Effect of Spraying Some Organic and Inorganic Components on Improving Yield and Tuber Quality of Potato Plants during Late Winter Season

Nadia M. Ibrahim[1] and Hatem M. Ashour[2]

[1]Dept. of Potato and Vegetatively Propagated Crops, Hort. Res. Inst., A. R. C., Egypt.
[2] Agric. Botany Dept., Fac. of Agric. Ain Shams Univ., Shoubra El-Kheima, Cairo, Egypt.
nadia_mohamed33@yahoo.com

Abstract This study was conducted at a private farm, El Mansoura, Dakahlia Governorate, Egypt during the two winter successive seasons of 2013/2014 and 2014/2015 to investigate the effect of some organic and inorganic components, i.e., potassium silicate (2000, 4000 and 6000 ppm), diatomite (10000, 15000 and 20000 ppm) and seaweed extracts (3, 4 and 5 cm/l) beside control on vegetative growth, yield and its components, as well as, chemical constituents of potato cv. Diamant. The obtained results revealed that the highest values for vegetative growth, i.e., stem length, number of stems and leaves, foliage fresh and dry weight /plant were obtained for diatomite at 20000 ppm and potassium silicate at 6000 ppm. Data also exhibited that diatomite at 20000 ppm following by potassium silicate at 6000 ppm produced the highest total and marketable yield per plant and per fed. Average tuber weight and specific gravity recorded the highest values using diatomite at 20000 ppm in addition to starch and silicon of tubers, total chlorophyll, nitrogen, phosphorus and potassium of leaves contents. In general, the best foliar application treatment was diatomite with 20000 ppm followed by potassium silicate at 6000 ppm which reflected the highest growth, yield per fed. and chemical contents in tubers.

[Nadia M. Ibrahim and Hatem M. Ashour. **Effect of Spraying Some Organic and Inorganic Components on Improving Yield and Tuber Quality of Potato Plants during Late Winter Season.** *Nat Sci* 2017;15(10):27-33]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 4. doi:10.7537/marsnsj151017.04.

Key words: Potato, Diatomite, Potassium Silicate, Seaweed extracts, Silicon, Chlorophyll and yield.

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the most popular and favorite vegetable crops cultivated for local market and exportation. The cultivated area in Egypt was about 867091 fed. and production 10003971 ton in Winter season of 2014/2015 **(FAO, 2014/2015)**. Besides, Potato tubers are rich in starch, proteins, vitamins, minerals, organic acids and antioxidants **(Lachman and Hamouz, 2005. and Qadri, *et al.*, 2015).**

Silicon is considered as an important beneficial element as it helps in growth and development of plant. The role of silicon in plant biology is known to tolerate multiple stresses including biotic and abiotic stresses. It is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels regulating transpiration rates **(Melo *et al.*, 2003).** The highest weight and size of tomato fruits were obtained from plants treated with Silicon at 50 and 100 mg\l **(Darshani and Dilshan 2015)**. **Ismail and Mubarak (2016)** showed that there was a positive correlation with plant height, number of leaves, fruit weight, yield, chlorophyll content, NPK and silicon contents of strawberry plants treated with potassium silicate.

Diatomite, being mostly chemically composed of SiO_2 (86-89%) and small amount of trace elements, it is considered as a complete fertilizer. Moreover, it has a multi- functional purpose as it improves the physical structure of soil by breaking up heavy based soil and retaining moisture in light or sandy soil for longer period (absorb up to 200% of its weight in water) without interfering with soil chemistry nor breaking down or decomposing like other growing medium. It also increases crop production and quality and help restore heavy metals and hydrocarbon polluted areas **(Kruger, 2006).** Moreover, **Abdalla (2010)** showed that increasing the concentration of diatomite in the soil, elevated each of the photosynthetic rates, the stomatal conductance of leaf relative humidity in Vicia faba leaves, whereas it reduced the transpiration rates. In addition, **Franscinely *et. al*., (2011)** found that the application of diatomaceous earth (DE) provide protection to potato plants. Likewise, The best treatments measured by crop yields were diatomaceous earth with compost for beans and potatoes, diatomaceous earth with compost treatment shows significant differences, probably for nutrient deficiencies **(Escobar *et.al.*, 2014).**

