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THE EFFECT OF DIFFERENT CONCENTRATIONS AND FREQUENCIES OF SILICON ON GROWTH, YIELD AND SEED QUALITY OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) CV. GIZA – ١٠٢

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ABSTRACT

Field experiment was conducted during ٢٠١١ and ٢٠١٢ growing seasons to study the effect of different concentrations (٠.٠, ٠.٠٥, ٠.١ and ٠.٢ %) and frequencies (once, twice and thrice) of potassium silicate as a source of silicon (١٠ % $K_{٢}O$ + ٢٥ % SiO) on growth, yield and yield components of sunflower (Helianthus annuus L.cv. Giza ١٠٢).

Results showed that foliar application of potassium silicate at ٠.٠٥ to ٠.٢ % applied once, twice or thrice had an announced effect on all growth characters. Seed, straw and oil yields per feddan in addition two yield components also positively affected with that treatment in relative to the check treatment. The promotion was associated with increasing concentrations and frequencies. Increasing concentrations from ٠.١ to ٠.٢ % and frequencies from twice to thrice had negligible effects on all the investigated traits.

In general, the maximum yield per fed (seed, straw and oil) of sunflower cv. Giza ١٠٢ was obtained in plants sprayed twice with potassium silicate at ٠.١ %.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) belonging to the family Compositae, is a major oilseed, used for the production of edible oil with an annual production of ٣٦.١ million tons wide world (FAO ٢٠١١). Sunflower oil is a source of fatty molecules that can be used as reagents for chemical modification. It is also has excellent nutritional properties. It is practically free considerable toxic compounds and has a relatively high concentrations of lionoleic acid. This poly unsaturated fatty acid is an essential fatty acid (not synthesize by hormones) and is the precursor of gamma linolenic and arachidonic acids (Seiler, ٢٠٠٧). The composition of fatty acids is a main determinant of the oil quality in sunflower.

Many trials will be accomplished nowadays to increase oil production of sunflower cvs by increasing total yield of seeds and the concentrations of oil in the seeds. Recently, using silicon in different field crops is considered a promised agricultural practices for improving yield quantitively and qualitatively (Ma, ٢٠٠٢).

Although silicon (Si) is the second most abundant element both on the surface of the earth crust and in the soils, it has not yet been listed among the essential elements for higher plants. Direct evidence is still lacking that Si is part of the molecule of an essential plant constituent or metabolite. However, the beneficial role of Si in stimulating the growth and development of many plant species has been generally recognized. More recently, Epstein and Bloom (٢٠٠٣) have proposed a new definition of essentiality. Based on this new definition, the essentiality of Si for higher plants will be finally established.

Over last two or three decades, the striking and unique role of Si in conferring plants against various abiotic and biotic stresses has received increasing interest. Silicon is known to effectively mitigate various abiotic (environmental) stresses including manganese, aluminum, and heavy metal toxicity, salinity, drought, chilling or freezing stresses etc. However, mechanisms for such Si-mediated alleviation of various abiotic stresses remain poorly understood. The key mechanisms of Si-mediated alleviation of abiotic stresses in higher plants include: ١) stimulation of antioxidant systems in plants, ٢) complexation or co-precipitation of toxic metal ions with Si, ٣) immobilization of toxic metal ions in growth media, ٤) uptake processes, and ٥) compartmentation of metal ions within plants (Epstein, ١٩٩٩).

Most silicon compounds had beneficial effects on growth, yield and yield components of various field crops (Ahmed *et al*., ١٩٩٢; Liang et al., ١٩٩٦; Agarie *et al*., ١٩٩٨; Matichenkov *et al*., ٢٠٠٠; Neumann and Zur- Nieden, ٢٠٠١; Ma *et al*., ٢٠٠١; Ma and Takahashi, ٢٠٠٢; Kanto, ٢٠٠٢; Zeyen, ٢٠٠٢ and Qin and Tian, ٢٠٠٤).

The aim of this study was elucidating the great benefits of using silicon for sunflower cv. Giza ١٠٢.

MATERIALS AND METHODS

This field experiment was conducted in a private field located at El- Kawamel village, near Souhag district, Souhag Governorate on Sunflower (*Helianthus annuus*, L.) grown on a clay soil. Soil samples were taken one week before sowing at ٣٠ cm. intervals depth for soil analysis (Table ١).

