Scientific Journal of Agricultural Sciences

Print (ISSN 2535-1796) / Online (ISSN 2535-180X)

Effect of Foliar Application with Potassium Silicate and Seaweed Extract on Plant Growth, Productivity, Quality Attributes and Storability of Potato

Mahmoud A. Saleh[1], Sheren A. Atala[1] and Enas A. Bardisi[2]

[1]Postharvest and Handling of Vegetable Crops Research Department, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt
[2]Horticulture Department, Faculty of Agriculture, Zagazig University, Egypt.

Citation: Mahmoud A. Saleh, Sheren A. Atala and Enas A. Bardisi. (2024). Effect of Foliar Application with Potassium Silicate and Seaweed Extract on Plant Growth, Productivity, Quality Attributes and Storability of Potato. Scientific Journal of Agricultural Sciences, 6 (2): 78-96. https://doi.org/10.21608/SJAS.2024.293878.1432.

Publisher :
Beni-Suef University, Faculty of Agriculture

Received: 30 / 5 / 2024
Accepted: 22 / 6 / 2024

Corresponding author:
Mahmoud A. Saleh

Email:
Giza_lab2016@yahoo.com

ABSTRACT

The research was carried out to examine how foliar spraying with 1% and 2% of potassium silicate and seaweed extract (SWE) affects the vegetative growth, yield components, storability, and tuber quality of potato cv. Spunta during the summer 2022 and 2023 seasons. The results indicated that foliar spraying with SWE at 2% or potassium silicate at 2% significantly improved vegetable growth parameters (plant height, leaf area, leaf numbers per plant, fresh and dry weight/ plant, chlorophyll reading (SPAD) in leaves, yield and its components (total tubers yield, tubers weight/plant and average weight of tuber, physical and chemical properties of tubers (tuber length, dry matter, total carbohydrates and starch) compared to untreated (control). Spraying with potassium silicate at 2% gave the highest values of silicon and potassium concentrations in leaves and tubers and improved the tuber firmness. Spraying with SWE at 2% was the most effective treatment in improving the vegetative growth, yield parameters, and tuber quality. Also, this treatment extended the postharvest life of the potato tubers, which lowers weight loss, maintains the quality parameters, and gives a good appearance of tubers after 4 months of storage at 10ºC without any decay.

KEYWORDS: Potato, SWE, potassium silicate, vegetative growth, yield, quality, storability

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is considered the fourth most important global vegetable crop for local consumption and export (Muthoni and Nyamongo, 2009). Improving vegetative growth is an important reason for increasing the productivity of potato tubers of high quality and good storability. This is a goal that must be achieved by spraying plants with SWE and potassium silicate treatments. SWE contains various microelements (i.e. Cu, Zn, Mo, B, Co), and also contains auxins, gibberellins, cytokinins, and large of polyamines (Papenfus *et al.*, 2012), abscisic acid, and brassinosteroids (Stirk *et al.*, 2014), several osmoprotectants (betaine, proline, mannitol) (González *et al.*, 2013) and other components of great biological importance that encourage plants to promote nutrient absorption and translocation (Craigie, 2011).

Spraying the SWE on plants increase the ability of root growth, stem thickness, growth, and crop yield (Thirumaran *et al*., 2009), and extended the shelf life (Khan *et al*., 2009).

Miceli *et al.* (2021) found that Ecklonia maxima, which is extracted from brown algae, promote plant growth and increase crop yield, plant morphology and physiology (total biomass accumulations, expansion of leaves, intra-stomatic conduction, improvement of water use efficiency, nitrogen utilization, etc.).

SWE acts as a biostimulant for plants and is an effective and economical way to improve plant growth and tuber quality developments by increasing the efficiency of using water and available minerals (Ronga *et al.,* 2019), also, increases the absorption of many nutrients, enhances growth, and increases its resistance to frost, fungal diseases, and various stress conditions. Add to this its effectiveness in improving quality and increasing shelf life of fruits (Zodape, 2001), it also has a clear effect on plant growth, which leads to an improvement in the overall potato yield, both qualitatively and quantitatively (Sarhan, 2011).

The application of SWE to potato plants resulted in a notable improvement in various aspects of vegetable growth, such as plant height, leaf count, wet and dry weight, average leaf area, total carbohydrates, and chlorophyll levels in the leaves (Rizk *et al.*, 2018). All physical properties of potato tubers (diameter, length, volume, and specific gravity), tubers per hill, tuber yield and nutritional values were also improved.

Zaki *et al.* (2021) found that treatment with SWE at a concentration of 1% three times in a row gave the most reduced weight misfortune rate, the most noteworthy dry matter rate, and the most elevated rate of starch and protein amid the capacity period (4 months) beneath room temperature conditions.

Potassium silicate could be an awesome source of silicon and potassium and is exceedingly dissolvable. As of late, it is utilized in agrarian generation frameworks as a silica modifier, which gives sums of potassium that offer assistance increment the opportunity to exchange sugars from clears out to tubers. It is useful, especially when plants are under stresses. On the other hand, silicon enhances soil fertility, the absorption of minerals, and enhance resistance to diseases and pests, and plant growth, thus increasing yields (Crusciol *et al*., 2009), improve tuber quality (Dkhil *et al.,* 2011) and Improving the structure of plants, regulating the transpiration process, and increasing plant tolerance to toxic elements (Hou *et al*., 2006).