The seaweed concentrate (SWC) is rich in enzymes, hydrolyzed protein complexes, cytokinins, auxins, gibberlins, ascorbic acid, folic acid, Fe, Mn, Cu, Zn and mannitol. cytokinins, a class of phytohormones, function as antioxidants and have shown to improve drought resistance and seedling establishment, rooting, flowering, fruit production and yield **(Crouch and Staden 1994).** The effect of SWC on plant growth often depends on the concentrations used and the mode of application. Plant resistance to diseases provided by seaweed extracts is due to the antimicrobial activity of seaweeds against bacteria, yeast, and moulds, whereas, the increased plant growth, yield and quality is resulted from the influence of these extracts on cell metabolism via the induction of the synthesis of antioxidant molecules which could improve plant growth and plant resistance to stress **(Zhang and Schmidt, 2000).** In addation, **Blunden and Paul (2006)** sprayed potato plants with seaweed extracts, they found that there was a significant increase in total yield.

This experiment has been done to study the effect of foliar application of silicate potassium, diatomite and seaweed extracts on the vegetative growth and seed yield as well as the chemical constituents of potato plants growing in late winter season.

2. Materials and Methods

This study was conducted during the two winter season of 2013/2014 and 2014/2015 at a private farm, El Mansoura, Dakahlia Governorate. Tuber seeds of potato (*solanum tuberosum* L) cv. Diamant were used. The whole seed tubers were planted, on 11 and 16 of November in the first and second seasons, respectively, and harvested at 105 days from planting in the two seasons.

The average temperatures, relative humidity and sunshine of location are shown in Table (1).

Table (1): Location weather monthly data of average maximum and minimum temperatures, average relative humidity and sunshine during 2013 and 2014 in El- Dakahlia Governorate.

	2013/2014				2014/2015			
	Temperature (°C)		Relative humidity (%)	sunshine hours	Temperature (°C)		Relative humidity (%)	Sunshine hours
Month	min	max	Average	Average	min	max	Average	Average
November	10.00	29.60	82.80	7.30	11.50	28.10	88.10	7.90
December	9.20	28.10	86.90	6.50	9.10	22.00	89.10	7.20
January	9.50	25.00	82.10	6.80	9.30	23.10	84.30	7.50
February	8.40	27.80	85.80	7.60	8.50	29.50	86.10	8.70

These data coated from Central Laboratory for Agricultural Climate (CLAC)

Each plot area was 17.5 m^2 comprising of five rows 0.70 m width and 5 m length and tubers were planted on 25 cm spacing. The treatments were arranged in a randomized complete block design with three replicates. In addition, 35 m^3 farm yard manure plus 90 kg P_2O_5/fed. were mixed together and added during soil preparation. Potato plants were supplied with ammonium sulphate (20.6%N) as a source of nitrogen fertilizer was added at a rate of 150 kg N/fed. into two equal portions added at 40 and 60 days after planting. Potassium fertilizer was added as potassium sulphate (48 % K_2O) at a rate of 96 kg K_2O/fed., half of the total potassium amount was applied before planting (during soil preparation), whereas the rest of potassium was added at complete plant emergence (40 days after planting). Foliar spraying treatments were applied twice, at 45 and 65 days after planting.

The experiment included nine treatments as follows:- Potassium silicate at 2000, 4000 and 6000 ppm, diatomite at 10000, 15000 and 20000 ppm and seaweed extracts at 3,4 and 5 m/L in addition to control (tap water).

A commercial diatomite source from china product was used. Diatom contains SiO2 (91%), TiO_2 (0.13%), Al_2O_3 (3.12%), Fe_2O_3 (1.44%), MgO (0.27%), CaO (0.11%), Na_2O (2.22%), K_2O (0.51%).

A commercial seaweed extract product was used. Seaweed extract contains N (1%), K (2.5%), Ca (0.17%), Mg (0.43%), Fe (0.06%), S (2.2%), Zn 0.99 ppm, Boron 3.87 ppm alganic acids (10-12%) and plant hormones (500 ppm).

Data collected:

Vegetative growth parameters:

A random sample of five plants were taken at 75 days after planting for determination of vegetable growth, i.e., stem length, number of leaves /plant, number of main stems /plant, foliage fresh and dry weight.