Table ١: Analysis of the tested soil:

Constituents	Values
Sand %	: ٤.٥
Silt %	: ٢٥.٥
Clay %	: ٧٠.٠
Texture	: Clay
pH (١:٢.٥ extract)	: ٧.٥٥
E.C (١: ٢.٥ extract as mmhos/ ١ cm ٢٥° C)	: ٠.٩٦
O.M. %	: ١.٨٠
$CaCO_{٣}$ %	: ٢.٢٠
Total N %	: ٠.٠٩
Available K (ammonium acetate, ppm)	: ٣٥٠
Available P (Olsen method, ppm)	: ٤.٢

After tilling practice in the region, sunflower cv. Giza ١٠٢ seeds were sown in the first week of May during ٢٠١١ and ٢٠١٢ seasons. Row spacing was ٥٠ cm. and plant density was ١٠ plants per cm^{٢}. The experimental plot area was ٢١ m^{٢} and each plot contained six ridges.

Two ridges without planting were left between each plot to avoid shading effect. Three seeds per hill were planted. One plant per hill was maintained at ٢ – ٤ leaf stage of the crop (nearly ٢١ days after sowing) (٢٠٠ plot/ fed.). Plants exhibited no sign of insect/ pest attack and disease incidence, therefore no protection measures were adopted. Crop harvested in the last week of September. Yields were recorded on plot basis and then converted to kg and tons per feddan. Irrigation was done using Nile water.

Ten treatments of different concentrations and frequencies of potassium silicate were applied as follows:-

١- Control (sprayed plants with tap water).
٢- Spraying potassium silicate (١٠ % $K_٢O$ + ٢٥ % SiO) at ٠.٠٥ % once (at ٤ – ٦ leaf stage).
٣- Spraying potassium silicate at ٠.١ % once (as previously mentioned).
٤- Spraying potassium silicate at ٠.٢ % once (as previously mentioned).
٥- Spraying potassium silicate at ٠.٠٥ % twice (at ٤ – ٦ leaf stage and again at flowering stage).
٦- Spraying potassium silicate at ٠.١ % twice (as previously mentioned).
٧- Spraying potassium silicate at ٠.٢ % twice (as previously mentioned).
٨- Spraying potassium silicate at ٠.٠٥ % thrice (at ٤ – ٦ leaf stage, flowering stage and at three weeks later).
٩- Spraying potassium silicate at ٠.١ % thrice (as previously mentioned).
١٠- Spraying potassium silicate at ٠.٢ % thrice (as previously mentioned).

Each treatment was replicated three times, one plot per each. Triton B was added as a wetting agent to all potassium silicate solutions at ٠.٠٥ %. Spraying was done till runoff. Untreated plants were sprayed with tap water contains Triton B. The preceding crop was *Ficia faba* L. in both seasons. Other cultural practices were carried out as usual. Randomized complete blocks design with three replicates was used.

At heading stage, heads of five plants were chosen at random from external ridges of each plot and bagged at early seeds development by using magazine paper to avoid bird's damage until maturity. The sunflower plants were hand- harvested at the stage of physiological maturation when the back of the heads has turned from green to yellow and the bracts are turning brown (last week of September).

At harvest (last week of September), a samples of five plants which randomly chosen from external ridges in every treatment in the three replications were taken to measure the following growth characters:-

١. Plant height (cm.).
٢. Stem diameter (cm.).
٣. Number of leaves per plant.
٤. Leaf area/ plant ($cm^٢$) (Bremner and Taha, ١٩٦٦).

Also, samples of five bagged plants were taken and the following traits were recorded:-

١. Head diameter (cm.).
٢. Average head weight/ plant (g.).
٣. Seed yield per plant (g.).
٤. Shelling percentage was calculated by dividing seed yield/ plant by head weight per plant and multiplying the product by ١٠٠.
٥. Seed index was estimated by weighing two random ١٠٠- seed samples per plot.
٦. Number of seeds per head was calculated by dividing seed yield/ plant by seed index and multiplying the product by ١٠٠.
٧. Straw yield/ plant (g.) was obtained from a five guarded plants sample per plot, then straw yield/ fed. (ton) was estimated.
٨. Biological yield/ plant (g.) was estimated by summation of seed yield/ plant and straw yield/ plant, then biological yield (ton/ fed) was estimated.

٩. Seed yield/ fed (tons). Heads of two bagged inner ridges of each plot were harvested and left two weeks until fully air dried and seed yield/ plant was used to estimate yield/ fed (tons).
١٠. Oil percentage in the seeds was determined according to A.O.A.C., (١٩٩٥) using soxhlet apparatus using petroleum ether as a solvent.
١١. Seed oil yield/ fed. (kg.) was calculated by multiplying oil % in the seeds by seed yield/ fed (kg.).
١٢. Total nitrogen in the seeds was determined by Kjeldahl method according to Cottenie *et al.*, (١٩٨٢).
١٣. Seed protein content % was calculated by multiplying the total N in the seeds by the converting factor ٦.٢٥ (Hymowitz *et al.*, ١٩٧٢).
١٤. Chlorophylls a & b as well as total carotenoids and total chlorophylls (mg/ ١.٠ g F.W) were determined in the fresh leaves (٩٠ days age) according to the procedure of Moran (١٩٨٢).

