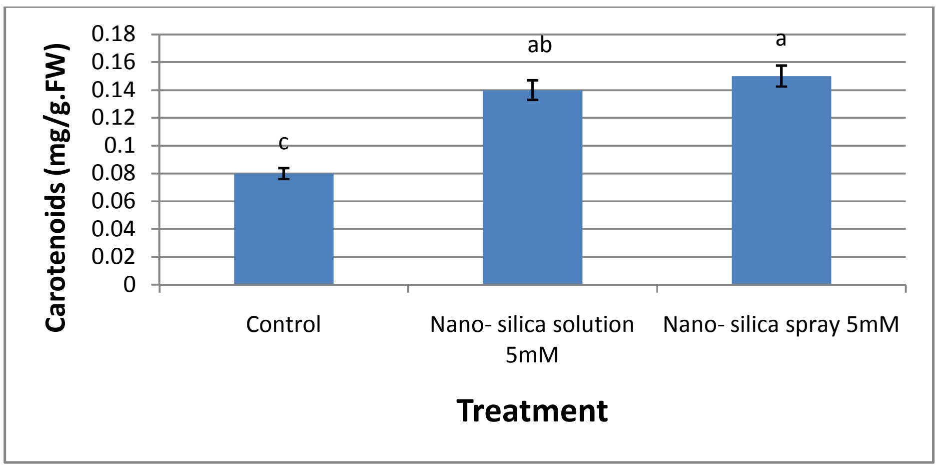

Fig. 3. Average of effects nano- silica on carotenoids. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

B. Soluble and insoluble sugars of leaves

Nano-silica 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 nano- silica 5mM spray treatment, that have significantly different with control group that had the least amount of soluble sugars (Fig. 4).

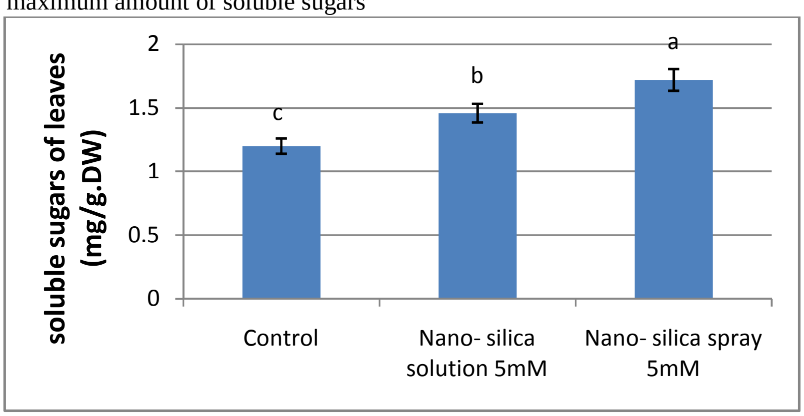

Fig. 4. Average of effects nano- silica on soluble sugars. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

Since the maximum amount of insoluble sugars in leaves was related to nano- silica spray treatment but it was not significantly different with nano- silica solution treatment and control groups (Fig. 5).

C. Protein

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

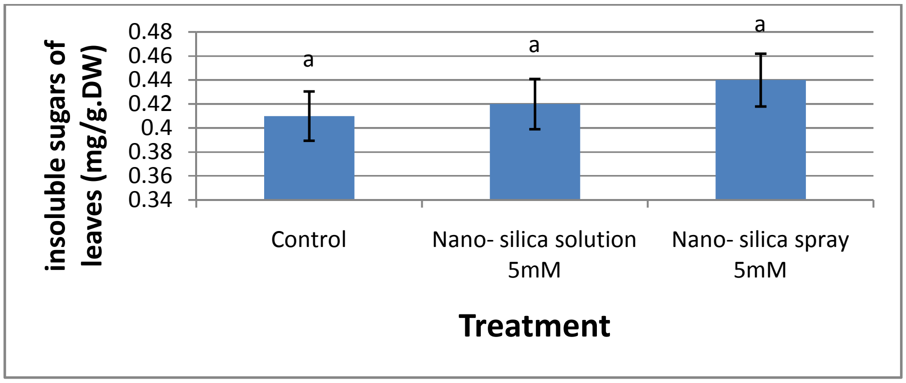

Fig. 5. Average of effects nano- silica on insoluble sugars. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

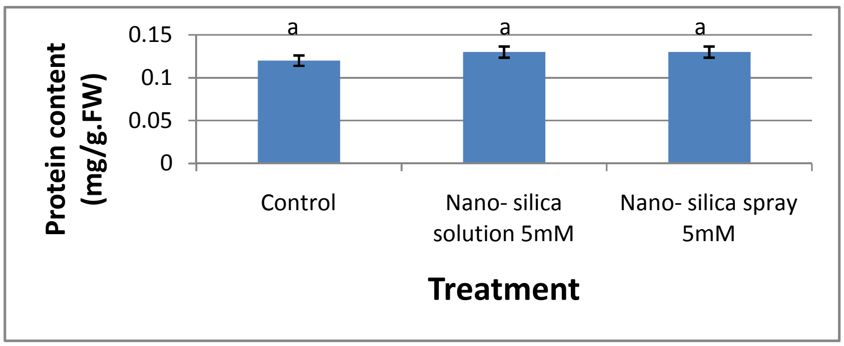

Fig. 6. Average of effects nano-silica on Protein. The columns which have joint letters have not a significant difference in level of 5%. (Means±SE).

DISCUSSION AND CONCLUSION

According to results of present research, nano-silica 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 nano-silica 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).

Nano-silica 5mM sprayed treatment showed the highest chlorophyll a amount compared to Nano- silica 5mM solution treatment and control groups, but this difference was not statistically significant.

The results of research was consistent with Agarie *et al* (1996) 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.

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). Haqiqi *et al* reported that using nano-silica at optimal conditions of tomatoes growth without stress increases photosynthesis and the photosynthetic water use efficiency which are consistent with test results (Hagigi, 2014).

The highest chlorophyll *b* amount, soluble sugars and carotenoids are related to nano-silica 5mM sprayed treatment and the least are related to control group. No significant difference was observed between nano-silica 5mM solution treatment and control in terms of chlorophyll *b* amount. No significant difference was observed between nano-silica 5mM solution treatment and nano-silica 5mM sprayed treatments in terms of measuring carotenoids.

The maximum amount of soluble sugars is related to nano- silica 5mM sprayed treatment. The amount of plants chlorophyll is an important factor in maintaining photosynthetic capacity (Jiang and Haung 2001). The results of this test are consistent with results of the researchers who stated that the maximum amount of barley plant chlorophyll is related to nano- silica 5Mm sprayed which can be due to deposition of silicon on leaf lamina and increased concentrations of chlorophyll per unit area (Liang *et al.,* 2003).

When plant's cell is under stress signaling pathway in corporation with calcium send signals to nucleus of cell, Due to this signaling, genes expression undergoes changes and because of increasing or decreasing of some genes, plant can resist against stress. Due to these genetic changes, content of special proteins changes (Amini *et al.,* 2007, Biglari *et al.,* 2012) showed that treatment of selenium can cause increasing of amino acid content, specially Asp in rice. The assessment of changes pattern of total protein content shows that under silica stress some new proteins can be generated, or the amount of some others can be increased or decreased (Vaculik *et al.,* 2009). According to findings, it seems that in increase amount of chlorophyll *b*, soluble sugars and carotenoids, nano-silica 5mM spray will be the best treatment. Given the importance of potato plant, this study aimed to assess plant responses to nano-silica effects on potatoes qualitative and quantitative performance.

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