Total yield and its component:-

- Total tuber yield as g /plant, and ton /fed., Marketable yield as g/plant and tons/fed., which included all tubers weighting >50 gm in weight were recorded for each plot.

- Average tuber weight (g) and specific gravity of potato tubers was determined using the method of **kleinkopf and Wassermann (1987).**

3-Chemical contents:

a-dry matter (%): One hundred grams of fresh tubers from each experimental plot were weighed, dried in an oven at 70°C until constant weight and the dried tubers were weighed. The dry matter weight / 100g fresh weight of tubers was then calculated.

b- Total chlorophyll content:- It was measured by a Minolta SPAD unit chlorophyll meter.

c-Starch content was determined using the method of **A.O.A.C. (1990).**

d- Mineral contents: Silicon, nitrogen, phosphorus and potassium were determined in the digested dry matter of leaves as follows:

-Silicon concentration: It was determined with an inductively coupled plasma (ICP) spectrometer according to **Stefansson (2007)**.

-Total nitrogen was determined according to **Kock and Mcmeekin (1924).**

-Phosphorus content was determined according to **Troug and Meyer (1939).**

-Potassium percentage was determined by using Flame photometer according to **Brown and Lilliland (1946).**

4-Statistical analysis:

Data were subjected to statistical analyzed according to the procedure described by **Snedecor and Cochran (1982).**

Results and Discussion

1- Vegetative growth:

Data presented in Table (2) clearly showed that stem length was significantly increased with increasing the rate of diatomite at 20000 ppm without significant difference with potassium silicate at 6000 ppm compared with untreated plants and Seaweed extract at 4 m/L. Spraying of diatomite at 20000 ppm caused significant effect on number of leaves per plant compared with the other treatments. In addition, it gaves the highest value of stem number per plant in both seasons.

Results in the same table indicated that foliar spray with diatomite at 20000 ppm significantly increased foliage fresh weight per plant following by potassium silicate at 6000 ppm compared with control treatment. Furthermore, foliage dry weight % was increased in plants treated with diatomite at 20000 ppm and potassium silicate at 6000 ppm compared with untreated plants in the first and second seasons. These results may be due to using the highest rate of diatomite which leads to enrichment plants with silica which enhanced photosynthetic and development of chlorophyll **(Flörke *et al.*, 2000).**

Table (2): Effect of some organic and inorganic components on vegetative growth of potato plants during 2013/2014 and 2014/2015seasons.

	stem length (cm)		No.of leaves/plant		No.of main stem /plant		Foliage fresh weight/plant (g / plant)		Foliage dry weight/plant %	
Treatments	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
T1	30.00 H	28.67 DE	22.33 G	24.64 E	1.83 E	2.43 D	234.49 E	244.74 D	23.23 E	23.94 D
T2	36.67 EF	29.50 DE	23.67 FG	27.79 DE	1.93 DE	2.83 CD	245.5 D	252.78 CD	25.12 DE	27.54 BC
T3	40.67 DE	39.00 BC	26.00 DEF	29.67 D	2.13 CDE	3.00 BCD	265.66 C	254.83 CD	26.49 CD	28.27 B
T4	51.33 B	41.83 AB	36.33 B	43.67 B	2.73 B	4.00 AB	320.73 B	323.02 A	30.05 AB	32.45 A
T5	42.33 CD	33.00 D	28.67 D	31.67 D	2.12 CDE	3.23 BCD	260.63 C	252.48 CD	27.56 BCD	25.46 CD
T6	45.33 C	33.50 D	32.67 C	29.68 D	2.17 CD	3.00 BCD	264.30 C	295.10 B	26.94 CD	27.13 BC
T7	71.67 A	45.33 A	43.33 A	50.67 A	3.23 A	4.43 A	341.57 A	332.40 A	31.92 A	32.58 A
T8	34.33 FG	29.60 DE	27.67 DE	38.00 C	2.23 CD	3.23 BCD	232.70 E	279.03 BC	26.21 CD	26.33 BCD
T9	32.00 GH	27.50 E	21.33 G	37.33 C	2.10 CDE	3.57 ABC	232.27 E	282.10 B	25.27 DE	28.38 B
T10	36.33 F	33.75 CD	24.67 EFG	32.00 D	2.33 C	3.97 AB	258.51 C	287.5 B	28.42 BC	28.25 B

Means in each column, followed by similar letter (s) are not significantly different at 5% probability Level, using Duncan's Multiple Range Test

T1=Control T2= potassium silicate (2000 ppm) T3= potassium silicate (4000 ppm) T4= potassium silicate (6000 ppm) T5= diatomite (10000 ppm) T6= diatomite (15000 ppm) T7= diatomite (20000 ppm) T8= Seaweed extracts (3m/L) T9= Seaweed extracts (4m/L) T10= Seaweed extracts (5m/L).