All the obtained data were subjected to statistical analysis according to Mead *et al.*, (١٩٩٣) and mean comparisons were done using revised L.S.D test at ٥ %.

RESULTS AND DISCUSSION

١- Growth characters:

Data in Table (٢) showed that varying concentrations and frequencies of potassium silicate had significant effect on the four growth aspects namely plant height, stem diameter, number of leaves per plant and leaf area/ plant in most cases. Treating the sunflower plants with potassium silicate at ٠.٠٥ to ٠.١ % either once, twice or thrice significantly was responsible for stimulating all growth characters in comparison to the control treatment. The promotion was associated with increasing concentrations and frequencies of silicon compound. Meaningless promotion on these growth characters were observed among the higher two concentrations (٠.١ and ٠.٢ %) and at specific frequencies (twice or thrice). The maximum values were recorded on the plants received three sprays of potassium silicate at

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٠.٢ %. The untreated plants had the lowest values. Similar results were obtained during both seasons.

Table ٢: Effect of concentrations and frequencies of potassium silicate on some growth characters and head diameter of sunflower cv. Giza ١٠٢ plants during ٢٠١١ and ٢٠١٢ seasons.

Concentrations and frequencies of potassium silicate treatments	Plant height (cm.)		Stem diameter (cm.)		Number of leaves/ plant		Leaf area/ plant (cm٢)		Head diameter (cm.)	
	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢
Control.	١٣١.٠	١٣٣.٧	١.٩٩	١.٩٥	١٨.٠	١٩.٠	٤٣١.٠	٤٣٧.٠	١٦.٩٢	١٧.١٢
Spraying potassium silicate at ٠.٠٥ % once	١٣٣.٠	١٣٥.٨	٢.٠٥	١.٩٩	٢٠.٦	٢١.٥	٤٥١.٠	٤٥٨.٠	١٧.١٢	١٧.٣٢
Spraying potassium silicate at ٠.١ % once	١٣٥.٠	١٣٧.٦	٢.١٠	٢.٠٩	٢٢.٧	٢٣.٠	٤٧٢.٠	٤٨٠.٠	١٧.٢٩	١٧.٤٩
Spraying potassium silicate at ٠.٢ % once	١٣٥.٥	١٣٧.٩	٢.١١	٢.١٠	٢٣.٠	٢٣.٧	٤٧٤.٣	٤٨١.٠	١٧.٣٠	١٧.٥٠
Spraying potassium silicate at ٠.٠٥ % twice	١٣٩.٠	١٤٢.٠	٢.١٥	٢.٢٢	٢٥.٣	٢٦.٠	٤٨٠.٢	٤٩٠.٠	١٧.٧١	١٧.٩١
Spraying potassium silicate at ٠.١ % twice	١٤٣.٠	١٤٦.٠	٢.١٨	٢.٢٨	٢٨.٠	٢٩.٠	٥٠٠.٣	٥١١.٩	١٨.١١	١٨.٣١
Spraying potassium silicate at ٠.٢ % twice	١٤٣.٦	١٤٦.٧	٢.١٩	٢.٢٩	٢٨.٦	٣٠.٠	٥٠٣.٠	٥١٢.٠	١٨.١٥	١٨.٣٥
Spraying potassium silicate at ٠.٠٥ % thrice	١٣٩.٥	١٤٢.٣	٢.١٦	٢.٢٣	٢٦.٠	٢٦.٣	٤٨٢.٠	٤٩١.٠	١٧.٧٢	١٨.٠٠
Spraying potassium silicate at ٠.١ % thrice	١٤٣.٦	١٤٦.٧	٢.٢٠	٢.٢٩	٢٨.٣	٢٩.٩	٥٠١.٠	٥١٢.٠	١٨.١٢	١٨.٣٣
Spraying potassium silicate at ٠.٢ % thrice	١٤٤.٠	١٤٧.٠	٢.٢١	٢.٣٠	٢٩.٠	٣٠.٧	٥٠٥.٣	٥١٣.٠	١٨.١٨	١٨.٣٩
Revised L.S.D at ٥ %	١.٩	٢.٠	٠.٠٤	٠.٠٣	١.٥	١.٦	١١.٩	١٢.٠	٠.١١	٠.١١

The beneficial effects of silicon on growth were mainly attributed to the high accumulation of silicon on the tissue surface which accompanied with enhancing photosynthesis, nutrient uptake root development and controlling various pests and diseases caused by both fungi and bacteria. In addition, the effect of silicon on increasing the tolerance of plants to abiotic, stresses such as salt stress, metal toxicity, drought stress, radiation damage as well as higher and lower temperature could added another explanation. The problem of solving silicon deficiency surely reflected in reducing various abnormalities in plant growth (Epstein, ١٩٩٩ and Epstein and Bloom, ٢٠٠٣).