Talebi *et al.* (2015) found that spraying potassium silicate increases the content of soluble carbohydrates and protein in the leaves of potato plants, thus increasing the yield. Abd El-Gawad *et al.* (2017) found that spraying silicate of potassium improved the performance of plants by stimulating more than one mechanism to relieve stress on the plant, as it gave higher readings of leaf area, total chlorophyll, dry matter of leaves, total dissolved carbohydrates, starch, protein, amino acids in leaves compared to control.

Potassium silicate treatment improves plant growth of potato (cv. Lady Rosetta) and the nutrient content (NPK) of the plants, in addition to, increasing the productivity and quality compared to untreated plants. It also reduces weight loss, reduces tuber decomposition, and increases their shelf life during storage (Abou-El-Hassan *et al.*, 2020).

Spraying potassium silicate improved the overall indicators of vegetative growth, as well as content of mineral, starch in plants and tubers (Pilon *et al.*, 2014 and Salim *et al.,* 2014), increased dry matter accumulation of tubers (Vulavala *et al.*, 2016) and increased the starch content (Wadas, 2023).

Pre-harvest spraying of potassium silicate is a promising strategic treatment for fruit quality management and great control of post-harvest losses for all horticultural crops (Mohamed *et al*., 2017).

Consequently, we carried out a study to investigate how foliar spraying with varying concentrations of SWE and potassium silicate impacts the growth, yield, components, physical and chemical properties, quality, and storability of potatoes.

2. MATERIALS AND METHODS

2.1. Field experiment

The experiment was implemented during the summer years of 2022 and 2023 at the Faculty of Agriculture, Cairo University, in cooperation with the Post-Harvest Vegetables Research Department, Horticultural Research Institute (HRI), Agricultural Research Center (ARC) to determine the spraying effect of potassium silicate and seaweed extract (SWE) on vegetative growth and yield components, tuber quality and storability of potato (*Solanum tuberosum* L.). Spunta.

The physical and chemical properties of clay soils (Table 1) were analyzed at the Soil and Water Research Institute, (ARC).

Table 1. Physical and chemical characteristics of experimental soil as average of both seasons 2022 and 2023.

Physical properties				
Sand %	**Silt %**	**Clay %**	**Organic matter %**	**Texture**
18.5	21.2	57.6	2.7	Clay loam

Chemical properties								
EC m.mhos/cm	**pH**	**Cations (Meq.L^{-1})**				**Anions (Meq.L^{-1})**		
		Ca^{++}	**Mg^{++}**	**K^{+}**	**Na^{+}**	**Cl^{-}**	**HCO_3^{-}**	**SO_4^{-}**
0.89	7.8	4.6	5.4	0.8	1.1	1.0	5.1	4.5

The tubers were planted amid the primary week of February amid both think about seasons. The planning was carried out agreeing to the suggestions of the Service of Agribusiness, at that point it was isolated into plots with an range of 12.6 m2 (length 4.5 m and width 2.8 m), each piece containing 4 ridges (width 70 cm). Tubers were planted at a profundity of 15 cm and 25 cm separated on one side of the ridges, and each test plot contained 72 plants. Concentrations 1%, 2% from each medication potassium silicate and SWE were splashed foliar another to the untreated plants (spraying with water as it were) as a control. The medications were connected three times amid the development period of potato plants, beginning 30 days after planting and each 15 days. The past medications were organized in a totally randomized square plan with three replications.

The following data were recorded

Vegetative growth

Five plants from each experimental plot were randomly taken 80 days after planting to measure the growth characteristics. Plant height, leaf area, number of leaves per plant, fresh and dry weight/ plant were measured. The chlorophyll reading of the third upper leaf was measured in SPAD, where SPAD = 10 mg chlorophyll/g fresh weight using a Minolta model SPAD-502.

Si and K determined by ICP atomic emission spectrometer (Stefánsson *et al.*, 2007).

Yield component and tuber properties

The total yield per plot and tubers weight/plant were determined after 105 days form planting. Ten potato tubers were taken randomly for the average weight, tuber length, and diameter determinations. Tuber firmness, dry matter, total carbohydrates, and starch content, silicon and potassium were determined in tubers.

2.2. Storage experiment

Tubers were collected at the appropriate harvest time from each experimental plot, then transported to the laboratory, and sorting. It was packaged in a plastic net bag (weight 2 kg) and stored at 10°C and 85% relative humidity. Each replicate consists of 3 packages weighing 6 kg. Each 2 kg bag is represented in trial units (EU).

Fifteen EUs were prepared for each treatment. Samples were pooled from three replicates of each EU and randomly selected in a completely random distribution. Measurements were performed immediately after harvesting and at 0-1, 2-3 and 4-monthly intervals for the following parameters:

1. Weight loss (%): It was calculated according to the equation: = [(initial weight of tubers – weight of tubers at sampling data)/ (initial weight of tubers)] x100.
2. Tubers with a general appearance rating of 5 or lower were deemed unmarketable. The scale used to judge general appearance was 9 to 1, with 9 denoting excellent, 7 good, 5 fair, 3 poor, and 1 unsalable.
3. Decay percentage: All tubers that were shriveled, broken, or ruined as a result of an infection with microorganisms were counted and documented visually. This information was then computed in relation to the total original weight of tubers that had been preserved (Cheour et al., 1990).
4. Firmness: A 1.5 mm diameter firmness tester, also known as a pressure tester, was used to measure it at the same two locations on every tuber.
5. Dry matter: the percentage was calculated by: % Dry matter = (dry weight / fresh weight) ×100.
6. Total carbohydrates were determined using spectrophotometer at wave length 420 nm according to AOAC. (1990).
7. Starch content in tubers was determined in dry matter according to AOAC. (1990).