These results are in agreement with **Liang *et al.*, (2007)** they showed that the application of silicon gave increasing in growth of maize. Also, it stimulates both the fresh and dry weights in squash **(Savvas *et al.*, 2009).** In addition, **Abdalla (2010) and Freita *et al.*, (2011.)** found that the highest concentration of diatomite and silicon displayed the highest growth rates and increased production of potato plants**.**

2- Yield and its components:

Regarding the effect of organic and inorganic components, data presented in Table (3) illustrated that foliar application of diatomite at 20000 ppm significantly increased total tuber yield per plant without significant differences compared with the potassium silicate at 6000 ppm. This increase reached 1.90 or 1.63 kg/plant compared with control treatment that recorded 0.55 kg/plant. In addition, the highest values of total tuber yield per fed. were produced by treatment received diatomite at 20000 ppm, since it increased their values by 15.80 and 15.48 t/fed. in the first and second seasons, respectively. The second treatment regarding the increase in tuber yield per fed. was potassium silicate at 6000 ppm. While, the lowest value of total tuber yield per fed. was recorded the untreated plants (9.94 t/fed.). Such results are similar to **Escobar *et. al.*, (2014)** who showed that the best treatments measured by crop yields were diatomite with chemical fertilizer for carrots and potatoes.

Table (3): Effect of some organic and inorganic components on yield of potato plants during 2013/2014 and 2014/2015 seasons.

Treatments	Total yield/plant (kg/plant)		Total yield/fed (ton) (ton/fed.)		Marketable yield/plant (g/plant)		Marketable yield/fed (ton/fed.)		Average tuber weight (g)	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
T1	0.55 I	0.51 D	9.94 I	9.50 F	389.00 H	405.00 F	7.14 I	8.14 E	75.96 H	75.55 F
T2	0.77 D	0.89 B	13.43 D	13.96 B	551.68 F	698.17 C	10.64 D	11.76 B	79.80 G	113.45 E
T3	0.86 C	0.86 B	13.82 C	13.41 BC	746.33 C	721.33 BC	11.27 C	11.56 BC	88.92 F	148.20 BC
T4	1.63 AB	1.60 A	14.45 B	16.19 A	785.00 B	901.05 A	12.78 AB	12.73 A	108.24 B	165.48 AB
T5	0.66 GH	0.85 B	11.15 H	13.84 BC	499.00 F	769.97 B	9.84 FG	11.32 BC	91.49 DE	164.40 AB
T6	0.72 E	0.75 C	11.73 G	12.34 DE	620.67 D	645.67 DE	9.71 G	10.02 D	94.00 C	166.42 A
T7	1.60 A	1.90 A	15.80 A	15.48 A	895.67 A	943.00 A	13.18 A	13.10 A	148.29 A	174.62 A
T8	0.65 H	0.76 C	12.69 E	13.44 BC	430.00 G	670.08 CD	10.06 EF	10.85 C	94.04 CD	161.19 AB
T9	0.68 F	0.75 C	10.85 H	11.68 E	505.00 F	603.33 E	8.66 H	9.44 D	89.49 EF	127.14 DE
T10	0.67 FG	0.82 BC	12.24 F	13.06 CD	551.67 E	696.75 CD	10.18 E	11.07 BC	66.76 I	132.23 CD

Means in each column, followed by similar letter (s) are not significantly different at 5% probability Level, using Duncan's Multiple Range Test

T1=Control T2= potassium silicate (2000 ppm) T3= potassium silicate (4000 ppm) T4= potassium silicate (6000 ppm) T5= diatomite (10000 ppm) T6= diatomite (15000 ppm) T7= diatomite (20000 ppm) T8= Seaweed extracts (3m/L) T9= Seaweed extracts (4m/L) T10= Seaweed extracts (5m/L).