These results are in agreement with those obtained by Agarie *et al*., (١٩٩٨); Ma (٢٠٠٢); Kanto (٢٠٠٢) and Zeyen (٢٠٠٢).

٢- Head character:

Data in Tables (٢ & ٣) indicated that foliar application of potassium silicate at ٠.٠٥ to ٠.٢ % once, twice or thrice significantly improved head diameter and weight of head/ plant in relative to the control treatment. There was a gradual and significant differences on such two head characters with increasing concentration from ٠.٠ to ٠.٢ % and frequencies from once to thrice of such silicon source. Negligible promotion on head diameter and head weight/ plant was observed with increasing concentrations of potassium silicate from ٠.١ to ٠.٢ % and frequencies from twice to thrice. The maximum values were recorded with using three sprays of potassium silicate at ٠.٢ %. The lowest values were recorded on untreated plants.

The beneficial of silicon on growth and nutritional status of the plants surely reflected on producing bigger and wider heads (Epstein, ١٩٩٩).

٣- Seed, straw, oil and biological yields, shelling %, seed index and number of seeds/ head.

It could be concluded from the data in Tables (٣ & ٤) that carrying out one, two or three sprays of potassium silicate at ٠.٠٥ to ٠.٢ % significantly improved seed, straw and biomass yields per plant and per feddan, oil yield, seed index, number of seeds per head and biological yield per plant and per feddan rather than non- application. The promotion was related to the increase in concentrations and frequencies of potassium silicate. Increasing concentrations of potassium silicate from ٠.١ to ٠.٢ % and frequencies from twice to thrice had no significant promotion on these parameters. The present silicon treatments had no significant effect on shelling % and there was a slight promotion on such character in response to application of potassium silicate.

Table ٣: Effect of concentrations and frequencies of potassium silicate on head weight/ plant, seed yield/ plant, shelling %, seed index and number of seeds/ head of sunflower cv. Giza ١٠٢ plants during ٢٠١١ and ٢٠١٢ seasons.

Concentrations and frequencies of potassium silicate treatments	Head weight/ Plant (g.)		Seed yield/ plant (g.)		Shelling%		Seed index (g.)		Number of seeds/ head	
	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢
Control.	٧٤.٠٠	٧٤.١١	٤٤.١	٤٤.٥	٥٩.٦	٦٠.٠	٦.٠٠	٦.٠٥	٧٣٥.٠	٧٣٥.٥
Spraying potassium silicate at ٠.٠٥ % once	٧٤.٣٣	٧٤.٦٠	٤٤.٨	٤٥.٢	٦٠.٣	٦٠.٦	٦.٢١	٦.٢٦	٧٢١.٤	٧٢٢.٠
Spraying potassium silicate at ٠.١ % once	٧٥.٠٠	٧٥.٥٠	٤٥.٤	٤٥.٩	٦٠.٥	٦٠.٨	٦.٣٥	٦.٤١	٧١٥.٠	٧١٦.١
Spraying potassium silicate at ٠.٢ % once	٧٥.٠٥	٧٥.٥٥	٤٥.٥	٤٦.٠	٦٠.٦	٦٠.٩	٦.٣٦	٦.٤٣	٧١٥.٤	٧١٥.٤
Spraying potassium silicate at ٠.٠٥ % twice	٧٥.٥٥	٧٦.٠٠	٤٦.٥	٤٧.٠	٦١.٥	٦١.٨	٦.٥٩	٦.٦٦	٧٠٥.٦	٧٠٥.٧
Spraying potassium silicate at ٠.١ % twice	٧٦.١٠	٧٦.٦٠	٤٧.٠	٤٨.٠	٦١.٨	٦٢.٧	٦.٨٢	٦.٩٠	٦٨٩.١	٦٩٥.٧
Spraying potassium silicate at ٠.٢ % twice	٧٦.١٦	٧٦.٦٦	٤٧.٣	٤٨.١	٦٢.١	٦٢.٧	٦.٨٣	٦.٩١	٦٩٢.٥	٦٩٦.١
Spraying potassium silicate at ٠.٠٥ % thrice	٧٥.٦٠	٧٦.٠٥	٤٦.٧	٤٧.١	٦١.٨	٦١.٩	٦.٦٠	٦.٦٧	٧٠٧.٦	٧٠٦.١
Spraying potassium silicate at ٠.١ % thrice	٧٦.١١	٧٦.٦٦	٤٧.١	٤٨.١	٦١.٩	٦٢.٧	٦.٨٣	٦.٩١	٦٨٩.٦	٦٩٦.١
Spraying potassium silicate at ٠.٢ % thrice	٧٦.١٨	٧٦.٧١	٤٧.٢	٤٨.٢	٦٢.٠	٦٢.٨	٦.٨٤	٦.٩٣	٦٩٠.١	٦٩٥.٥
Revised L.S.D at ٥ %	**٠.١١**	**٠.١١**	**٠.٣**	**٠.٣**	**NS**	**NS**	**٠.١١**	**٠.١١**	**٥.١**	**٤.٩**