2.3. Statistical analysis

For field experiment: Every season's data was subjected to statistical analysis, and when the errors were uniform, a pooled analysis was done. Levene (1960) test was used to determine whether the variances for the two seasons were homogeneous. The study's two seasons' worth of combined data was examined.

For storage experiment: Snedecor and Cochran's (1980) analysis of variance was used to statistically evaluate the data. Waller and Duncan (1969) said that the Duncan multiple range test method was used rather than a mean comparison.

3. RESULTS AND DISCUSSION

3.1. Field experiment

3.1.1. Vegetative growth

The data shown in Table (2) show that, when compared to untreated (control) potato plants, plants treated with 1% or 2% SWE and potassium silicate significantly increased their chlorophyll reading and other parameters of vegetative growth, such as plant height, leaf area, number of leaves per plant, fresh and dry weight of the plant. Vegetative growth is enhanced by high concentrations of both treatments over lower concentrations. But when it came to enhancing vegetative growth indices, 2% SWE worked best. In this regard, untreated (control) had the lowest results. These outcomes agreed with the findings of Abou-El-Hassan *et al.* (2020), Rizk *et al.* (2018), and Abd El-Gawad *et al.* (2017).

The fact that SWE contains essential elements for growth, such as macro- and micronutrients, amino acids, vitamins, betaine, betaine-like compounds, gibberellins, cytokinins, and auxins, may account for its beneficial effect on plant growth. It might raise levels of phytohormones like indole acetic acid (IAA), gibberellins (GA_3), and active cytokinins, which encourage cell division and elongation. (Awad *et al.,* 2006); improves and stimulates the primary biosynthesis of chlorophyll (Garbaye and Churin, 1996); increases plant resistance to disease due to its antimicrobial, antibacterial, anti-yeast, and anti-mold activity; and stimulates the uptake of N, P, K, Mg, Ca, Zn, Fe, and Cu, which lessens the inhibitory effect of toxic sodium and restores growth (Selvan and Sivakumar, 2013).

Silicon strengthens the cell walls of plants. This results from silicon being deposited as amorphous silica in the cell wall, which is a positive effect (Khan *et al.,* 2017). Furthermore, when micronutrients like iron, zinc, copper, and manganese are present in high concentrations, silicon lessens their toxicity, which promotes plant growth through interactions with nutrient absorption. (Wang *et al*., 2013).

Table 2. Effect of foliar application with potassium silicate and seaweed extract on vegetative growth characters of potato in 2022 and 2023 seasons (combined analysis).

Treatments	Plant height (cm)	Leaf area (cm^2)	Leaf No./plant	Plant fresh weight (g)	Plant dry weight (g)	Chlorophyll (SPAD)
1% potassium silicate	35.03 D	214.30 D	18.00 D	106.40 D	16.72 D	40.58 D
2% potassium silicate	41.10 B	321.30 B	23.33 B	127.80 B	21.04 B	47.58 B
1% seaweed extract	37.80 C	268.00 C	20.00 C	117.40 C	19.02 C	44.59 C
2% seaweed extract	43.87 A	374.30 A	27.00 A	137.90 A	22.73 A	50.50 A
Control	31.80 E	159.70 E	15.00 E	90.54 E	14.71 E	35.12 E

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

Potassium silicate also enhancing tissue elasticity and the volume of interconnected water that is associated with all expansion and growth (Shi *et al*., 2016).

Spraying with potassium silicate improves vegetative growth indicators of plants. This may be due to the vital role of potassium in nutrition and enhancing the transport of substances and protein synthesis (Abd El-Gawad *et al.,* 2017).

In this regard, silicon has a role in the photosynthesis process chain, as it improves it and prevents the deterioration of chlorophyll. Silica bodies act as healthy windows that allow light to be transmitted to the mesophyll area, which in turn increases the content of chlorophyll (Pilon *et al*., 2014).

Potassium clearly has a beneficial effect on potatoes by lessening the occurrence or intensity of early blight. It plays a significant role in numerous essential metabolic processes as well because it enhances growth indicators by acting as an activator or catalyst for numerous enzymes (Abou-El-Hassan *et al.,* 2020).

3.1.2. Silicon and potassium contents in leaves

The data in Table (3) show that leaf silicon and potassium content varies significantly between different concentrations of SWE and potassium silicate treatments. Regarding silicon content, potassium silicate with 2% or 1% provided the highest silicon content values in the leaves with significant differences between them, while the lowest values were obtained with the 1% or 2% SWE treatments and the untreated control with no significant differences between them. Regarding the potassium content in the leaves, 2% potassium silicate gave the highest values, followed by 1% with significant differences between them, while 1% or 2% SWE were less effective in this regard. Untreated plants (control) gave the lowest values. Since potassium silicate contains potassium as a primary element, this facilitates the absorption of more of it as well as silicon as a secondary element, resulting in more potassium and silicon accumulating in the leaf and thus being transferred to the tubers very easily (Shehata *et al.,* 2018 and Abdel-Latif *et al.,* 2019).

Kanto *et al.* (2004) proved that spraying strawberry plants with potassium silicate leads to an increase in their silicon content by approximately 2 to 24 times compared to the control. They reported that in leaves containing more than 1.5% silicates, diseases were significantly suppressed. Also, Shehata *et al.* (2018) found that spraying cucumbers with potassium silicate results in an increase in silicon and potassium content in the leaves and fruits compared to the control.