The obtained data in Table (3) showed that increasing diatomite at 20000 ppm gave significant effects on marketable tubers per plant over 50 mm in diameter followed by potassium silicate at 6000 ppm compared with the other treatments. In addition, diatomite at 20000 ppm gave the significant values of the studied parameter of marketable yield per fed. the highest values were 13.18 and 13.10 t/fed. in the first and second seasons, respectively. This increase was not significant as compared to the potassium silicate at 6000. ppm It is worthily to mention that foliar application of potassium silicate at 6000 ppm was the most favorable Si rate for increasing marketable yield per fed compared with the untreated plants. This increase of yield may be due to diatomite contains the sedimentary deposit of silica-rich ($SiO2$ 86-89%) diatom frustules and Silicon is effectively on chilling and freezing stresses **(Flörke, *et al.*, 2000, Kruger, 2006 and Liang *et al.*, 2007)**. These results are in agreement with those obtained by **Liang *et al.*, (2007), Crusciol *et. al.*, (2009), Freita *et. al.*, (2011) and Escobar *et. al.*, (2014)** recorded that increasing the application of diatomite and increasing of Si rate gave the highest values of yield.

Data presented in Table (3) demonstrate also that significant effects on average tuber weigh were obtained with foliar application of diatomite compared with the other treatments in the first season. Moreover, the highest values of average tuber weight were obtained due to the foliar application of diatomite at 10000, 15000 and 20000 ppm without significant differences with potassium silicate at 6000 ppm and seaweed extract at 3 m/L compared with untreated plants in the second season. **Freita *et. al.*, (2011)** found that foliar silicon improved potato quality. Moreover, the weights of tomato were higher in the fruits from plants treated with Si (**Darshani and Dilshan 2015).**

It is evident from the results in Table (4) that the foliar application of diatomite at 20000 or 15000 ppm and potassium silicate at 6000 ppm produced the highest specific gravity of potato tubers in the both seasons. On the other hand, the lowest value was detected to foliar application of seaweed extract.

3- Chemical content:

a- Dry matter:

It is obvious from Table (4) that the foliar application of potassium silicate at 6000 ppm significantly increased dry matter of tubers in the first season. The second treatment regarding the increase in dry matter % was diatomite at 20000 ppm compared with untreated plants. Moreover, significant increment on dry matter % was obtained under both of potassium silicate at 6000 ppm or diatomite at 20000 ppm compared with other treatments, in the second season.

b-Total chlorophyll of leaves:

Data presented in Table (4) showed that increasing diatomite rates exerted significant increment in total chlorophyll of potato leaves in both seasons. Maximum value of total chlorophyll of potato leaves was obtained from the foliar application of diatomite at 20000 in the two seasons. While, the minimum value was obtained from the untreated plants in both seasons. These results could be due to the role of silicon which enhanced photosynthetic and development of chlorophyll. Moreover, the synergistic effect of Si on photosynthesis and chlorophyll content improved markedly the carbohydrate biosynthesis, the supply of cell wall material e.g. cell wall polysaccharides and lignin polymers and eventually the dry matter production **(Savant *et al.,* 1997; Rodrigues *et al.,* 2005)**.

These results are consistent with those obtained from **Nwugo and Huerta, (2008)**, **Abdalla (2010) and Freita *et. al.* (2011)**.

c- Starch content of tubers:

Results in Table (4) appeared that foliar application of potassium silicate at 6000 ppm or diatomite at 20000 ppm recorded the highest values of starch content of tubers, since it increased their values by 14.67 % and 14.48 % in the two growth seasons, respectively. On the other hand, the lowest value of starch content of tubers was obtained from plants supplied with the seaweed extract at 5ml / L in the two tested seasons.

Table (4): Effect of some organic and inorganic components on chemical of potato during 2013/2014 and 2014/2015 seasons.