The maximum straw, seeds and oil yields from economical point of view was recorded with using potassium silicate twice at ٠.١ % (since no significant increase on these yields was observed among ٠.١ and ٠.٢ % of potassium silicate as well as between using two or three sprays). Under such promised treatment, straw yield reached ٧.٢٠ and ٧.٢٤ tons while, seed yield reached ١.٨٨ and ١.٩٢ tons and oil yield reached ٦٢٠.٤ and ٦٤٣.٢ kg during both seasons, respectively.

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Untreated plants produced ٦.٧٦ and ٦.٨٠ tons straw yield, ١.٧٦ and ١.٧٨ tons seed yield and ٥٤٥.٦ kg and ٥٦٠.٧ kg oil yield during both seasons, respectively. The percentage of increase on seed yield reached ٦.٨ % and ٧.٩ % over the check treatment, while was ١٣.٧ and ١٤.٧ % in the oil yield per feddan in relative to the check treatment. These results were similar during both seasons.

These results might be attributed to the profits of silicon on enhancing growth and nutritional status of the plants.

These results are in agreement with those obtained by Agarie *et al*., (١٩٩٨); Ma (٢٠٠٢); Kanto (٢٠٠٢) and Zeyen (٢٠٠٢).

٤- Percentages of oils and proteins in the seeds.

It is obvious from the data in Tables (٤ & ٥) that supplying sunflower plants via leaves with potassium silicate at ٠.٠٥ to ٠.٢ % once, twice or three times significantly improved percentages of fats and proteins comparing with the check treatment. The stimulation was associated with increasing concentrations and frequencies of such source of silicon. Increasing concentrations from ٠.١ to ٠.٢ % as well as frequencies from twice to thrice failed significantly to show any differences on such two parameters. The best results with regard to quality of the seeds were obtained with using potassium silicate twice at ٠.١ % (since no measurable differences were observed among the higher two concentrations and frequencies). The untreated plants produced the seeds with lower fats and proteins. Similar results were announced during both seasons.

The essential roles of silicon on enhancing the formation of plant pigments and carbohydrates as well as enhancing plant metabolism (Epstein, ١٩٩٩) could explained the present results.

These results are in agreement with those obtained by Agarie *et al*., (١٩٩٨); Ma (٢٠٠٢); Kanto (٢٠٠٢) and Zeyen (٢٠٠٢).

٥- Plant pigments:

Data of Table (٥) shows that plant pigments namely chlorophylls a & b, total carotenoids and total chlorophylls were significantly increased with spraying potassium silicate once, twice or thrice at ٠.٠٥ to ٠.٢ % in relative to the check treatment. They were gradually improved with increasing concentrations and frequencies of such compound. A slight and unsignificant stimulation on these pigments was revealed among the higher two concentrations and frequencies.

Table ٤: Effect of concentrations and frequencies of potassium silicate on straw yield/ plant and per feddan above ground biomass/ plant and per feddan, seed yield/ fed. (ton), oil yield/ fed. and oil % of sunflower cv. Giza ١٠٢ plants during ٢٠١١ and ٢٠١٢ seasons.