Table 3. Effect of foliar application with potassium silicate and seaweed extract on silicon and potassium content in leaves of potato plants in 2022 and 2023 seasons (combined analysis).

Treatments	Silicon (ppm)	K (%)
1% potassium silicate	262.10 B	2.04 B
2% potassium silicate	310.30 A	2.71 A
1% seaweed extract	204.00 C	1.06 C
2% seaweed extract	204.70 C	1.39 C
Control	203.90 C	0.39 D

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

3.1.3. Yield and its components

The data in Table 4 show that preharvest treated plants resulted in a significant increase in average tuber weight, tuber weight per plant, and total yield per plot compared to unsprayed plants. SWE at 2% and potassium silicate at 2% were the best treatments in terms of yield increase and organic ingredients, but the lower concentration of these treatments was less effective in this regard. The increase in yield is due to the increase in the weight of the tubers. The lowest value in this regard was found in untreated plants (control). This result is consistent with the one obtained by Abd El-Gawad *et al.* (2017); Rizk *et al.* (2018) and Abou-El-Hassan *et al.* (2020).

The main effect of SWE application on potato plants increases the yield and its components, which is probably due to an increase in growth indicators, resulting in an increase in tuber number and tuber/plant weight, which is reflected in the total yield (Sarhan, 2011), the role of SWE as a tuber growth stimulator may be associated with increasing the availability of various nutrients and facilitating the availability of macronutrients, as well as its ability to meet some micronutrient requirements of the crop (Helaly, 2021).

Table 4. Effect of foliar application of potassium silicate and seaweed extract on total tuber yield and its components of potato in 2022 and 2023 seasons (combined analysis).

Treatments	Total yield kg/plot (12.6 m^2)	Tubers weight/ plant (g)	Average weight of tuber (g)
1% potassium silicate	54.85 D	761.80 D	98.79 D
2% potassium silicate	61.24 B	850.60 B	117.70 B
1% seaweed extract	58.28 C	809.40 C	110.60 C
2% seaweed extract	64.33 A	893.50 A	123.10 A
Control	50.66 E	703.60 E	89.64 E

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

Also, presence of auxins in seaweed extracts will increase production of vitamins and hormones. In addition, naturally contain the hormones GA_3, GA_7, cytokinins, vitamins, and macro- and microelements present in chelated forms, which are easily absorbed by plants and thus enhance the efficiency of the plant photosynthesis, which increases the yield (Helaly, 2016). Cytokinins have a role in dividing nutrients in the vegetative organs, while in the reproductive organs; High levels of cytokinin may be related to nutrients. The response of the plant treated with SWE suggests that it is involved in stimulating the transfer of cytokinin from the roots of the plant to its reproductive organs, or most likely in stimulating the amount or synthesis of endogenous cytokinin (Arthur et al., 2003). Increased available cytokinin will in turn lead to increased cytokinin supply to ripening fruits (Abd El-Moniem and Abd-Allah, 2008).

It is possible that the stimulating effect of potassium silicate treatment on the crop is a result of increased plant absorption of nitrogen, phosphorus and potassium, which improves the characteristics of vegetative growth and increases the yield. This led to increased stimulation of photosynthesis and metabolism of various organic compounds that are transmitted through the leaves of plants to the tubers, with increasing in the weight and qualitative characteristics of the tubers (Abou-El-Hassan *et al.,* 2020), also Salim *et al.* (2014) and Talebi *et al.* (2015) explained that potassium silicate helps plants grow, become more resistant to yeast, fungal and bacterial diseases, increase tolerance to environmental stresses and increase plant productivity. Fertilization with silicon in turn leads to an impressive result in producing potato tubers with a greater fresh weight and thus an increase in the total yield (Soltani *et al.,* 2018).

3.1.4. Tuber quality characteristics

The data presented in Tables 5 and 6 revealed that all pre-harvest applications resulted in a significant moral increase in tuber physical properties: tuber length and dry matter as well as their chemical properties (carbohydrates and starch contents) compared to untreated plants. In this regard, SWE at 2% and potassium silicate at 2% were the best in tuber quality, with significant differences between them in these characteristics, these substances are follow by 1%. The lowest values for these traits were found in untreated plants. There were no significant differences in tuber diameter between all treatments and control. However, the highest values of tuber firmness were obtained with potassium silicate at 2% or 1% with significant differences between them, followed by SWE at 2% or 1% with significant differences between them. These results were in agreement with those obtained by Abd El-Gawad *et al.* (2017); Rizk *et al.* (2018) and Abou-El-Hassan *et al.* (2020).

The effect of SWE concentrations could be due to increased absorption of various nutrients and increased photosynthesis, which led to increased accumulation of metabolites in the reproductive organs, which in turn ultimately led to improved tuber quality (Haider, 2012).

Potassium silicate increased the firmness of the tubers. This occurs due to the deposition of silicon in the walls of plant cells, which can increase the firmness and rigidity of their walls (Khan *et al.,* 2017).

Table 5. Effect of foliar application of potassium silicate and seaweed extract on physical properties of potato tubers in 2022 and 2023 seasons (combined analysis).

Treatments	Tuber length (cm)	Tuber diameter (cm)	Firmness (kg/cm^2)	Dry matter (%)
1% potassium silicate	10.04 D	5.25 A	6.61 B	18.47 D
2% potassium silicate	11.18 B	5.27 A	6.82 A	19.30 B
1% seaweed extract	11.03 C	5.29 A	5.97 D	18.96 C
2% seaweed extract	11.31 A	5.30 A	6.29 C	19.69 A
Control	9.88 E	5.24 A	5.74 E	18.00 E

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

Table 6. Effect of foliar application of potassium silicate and seaweed extract on chemical properties of potato tubers in 2022 and 2023 seasons (combined analysis).