Treatments	Specific gravity (%) of tubers		Dry matter (%) of tubers		Starch (%) of tubers		Total chlorophyll (%) of leaves	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
T1	1.073 BC	1.075 C	17.78 H	17.54 E	12.70 D	11.46 D	25.35E	26.39 DE
T2	1.094 A	1.053 D	20.12 EF	19.11 CD	13.58 C	11.42 D	24.84 F	23.72 G
T3	1.070 BC	1.086 B	21.58 C	19.77 BC	14.04 B	12.52 C	27.63 C	28.06 C
T4	1. (096 A	1.097 A	24.76 A	22.02 A	14.67 A	14.61 A	29.27 B	31.33 A
T5	1.070 BC	1.084 B	20.09 EF	18.21 DE	14.39 AB	13.59 B	24.17 H	25.76 EF
T6	1.086 AB	1.095 A	20.28 E	18.88 CD	12.80 D	13.63 B	29.19 B	30.40 B
T7	1.095 A	1.093 A	22.03 B	20.87 AB	14.47 AB	14.48 A	29.84 A	31.88 A
T8	1.066 BC	1.81 B	19.06 G	18.87 CD	12.70 D	15.08 B	25.90 D	27.21 CD
T9	1.067 BC	1.066 D	19.97 F	19.81 BC	11.14 E	12.53 C	24.38 G	25.17 F
T10	1.063 C	1.04 E	20.55 D	20.35 B	11.39 E	11.13 D	25.26 E	26.06 E

Means in each column, followed by similar letter (s) are not significantly differ ent at 5% probability Level, using Duncan's Multiple Range Test

T1=Control T2= potassium silicate (2000 ppm) T3= potassium silicate (4000 ppm) T4= potassium silicate (6000 ppm) T5= diatomite (10000 ppm) T6= diatomite (15000 ppm) T7= diatomite (20000 ppm) T8= Seaweed extracts (3m/L) T9= Seaweed extracts (4m/L) T10= Seaweed extracts (5m/L).

d- Silicon content of tubers:

Table (5): Effect of some organic and inorganic components on Silicon of tuber, N, P and K of potato leaves during 2013/2014 and 2014/2015 seasons.

Treatments	Silicon (%) of tubers		N %		P%		K%	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
T1	0.95 I	1.05 F	2.32 F	2.48 G	0.22 I	0.23 F	2.37 G	2.64 G
T2	1.53 F	1.76 D	2.58 E	2.73 E	0.26 F	0.29 C	2.69 D	2.97 D
T3	1.78 E	1.90 D	2.73 CD	2.87 C	0.25 G	0.27 D	2.85 C	3.19 BC
T4	2.16 B	2.29 B	2.93 B	2.94 B	0.66 C	0.29 C	3.15 A	3.24 A
T5	2.05 C	1.78 D	2.39 F	2.64 F	0.67 B	0.31 B	2.93 B	3.16 C
T6	1.97 D	2.09 C	2.86 B	2.87 CD	0.58 D	0.29 C	2.94 B	3.19 BC
T7	2.45 A	2.49 A	3.03 A	3.17 A	0.85 A	0.32 A	3.24 A	3.21 AB
T8	1.82 E	1.88 D	2.67 D	2.77 DE	0.23 H	0.29 C	2.62 E	2.78 F
T9	1.06 H	1.08 F	2.68 CD	2.81 D	0.29 E	0.26 E	2.50 F	2.75 F
T10	1.34 G	1.40 E	2.76 C	2.83 CD	0.26 F	0.27 D	2.57 E	2.85 E

Means in each column, followed by similar letter (s) are not significantly different at 5% probability Level, using Duncan's Multiple Range Test

T1=Control T2= potassium silicate (2000 ppm) T3= potassium silicate (4000 ppm) T4= potassium silicate (6000 ppm) T5= diatomite (10000 ppm) T6= diatomite (15000 ppm) T7= diatomite (20000 ppm) T8= Seaweed extracts (3m/L) T9= Seaweed extracts (4m/L) T10= Seaweed extracts (5m/L).