Concentrations and frequencies of potassium silicate treatments	Straw yield/ plant (g.)		Above ground biomass/ plant (g.)		Straw yield/ fed (ton)		Above ground biomass/ fed (ton)		Seed yield/ fed. (tons)		Oil yield/ fed. (kg.)		Oils %	
	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢
Control.	١٦٩.١	١٧٠.٠	٢١٣.٢	٢١٤.٥	٦.٧٦	٦.٨٠	٨.٥٢	٨.٥٨	١.٧٦	١.٧٨	٥٤٥.٦	٥٦٠.٧	٣١.٠٠	٣١.٥٠
Spraying potassium silicate at ٠.٠٥ % once	١٧٢.٢	١٧٣.١	٢١٧.٠	٢١٨.٣	٦.٨٩	٦.٩٢	٨.٦٨	٨.٧٣	١.٧٩	١.٨١	٥٦٣.٩	٥٧٩.٢	٣١.٥٠	٣٢.٠٠
Spraying potassium silicate at ٠.١ % once	١٧٥.٠	١٧٥.٩	٢٢٠.٤	٢٢١.٨	٧.٠٠	٧.٠٤	٨.٨٢	٨.٨٨	١.٨٢	١.٨٤	٥٨٢.٤	٥٩٨.٠	٣٢.٠٠	٣٢.٥٠
Spraying potassium silicate at ٠.٢ % once	١٧٥.٥	١٧٦.٤	٢٢١.٠	٢٢٢.٤	٧.٠٢	٧.٠٦	٨.٨٤	٨.٩٠	١.٨٢	١.٨٤	٥٨٣.٣	٦٠٠.٠	٣٢.٠٥	٣٢.٦٠
Spraying potassium silicate at ٠.٠٥ % twice	١٧٨.٠	١٧٨.٩	٢٢٤.٥	٢٢٥.٩	٧.١٢	٧.١٦	٨.٩٨	٩.٠٤	١.٨٦	١.٨٨	٦٠٦.٤	٦٢٢.٣	٣٢.٦٠	٣٣.١٠
Spraying potassium silicate at ٠.١ % twice	١٧٩.٩	١٨١.٠	٢٢٦.٩	٢٢٩.٠	٧.٢٠	٧.٢٤	٩.٠٨	٩.١٦	١.٨٨	١.٩٢	٦٢٠.٤	٦٤٣.٢	٣٣.٠٠	٣٣.٥٠
Spraying potassium silicate at ٠.٢ % twice	١٨٠.٠	١٨١.٣	٢٢٧.٣	٢٢٩.٤	٧.٢٠	٧.٢٥	٩.٠٩	٩.١٧	١.٨٩	١.٩٢	٦٢٥.٤	٦٤٥.٣	٣٣.٠٩	٣٣.٦١
Spraying potassium silicate at ٠.٠٥ % thrice	١٧٨.٣	١٧٩.٠	٢٢٥.٠	٢٢٦.١	٧.١٣	٧.١٦	٩.٠٠	٩.٠٤	١.٨٧	١.٨٨	٦١٠.٠	٦٢٢.٧	٣٢.٦٢	٣٣.١٢
Spraying potassium silicate at ٠.١ % thrice	١٨٠.٠	١٨١.٤	٢٢٧.١	٢٢٩.٥	٧.٢٠	٧.٢٦	٩.٠٨	٩.١٨	١.٨٨	١.٩٢	٦٢٢.٣	٦٤٤.٢	٣٣.١٠	٣٣.٥٥
Spraying potassium silicate at ٠.٢ % thrice	١٨٠.٣	١٨١.٥	٢٢٧.٥	٢٢٩.٧	٧.٢١	٧.٢٦	٩.١٠	٩.١٩	١.٨٩	١.٩٣	٦٢٦.٠	٦٤٨.٩	٣٣.١٢	٣٣.٦٢
Revised L.S.D at ٥ %	**١.٤**	**١.٥**	**٢.٥**	**٢.٦**	**٠.٢٢**	**٠.٢٢**	**٠.٢٠**	**٠.٢٠**	**٠.٠٦**	**٠.٠٦**	**٥.١**	**٥.٢**	**٠.١١**	**٠.١٢**

Table ٥: Effect of concentrations and frequencies of potassium silicate on protein % and some plant pigments of sunflower cv. Giza ١٠٢ plants during ٢٠١١ and ٢٠١٢ seasons.