Treatments	Total carbohydrates (%)	Starch (%)
1% potassium silicate	64.19 D	62.40 D
2% potassium silicate	67.75 B	63.49 B
1% seaweed extract	66.07 C	62.90 C
2% seaweed extract	69.89 A	64.03 A
Control	61.76 E	61.44 E

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

Silicon enrichment contributes to the regulation of suberin biosynthesis genes and contributes to the enrichment of skin cell walls with oxidizing aromatic radicals, which indicates enhanced lignification, suberization and firmness. Silicon metabolism in potatoes was studied by Artyszak (2018) who explained that silicon would help ensure food safety under climatic changes. Marschner (2012) found that potassium silicate has a positive role on the dry matter content due to the presence of potassium in it. This plays an important role in improving the products of the photosynthesis process and their easy transfer from leaves to tubers.

3.1.5. Silicon and potassium content in tubers

The data presented in Table (7) show that the silicon and potassium content in the tubers differed significantly between treatments. As for silicon, potassium silicate 2% and 1% gave significantly higher silicon content in the nodules, although there were significant differences between them. The minimum values of silicon content were observed in SWE at 1% or 2% and in untreated plants (control), with no significant differences between them. Regarding the potassium content, potassium silicate gave the highest values for potassium with a proportion of 2% and 1%, although there were significant differences between them. However, 1% or 2% SWE were less effective in this regard and there were no significant differences between them. The lowest value was achieved in untreated plants (control). Shehata *et al.* (2018) came to a similar result.

Table 7. Effect of foliar application of potassium silicate and seaweed extract on silicon and potassium content in tubers of potato in 2022 and 2023 seasons (combined analysis).

Treatments	Silicon (ppm)	K (%)
1% potassium silicate	**230.10 B**	**1.85 B**
2% potassium silicate	**292.60 A**	**2.25 A**
1% seaweed extract	**190.40 C**	**1.43 C**
2% seaweed extract	**190.80 C**	**1.45 C**
Control	**190.10 C**	**0.90 D**

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan’s multiple rang test.

3.2. Storage experiment

3.2.1. Weight loss percentage

The data presented in Table 8 show that the percentage weight loss of potato tubers increases significantly and continuously during the storage period. These results are consistent with Zaki *et al.* (2021) agree about potato tubers. The increase in physiological weight loss may be due to damage and sprouting, but also to tuber moisture loss through the transpiration process and nutrient consumption during the respiration process, which increases with the length of storage time (Kazami *et al.,* 2001).

All preharvest treatments resulted in a significant decrease in percent weight loss compared to the untreated treatment (control); while 2% SWE minimized the percentage weight loss, followed by 2% potassium silicate, with a reasonably significant difference between them. Low concentrations of these substances had the least effect on reducing weight loss rates. In contrast, the untreated control group gave the highest percentage weight loss in two seasons, and this value was consistent with that reported by Shehata *et al.* (2018) and Shehata *et al.* (2019). Our results show a beneficial effect of SWE on chemical properties and vegetative growth of potato tubers, which maintained the physiological metabolic balance after harvest and reduced tuber dryness. This is consistent with Abd El-Basir, (2013). The decrease in weight loss enhances the role of SWE in reducing susceptibility to fungal and bacterial diseases, decreased respiratory rate, which greatly affects the ability of the tubers to store (Kolodziejczyk, 2016).

One of the tremendous effects of silicates on reducing the rate of weight loss during storage is that silicon covers the stomata of fruits with a

Table 8. Effect of foliar application of potassium silicate and seaweed extract on weight loss (%) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months				
Treatments	**1**	**2**	**3**	**4**	**Mean**
		Season 2022			
1% potassium silicate	1.31 K	1.78 J	3.86 E	4.43 D	2.84 B
2% potassium silicate	0.89 MN	1.20 KL	2.16 I	2.95 G	1.80 D
1% seaweed extract	1.00 LM	1.41 K	3.22 F	3.92 E	2.39 C
2% seaweed extract	0.72 N	1.04 LM	1.80 J	2.50 H	1.51 E
Control	3.23 F	5.14 C	8.63 B	10.30 A	6.83 A
Mean	1.43 D	2.11 C	3.93 B	4.82 A	
		Season 2023			
1% potassium silicate	1.19 KL	1.64 J	3.74 E	4.31 D	2.72 B
2% potassium silicate	0.81 NO	1.10 LM	2.05 I	2.87 G	1.71 D
1% seaweed extract	0.94 MN	1.34 K	3.14 F	3.86 E	2.32 C
2% seaweed extract	0.67 O	0.98 L-N	1.72 J	2.45 H	1.46 E
Control	3.07 FG	4.96 C	8.84 B	10.50 A	6.84 A
Mean	1.34 D	2.01 C	3.90 B	4.80 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

layer, which reduces their respiration rate and at the same time leads to a reduction in weight loss (Hammash and El Assi, 2007). In addition, silicon reduces the permeability of cell membranes (Laing et al., 1993), increases the stability of the membrane and confirms its integrity (Agarie et al., 1998). Following Si application, modification of cell membranes occurs, resulting in a reduction in surface water loss and thus reduced fruit weight loss (Epstein, 2001). Shehata et al. (2018) proved that the silicone also helps fruits improve their quality because it inhibits the respiration process and thus reduces the physiological loss in fruit weight.