Data shown in Table (5) indicate that foliar application of diatomite at 20000 ppm had significant effect on the silicon content of tuber and this increase reached to 2.45% and 2.49% in both seasons, respectively. The second treatment regard the increased in silicon content of tuber was potassium silicate at 6000 ppm. On the other hand, silicon content of tuber significantly decreased in untreated plants. The results are in harmony with those reported by **Chen *et al.* (2000)** who found that tissue analysis from a wide variety of plants had Si concentrations ranged from 0.2 to 10 percent, depending on plant species. Furthermore, **Freita *et. al.* (2011)** appeared that the foliar application of silicon gave the highest value of leaf silicon content of potato.

e- Nitrogen, phosphorus and potassium contents of leaves:

The effect of organic and inorganic components on NPK concentration (Table 5) revealed that the highest values of N and P concentrations were recorded from plants sprayed with diatomite at 20000 ppm in the two growth seasons. In addition to, foliar application of potassium silicate at 6000 ppm or diatomite at 20000 ppm which gave the highest values of potassium content of potato leaves in both seasons. On the other hand, the lowest values of NPK concentrations in leaves were obtained under the untreated plants in the two seasons. These findings are in agreement with those reported by **Ma *et al.* (2001)** who found that soil treatment with Si substances, like diatomite, optimizes fertility through improved water, physical and chemical soil properties and maintenance of nutrients in plant -available form. Furthermore, Increasing of Si reduced electrolyte leakage percentage thus increasing the element content of tissues **(Zhu *et al.*, 2004 and Nwugo and Huerta, 2008)**. Moreover, **Abdalla (2010)** showed that application of diatomite apparently raised the values of each of total nitrogen, phosphorus, potassium, compared with the untreated plants.

Conclusion:

The previous results in this investigation concluded that foliar application of potato plants with diatomite at 20000 ppm followed by potassium silicate at 6000 ppm in late winter season were superior treatments for enhancing growth, yield and its components.

References

1. Abdalla, M. M. (2010). Sustainable effects of diatomite on the growth criteria and phytochemical contents of *Vicia faba* plants. Agric. Biol. J. N. Am., 2010, 1(5):1076-1089.
2. A.O.A.C. (1990). Association of official analytical chemist "s Official method of analysis 15^{th} Ed., Washington, D. C., USA., pp:771.
3. Blunden, G. and P. B. Paul (2006). “The effect of aqueous seaweed extracts and kinetin on potato yields”, Journal of the Science of food and Agriculture, Vol. 28(2), pp. 535-543.
4. Brown, J.D. and O. Lilliland. (1946). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometry. Proc. Amer. Soc. Horticulture. Sci., 48: 341 – 346.
5. Chen, J., R. D. Caldwell, C.A. Robinson, and R. Steinkamp (2000). Lets put the Si back into the soil. Part I. Plant Nutrition 4:44-46.
6. Crouch, I.J. and J. Van Staden. (1994). Commercial seaweed products as bio stimulants in horticulture. J. Home Consumer Horticulture 1: 19-76.
7. Crusciol, C. A. C., A. L. Pulz, L. B. Lemos, R. P. Soratto, and G. P. P. Lima (2009). Effects of silicon and drought stress on tuber yield and leaf biochemical characteristics in potato. Crop Science.. 49(3): 949-954.
8. Darshani W. and D. Dilshan (2015). Effect of silicon and potassium on tomato anthracnose and on the postharvest quality of tomato fruit (*Lycopersicon esculentum* Mill.). J. Natn. Sci. Foundation Sri Lanka 43 (3):273-280.
9. Escobar, N., J. Espejo and L. Rodríguez (2014). Evaluation of the effect of diatomaceous earth as a sustainable alternative in commercial interest crops in Colombia. WIT Transactions on Ecology and The Environment, 181:409-418.
10. Flörke OW, Graetsch HA, Brunk F, Benda L, Paschen S, Bergna. Silica. In: Ullmann’s encyclopedia of industrial chemistry. 2000. http://online library.wiley.com/doi/10.1002/14356007.a23_583/abstract; Wiley-VCH Verlag GmbH & Co. KGaA.
11. Franscinely, A. A., C. M. Jair, M. N. Amanda and F. Jonas (2011). Effects of Diatomaceous earth on *Diabrotica speciosa* (Germar, 1824) Ciênc. (*Coleoptera: Chrysomelidae*) in potato. agrotec., Lavras, v. 35, n. 3, p. 482-486.
12. Freitas, L. B., E. M. Coelho, S. C. M. Maia, and T. R. B. Silva (2011). Foliar fertilization with silicon in maize. Revista Ceres. 58 (2): 262-267.
13. Kleinkopf, G. E. and D. T. Wassermann (1987). Specific gravity of Russet Burbank potatoes. American Potato Journal, 64: 579-587.
14. Koch, F.C. and T.L. McMeekin (1924). A new direct Nesslerization micro-Keldahl method and a modification of the Nessler folin reagent for ammonia. J. Amer. Chem. Soc. 46:2066.