Concentrations and frequencies of potassium silicate treatments	Proteins %		Chlorophyll a (mg/ ١ g. F.W)		Chlorophyll b (mg/ ١ g. F.W)		Total chlorophylls (mg/ ١ g. F.W)		Total carotenoids (mg/ ١ g. F.W)	
	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢	٢٠١١	٢٠١٢
Control.	١٥.٨	١٥.٥	١.٩٩	٢.٠٥	١.٠٥	١.١٢	٣.٠٤	٣.١٧	١.٥١	١.٦١
Spraying potassium silicate at ٠.٠٥ % once	١٦.٢	١٥.٩	٢.١٩	٢.٢٥	١.١٦	١.٢٣	٣.٣٥	٣.٤٨	١.٦٤	١.٧٣
Spraying potassium silicate at ٠.١ % once	١٦.٥	١٦.٢	٢.٤١	٢.٤٧	١.٣٠	١.٣٧	٣.٧١	٣.٨٤	١.٨٢	١.٩١
Spraying potassium silicate at ٠.٢ % once	١٦.٦	١٦.٣	٢.٤٢	٢.٤٨	١.٣١	١.٣٨	٣.٧٣	٣.٨٦	١.٨٣	١.٩٢
Spraying potassium silicate at ٠.٠٥ % twice	١٧.٤	١٧.١	٢.٦٥	٢.٧١	١.٤١	١.٤٨	٤.٠٦	٤.١٩	١.٩٥	٢.٠٦
Spraying potassium silicate at ٠.١ % twice	١٧.٨	١٧.٥	٢.٨٩	٢.٩٥	١.٤٩	١.٥٦	٤.٣٨	٤.٥١	٢.١١	٢.١٩
Spraying potassium silicate at ٠.٢ % twice	١٧.٩	١٧.٦	٢.٩٠	٢.٩٦	١.٥٠	١.٥٦	٤.٤٠	٤.٥٢	٢.١٣	٢.٢٠
Spraying potassium silicate at ٠.٠٥ % thrice	١٧.٥	١٧.٢	٢.٦٦	٢.٧٢	١.٤٢	١.٤٩	٤.٠٨	٤.٢١	١.٩٦	٢.٠٧
Spraying potassium silicate at ٠.١ % thrice	١٧.٩	١٧.٦	٢.٩٠	٢.٩٥	١.٥٠	١.٥٦	٤.٤٠	٤.٥١	٢.١٢	٢.٧٠
Spraying potassium silicate at ٠.٢ % thrice	١٨.٠	١٧.٧	٢.٩٢	٢.٩٧	١.٥١	١.٥٧	٤.٤٣	٤.٥٤	٢.١٤	٢.٢٢
Revised L.S.D at ٥ %	٠.٢	٠.٢	٠.١٥	٠.١٥	٠.٠٩	٠.٠٨	٠.٢١	٠.٢٢	٠.١١	٠.١٢

The highest values were recorded with using potassium silicate thrice at ٠.٢ %. The lowest values were recorded in untreated plants. Similar results were announced during both seasons.

The important role of silicon on enhancing uptake of nutrients especially N and Mg as well as its positive action on enhancing metabolism of plants (Epstein, ١٩٩٩) could explaine the present results.

These results are in approval with those obtained by Kanto (٢٠٠٠) and Qin and Tian (٢٠٠٤).

From the previous mention results, it could be suggested that spraying potassium silicate twice at ٠.١ % on sunflower plants can improve seed, straw and oil yield in addition to seed quality.

REFERENCES

Agarie, S.; Hanaoka, N.; Ueno, O.; Miyazaki, A. Kubota, E.; Agata, W. and Kaufman, P. B. (١٩٩٨): Effect of silicon on tolerance to water deficit and heat stress in rice plants (*Oyza sativa* L.), monitored by electrolyte leakage. Plant Prod. Sci., ١. ٩٦ – ١٠٣.

Ahmed, R.; Zaheer, S. and Ismail, S. (١٩٩٢): Role of silicone in salt stress tolerance of wheat (*Triticum aestivum* L.). PL Sci. ٨٥: ٤٣ – ٥٠.

A. O. A. C. (١٩٩٥): Official Methods of Analysis ١٦th Ed, A.O.A.C Benjamin Franklin Station, Washington, D.C, U.S.A. pp ٤٩٠ – ٥١٠.

Bremner, P. M. and Taha, M. A. (١٩٦٦): Studies in potato agronomy. The effect of variety, seed size and spacing on growth, development and yield. J. of Agric. Sci. ٦٦: ٢٤١ – ٢٥٢.

Cottenie, A; Verloo, M.; Velghe, M. and Camerlynck, R. (١٩٨٢): Chemical Analysis of Plant and Soil. Laboratory of Analytical and Agro chemistry. State Univ. Ghent, Belgium.

Epstein, E. (١٩٩٩): Silicon. Annual Rev. of Plant Physiology and Plant molecular Biology. ٥٠: ٦٤١ – ٦٦٤.

Epstein, E. and Bloom, A. J. (٢٠٠٣): Mineral nutrition of plant, principles and perspectives. ٢nd Ed. John Wiley & Sons, New York pp ١ – ١٢٠.

Food and Agriculture Organization of the United Nations (FAO) (٢٠١١): Production Year Book, ٥٦ pp. ١٤٦.

Hymowitz, T. F.; Collins, P. and Walker, W. M. (١٩٧٢): Relationship between the content of oil, protein and sugar in soybean seed. Agronomy J. ٦٤: ٦١٣ – ٦١٦.