The interaction between storage times and preharvest treatments had a significant impact on the percentage of weight loss. After 4 months of storage, the 2% SWE treatment showed the lowest percentage of weight loss, while the untreated control showed the highest percentage of weight loss. These results were for both seasons.

3.2.2. General appearance (GA)

The data presented in Table (9) showed that the general appearance decreases with the length of storage time of the tubers at 10 °C. Similar results were reported by Kassem *et al.* (2014) reported about potato tubers. The decrease in GA during storage could be due to wilting, decay, shrinkage, color change and germination (Banaras *et al.*, 2005). All treatments had the highest GA value compared to the untreated control. However, SWE treatment at 2% and potassium silicate treatment at 2% were the most effective in maintaining GA, with no significant difference between them. A lower concentration of these substances was less effective. The worst GA was recorded for the untreated control. These results were obtained across two seasonal studies and were consistent with those of Shehata *et al.* (2018) and Shehata *et al.* (2019).

The enhanced effect of the two seasons can be attributed to the fact that SWE contains nutrients, organic compounds, and macro- and microelements (Khan *et al.*, 2009) and is rich in organic acids, enzymes and several mineral substances (Gad EL-Hak *et al.*, 2012), these minerals (K, Ca, Fe, Mg and Mn) reduce the percentage weight loss and preserve color during different storage times (Shehata *et al.*, 2015). Kaluwa *et al.* (2010) proved that the general effect of silicon is a suppression of respiratory rate and an increased accumulation of antioxidants and total phenols, which increases

Table 9. Effect of foliar application of potassium silicate and seaweed extract on general appearance (score) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months					
Treatments	**Start**	**1**	**2**	**3**	**4**	**Mean**
			Season 2022			
1% potassium silicate	9.00 A	9.00 A	7.00 C	5.00 D	2.33 E	6.47 C
2% potassium silicate	9.00 A	9.00 A	8.33 AB	7.67 BC	7.00 C	8.20 AB
1% seaweed extract	9.00 A	9.00 A	7.67 BC	7.00 C	5.67 D	7.67 B
2% seaweed extract	9.00 A	9.00 A	9.00 A	8.33 AB	7.67 BC	8.60 A
Control	9.00 A	7.00 C	5.00 D	2.33 E	1.00 F	4.87 D
Mean	9.00 A	8.60 A	7.40 B	6.07 C	4.73 D	
			Season 2023			
1% potassium silicate	9.00 A	9.00 A	7.00 C	5.00 D	2.67 E	6.53 C
2% potassium silicate	9.00 A	9.00 A	9.00 A	8.33 AB	7.67 BC	8.60 A
1% seaweed extract	9.00 A	9.00 A	8.33 AB	7.67 BC	5.67 D	7.93 B
2% seaweed extract	9.00 A	9.00 A	9.00 A	9.00 A	7.67 BC	8.73 A
Control	9.00 A	7.00 C	5.00 D	2.33 E	1.00 F	4.87 D
Mean	9.00 A	8.60 A	7.67 B	6.47 C	4.93 D	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

the fruit's ability to relieve stress and tolerate long-term storage.

The interaction between storage periods and treatments was significant. However, 2% SWE and potassium silicate showed good appearance after 4 months of storage, while 1% SWE gave good appearance after 3 months, while the untreated control showed unacceptable appearance at the end of storage (4 months) in both seasons.

3.2.3. Decay percentage

The data presented in Table (10) clearly show that the degree of decay of potato tubers increased steadily and consistently with increasing storage time. These results are consistent with Zaki *et al.* (2021) on potato tubers and may be due to the increased water loss and use of complex molecules in the respiration process, which affects the shine and shine of the tubers, reduces the strength of the tubers and makes them more susceptible to fungal infections (Kolodziejczyk, 2016).

All treatments reduced the rate of decay and prolonged the storage period of tubers compared to the control treatment. However, seaweed extract at 2% and potassium silicate at 2% treatments did not show any decay during 4 months. However, SWE at 1% showed no decay up to 3 months of storage. It was also observed that decay began in the control tubers after two months of storage, then it increased during 4 months in both seasons, and it was consistent with Afifi (2016) and Zaki *et al.* (2021). This decrease in the decay of SWE treatment may be attributed to its role as an anti-disease, reducing susceptibility to disease, and reducing the respiration rate, which greatly affects the increase in the tubers' ability to store (Kolodziejczyk, 2016).

Tarabih *et al.* (2014) proved that potassium silicate plays a role in increasing the concentration of antifungal compounds, as well as enzymes such as the PAL enzyme, to have the ability to increase concentration of antioxidant compounds in the cells, which reduces the occurrence of decay in fruits, and this is a very good one effect.

Table 10. Effect of foliar application of potassium silicate and seaweed extract on decay (%) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months					
Treatments	**Start**	**1**	**2**	**3**	**4**	**Mean**
			Season 2022			
1% potassium silicate	0.00 G	0.00 G	0.00 G	2.84 F	5.11 D	1.59 B
2% potassium silicate	0.00 G	0.00 G	0.00 G	0.00 G	0.00 G	0.00 D
1% seaweed extract	0.00 G	0.00 G	0.00 G	0.00 G	4.20 E	0.84 C
2% seaweed extract	0.00 G	0.00 G	0.00 G	0.00 G	0.00 G	0.00 D
Control	0.00 G	0.00 G	5.41 C	7.22 B	11.40 A	4.80 A
Mean	0.00 D	0.00 D	1.08 C	2.01 B	4.14 A	
			Season 2023			
1% potassium silicate	0.00 G	0.00 G	0.00 G	2.23 F	4.85 D	1.42 B
2% potassium silicate	0.00 G	0.00 G	0.00 G	0.00 G	0.00 G	0.00 D
1% seaweed extract	0.00 G	0.00 G	0.00 G	0.00 G	3.93 E	0.79 C
2% seaweed extract	0.00 G	0.00 G	0.00 G	0.00 G	0.00 G	0.00 D
Control	0.00 G	0.00 G	4.96 C	6.75 B	10.96 A	4.53 A
Mean	0.00 D	0.00 D	0.99 C	1.80 B	3.95 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