15. Kruger, G. (2006). Certification decision for Diatomite de Mozambique code 1959ZA 0600R1 e doc. South Africa. Ecocert Interational. 1,3.
16. Lachman J. and K. Hamouz (2005). Red and purple coloured potatoes as a significant antioxidant source in human nutrition – a review. Plant Soil Environ. 51(11): 477-482.
17. Liang, Y., W. Sun, Y. G. Zhu and P. Christie, (2007). Mechanisms of silicon- Mediated alleviation of abiotic stresses in higher plants: A review. Environmental Pollution,147: 422-428.
18. Melo, S. P., G. H. Korndorfer, C. M. Korndorfer, R. M., Lana, and D. G. Santan (2003). Silicon accumulation and water deficient tolerance in grasses. *Scientia Agricola*. 60: 755-759.
19. Ma, J.F.; Miyake, Y. and E. Takahashi (2001). Silicon as a beneficial element for crop plants *Studies in Plant Science 8,17-39.*
20. Nwugo, C. and A. J. Huerta (2008). Effects of silicon nutrition on cadmium uptake, growth and photosynthesis of rice plants exposed to low – level cadmium. Plant and Soil 311, 1-2, 73-86.
21. Ismail, S. A. and M. M. Mubarak (2016). Influence of irrigation intervals and antitranspirants on growth, yield and quality of strawberry under drip irrigation system. J. Menoufia Plant Prod., 8: 71-87.
22. F.A.O., (2014/2015). Production of Potato. FAO quarterly bulletin of Statistics- Part (2)- Summer & Nili Crops.
23. Qadri, R.W.K., I. Khan, M.M. Jahangir, U. Ashraf, G. Samin, A. Anwer, M. Adnan and M. Bashir, 2015. Phosphorous and Foliar Applied Nitrogen Improved Productivity and Quality of Potato. American Journal of Plant Sciences, 6: 144-149.
24. Rodrigues, F. A., W. M. Jurick, L. E. Datnoff, J. A. Rollins and J. B. Jones (2005). Silicon influences cytological events in compatible and incompatible rice-Magnaporthe grisea interaction. lll Silicon in Agriculture conference, 22-26 October Uberlandia / M.G- Brazil.
25. Savant, N.K., G. H. Synder and L. E. Datnoff (1997). Silicon management and sustainable rice production. Adv. Agron. 58, 151-199.
26. Savvas, D., D. Giotis, E. Chatzieustratiou, M. Bakea and G. Patakioutas (2009). Silicon supply in soiless cultivations of zucchini alleviates stress induced by salinity and powdery mildew infections. Environmental and Experimental Botany 65, 11-17.
27. Snedecor, G. W. and W. G. Cochran (1982). Statistical Methods. 7^{th} Ed. 2^{nd} printing, Lowa State Univ., Press, Ames, USA, pp507.
28. Stefansson, A. I. and N. Giroud (2007). New method for the direct determination of dissolved inorganic and tota carbon in natural waters by regent-free ion chromatography and inductively coupled plasma atomic emission spectrometry. Anal. Chim. Acta.582 (1): 69-74.
29. Troug, E. and A. Meyer (1939). Improvement in deinesscolorimetric method for phosphorus and arsenic. 1 nd. Eng., Chem., Anal. Ed., 1: 136 – 139.
30. Zhang, X. and R. E. Schmidt (2000). "Hormone containing products' impact on antioxidant status of tall fescue and creeping bentgrass subjected to drought", *Crop Sci.* Vol. 40, pp. 1344–1349.
31. Zhu, Z., G. Wei, J. Li, Q. Qian and J. Yu, (2004). Silicon alleviates salt stress and increases antioxidant enzyme activity in leaves of salt – stressed cucumber (*Cucumis sativus* L.), Plant Sci., 167,527-533.

9/9/2017