Kanto, T. (٢٠٠٢): Research of silicate for improvement of plant defense against pathogens in Japan. Abstract of Second Silicon in Agriculture Conference p. ٢٢ – ٢٦.

Liang, Y.; Shen, Q.; Shen, Z. and Ma, T. (١٩٩٦): Effect of silicon on salinity tolerance of two barley cultivar. J. Plant Nutr. ١٩. ١٧٣ – ١٨٣.

Ma, J. F. (٢٠٠٢): Silicon requirement for rice. Res. Instit. for Bioresources Okayama Univ., Clw ٠٢ – ٢٠ – ١, Kurashiki, ٧١٠ – ٠٠٤٦. Japan.

Ma, J. F. and Takahashi, E. (٢٠٠٢): Soil, Fertilizer and Plant. Silicon Research in Japan. Elsevier Science, Amsterdam, the Netherlands p ١ – ٢٠٠.

Ma, J. F.; Miyake, Y. and Takahashi, E. (٢٠٠١): Silicon as a beneficial effect for crop plants. In Silicon Agriculture (Datnoff, L.E; Snyder, G. H. and Korndofer, G. H.) pp ١٧ – ٤٠, Elsevier Amsterdam.

Matichenkov, V. V.; Calvert, D. V. and Snyder, G. H. (٢٠٠٠): Prospective of silicon fertilization for citrus in Florida. Proc. Soil and Crop Sci. Soc. of Florida ٥ p: ١٣٧ – ١٤١.

Mead, R.; Currow, R. N. and Harted, A. M. (١٩٩٣): Statistical Methods in Agriculture and Experimental Biology. Second Ed. Chapman & Hall London. pp ١٠ - ٤٤.

Moran, R. (١٩٨٢): Formula determination of chlorophylls pigments extracted with N-N -dimethyl-Formamide. Plant Physiol., ٦٩: ١٣٧٦ – ١٣٨١.

Neumann, D. and Zur-Nieden, U. (٢٠٠١): Silicon and heavy metal tolerance of higher plants. Phytochemistry, ٥٦,٦٨٥ – ٦٩٢.

Qin, Z. and Tian, S. P. (٢٠٠٤): Enhancement of biocontrol activity of *Cryptococcus laurentii* by silicon and the possible mechanisms involved. Phytopathology ٩٥: ٦٩ – ٧٥.

Seiler, G. T (٢٠٠٧): Wild annual *Helianthus anomalous* and H. eleserticola for improving oil content and quality in sunflower. Industrial Crops and Products ٢٥: ٩٥ – ١٠٠.

Zeyen, R. J. (٢٠٠٢): Silicon in plant cell defenses against cereal powdery mildew disease. Abstract of second silicon in Agric. Conf. p ١٥ – ٢١.

The effect of different concentrations and treatment frequencies of silicon on growth

تأثير مختلف التركيزات وتكرار معاملات السليكون على النمو ، كمية المحصول وخصائص البذرة في عباد الشمس صنف جيزة ١٠٢

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أجريت هذه التجربة خلال موسمى نمو ٢٠١١ ، ٢٠١٢ لدراسة تأثير مختلف التركيزات صفر ، ٠,٠٥ ، ٠,١ ، ٠,٢ % وعدد مرات الرش (مرة واحدة ، مرتان ، ثلاثة مرات) بمادة سليكات البوتاسيوم كمصدر السليكون (١٠ % أكسيد بوتاسيوم ، ٢٥ % أكسيد السليكون) على النمو ، كمية المحصول ومكوناته في عباد الشمس صنف جيزة ١٠٢.

أشارت نتائج الدراسة إلى أن الرش الورقي لسليكات البوتاسيوم بتركيز ما بين ٠,٠٥ إلى ٠,٢ % مرة واحدة ، مرتان أو ثلاثة مرات يكون له تأثير واضح على جميع صفات النمو الخضري وكمية محصول البذرة والتبن والزيت/ الفدان وكذلك خصائص الجودة للبذرة مقارنة بمعاملة الكنترول. وكان التحسن مرتبطاً بزيادة التركيز وعدد مرات الرش المستخدمة وكانت التأثيرات طفيفة على جميع الصفات تحت الدراسة بزيادة التركيز المستخدم من ٠,١ إلى ٠,٢ % وعدد مرات الرش من اثنان إلى ثلاثة مرات.

بوجه عام فإن اكبر كمية محصول لفدان (بذرة وتبن وزيت) لعباد الشمس صنف جيزة ١٠٢ يمكن تحقيقها عند رش النباتات مرتان في الموسم بسليكات البوتاسيوم بتركيز ٠,١ %.