3.2.4. Tuber firmness

The firmness of the potato tuber is an important factor in consumer acceptance of the product (Kassem *et al.,* 2014). The data presented in Table (11) showed that the strength of potato tubers decreased significantly during storage in the two seasons. Kuyu *et al.* (2019) came to the same results for potato tubers.

Tigist *et al.* (2013) found that the decrease in firmness is due to the loss of moisture, which causes wilting and wrinkling on the surface of the tuber. Therefore, loss of firmness occurs as a result of weight loss or is a sign of it. An obvious decrease in hardness is expected and this may be due to increased metabolic process and activity of enzymes responsible for starch hydrolysis and degradation (Page *et al.*, 2008).

All treatments had a significant effect on increased tuber firmness compared to the control. However, potassium silicate at 2% or 1% were the most effective in reducing firmness loss, with significant differences between them, followed by SWE at 2% or 1%, while the highest firmness losses of tubers were found in the control. According to Shehata *et al.* (2018) and Shehata *et al.* (2019) these result achieved in two seasons. The results may be due to an increase SWE in the amount of K and Ca available in the ground and facilitated for plants (Abou El-Yazied *et al.*, 2012) These elements, in turn, increase in the fruit, increasing osmotic capacity and water absorption and reducing water loss, which affects the hardness of the fruit during storage (Afifi, 2016).

Potassium silicate had a positive effect on maintaining the firmenss of potato tubers by depositing silicon between the cell wall and membranes, which maintained the soluble barrier against leakage during storage (Tesfay *et al.*, 2011). Silicon increases the activity of many cellular enzymes, particularly chitinase, peroxidase and polyphenol oxidase, and increases the deposition of intracellular callose formation and hydrogen peroxidase (Shetty et al., 2012), this improves firmness and fabric firmness and extends durability (Liang *et al.*, 1993).

The interaction between treatments and storage times was significant during the two seasons. Potassium silicate at 2% showed the highest firmness values for the tubers in all storage periods, while the lowest values were recorded for the untreated tubers.

Table 11. Effect of foliar application of potassium silicate and seaweed extract on firmness (kg/cm^2) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months					
Treatments	**Start**	**1**	**2**	**3**	**4**	**Mean**
			Season 2022			
1% potassium silicate	6.54 AB	6.14 CD	5.71 EF	5.20 GH	4.71 IJ	5.66 B
2% potassium silicate	6.66 A	6.46 A-C	6.11 CD	5.69 EF	5.21 GH	6.03 A
1% seaweed extract	6.01 D-E	5.50 FG	4.98 HI	4.40 J-L	3.82 MN	4.94 D
2% seaweed extract	6.17 B-D	5.69 EF	5.19 GH	4.66 I-K	4.12 LM	5.17 C
Control	5.71 EF	5.18 GH	4.33 KL	3.50 N	3.00 O	4.34 E
Mean	6.22 A	5.79 B	5.26 C	4.69 D	4.17 E	
			Season 2023			
1% potassium silicate	6.68 AB	6.24 A-D	5.80 C-F	5.28 E-G	4.84 GH	5.77 B
2% potassium silicate	6.98 A	6.79 A	6.45 A-C	6.01 B-E	5.53 D-G	6.35 A
1% seaweed extract	5.93 B-F	5.45 E-G	4.95 GH	4.36 HIJ	3.69 I-K	4.88 D
2% seaweed extract	6.40 A-C	5.95 B-F	5.43 E-G	4.88 GH	4.37 HI	5.41 C
Control	5.76 C-F	5.22 FG	4.40 HI	3.60 JK	3.13 K	4.42 E
Mean	6.35 A	5.93 B	5.41 C	4.83 D	4.31 E	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

3.2.5. Dry matter percentage

The data obtained in Table (12) show that the dry matter content of potato tubers decreases significantly over the storage period. Similar results were obtained by Zaki *et al.* (2021) about potato. Fruit respiration is an important chemical process for all living plant tissues, as starches and sugars (dry matter) are oxidized to carbon dioxide and water vapor with the release of heat (Atala *et al.*, 2019).

Table 12. Effect of foliar application of potassium silicate and seaweed extract on dry matter (%) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months					
Treatments	**Start**	**1**	**2**	**3**	**4**	**Mean**
			Season 2022			
1% potassium silicate	18.21 C-E	17.72 E-G	17.14 HI	16.53 JK	15.93 LM	17.11 D
2% potassium silicate	19.04 AB	18.60 B-D	18.12 D-F	17.57 G-I	17.04 IJ	18.07 B
1% seaweed extract	18.70 BC	18.16 C-F	17.63 F-H	17.08 I	16.50 JK	17.62 C
2% seaweed extract	19.43 A	19.00 AB	18.60 B-D	18.14 D-F	17.64 F-H	18.56 A
Control	17.75 E-G	17.17 HI	16.11 KL	15.50 M	14.30 N	16.17 E
Mean	18.63 A	18.13 B	17.52 C	16.97 D	16.28 E	
			Season 2023			
1% potassium silicate	18.73 C-E	18.25 E-H	17.71 I-K	17.09 LM	16.48 NO	17.65 D
2% potassium silicate	19.57 AB	19.14 B-D	18.68 DE	18.11 H-J	17.57 KL	18.62 B
1% seaweed extract	19.21 BC	18.66 D-F	18.14 G-I	17.60 J-L	17.01 M	18.13 C
2% seaweed extract	19.94 A	19.49 AB	19.10 B-D	18.65 D-G	18.15 F-I	19.07 A
Control	18.24 E-H	17.68 I-K	16.63 MN	16.00 O	14.79 P	16.67 E
Mean	19.14 A	18.64 B	18.05 C	17.49 D	16.80 E	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

The treatments effectively maintain dry matter content compared to the control treatment. The 2% SWE and potassium silicate treatments were the most effective dry matter maintenance treatments, with significant differences, followed by the 1% SWE treatment, and the lowest values resulted in control. These results were obtained in two seasons and were reported by Zaki *et al.* (2021).

As for the interaction between treatments and storage times, it was significant after 4 months of storage. The 2% SWE treatment resulted in an increase in dry matter percentage, followed by the 2% potassium silicate treatment, with significant differences, while the control treatment gave the lowest percentage in the same period.

3.2.6. Total carbohydrates percentage

The total carbohydrate content data in Table (13) showed that tuber content decreases with the length of storage time, and these results were obtained in two consecutive seasons. The decrease in total carbohydrate concentration may be due to the greater loss of sugar through respiration compared to the loss of water through transpiration (Wills *et al.*, 1998).

The treatments had a significantly higher value of total carbohydrate content compared to the control. However, treatment with 2% SWE and 2% potassium silicate was most effective in maintaining total carbohydrate content, with significant differences. A lower concentration of these substances was less effective. The lowest value for total carbohydrate content was measured in tubers of untreated plants. These results were obtained in both seasons of the study and are consistent with Gad El-Rab (2018); This may be due to the enhanced effect of SWE on leaf area (photosynthetic surfaces), total chlorophyll and the content of some important minerals, as shown by a study by Hamed (2012), and the maintenance of carbohydrate content (Mohamed, 2014).

As for the interaction between storage time and treatment, it was significant during both study seasons.

Table 13. Effect of foliar application of potassium silicate and seaweed extract on total carbohydrates (%) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months					
Treatments	**Start**	**1**	**2**	**3**	**4**	**Mean**
			Season 2022			
1% potassium silicate	63.96 I-K	63.45 JK	63.15 J-L	62.86 KL	62.14 LM	63.11 D
2% potassium silicate	67.51 CD	67.06 C-E	66.61 D-F	66.13 E-G	65.59 F-H	66.58 B
1% seaweed extract	65.82 E-G	64.93 G-I	64.43 H-J	63.89 I-K	63.31 J-L	64.47 C
2% seaweed extract	69.67 A	69.44 AB	69.24 AB	68.82 AB	68.33 BC	69.10 A
Control	61.55 M	59.91 N	59.35 N	57.67 O	56.71 O	59.04 E
Mean	65.70 A	64.96 B	64.56 B	63.87 C	63.21 D	
			Season 2023			
1% potassium silicate	64.43 J-L	63.94 KL	63.63 K-M	63.35 LM	62.61 MN	63.59 D
2% potassium silicate	67.99 C-E	67.53 D-F	67.10 E-G	66.61 F-H	66.08 G-I	67.06 B
1% seaweed extract	66.32 F-H	65.44 H-J	64.95 I-K	64.40 J-L	63.81 K-M	64.98 C
2% seaweed extract	70.11 A	69.87 AB	69.68 AB	69.27 A-C	68.77 B-D	69.54 A
Control	61.97 N	60.35 O	59.80 O	58.14 P	57.17 P	59.49 E
Mean	66.16 A	65.43 B	65.03 B	64.35 C	63.69 D	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

3.2.7. Starch percentage

The data in Table (14) clearly show that the percentage of starch in potato tubers decreases steadily and continuously with the length of the storage period; the results were achieved in both seasons and were consistent with Zaki *et al.* (2021) on potato.

Starch hydrolysis takes place mainly inside the tubers, where phosphorus is broken down and phosphorylase is activated. This is related to the accumulation of sugar in the tubers (Claassen *et al.,* 1993). The treated tubers had a significantly higher starch content compared to the control. The most effective treatment was 2% SWE and potassium silicate as it maintained the starch content with significant differences, while the lowest starch content value was recorded in the control. These results were achieved over two seasons and were consistent with Zaki *et al.* (2021).

Table 14. Effect of foliar application of potassium silicate and seaweed extract on starch (%) of potato tubers during cold storage at 10 °C in 2022 and 2023 seasons.

	Storage period in months					
Treatments	**Start**	**1**	**2**	**3**	**4**	**Mean**
			Season 2022			
1% potassium silicate	62.10 C-I	61.56 F-J	60.98 I-L	60.31 K-M	59.67 M	60.93 D
2% potassium silicate	63.18 A-C	62.76 A-E	62.27 B-G	61.73 E-J	61.19 G-K	62.23 B
1% seaweed extract	62.59 B-F	62.14 C-H	61.59 F-J	61.02 H-L	60.41 K-M	61.55 C
2% seaweed extract	63.76 A	63.35 AB	62.96 A-D	62.49 B-F	61.98 D-I	62.91 A
Control	61.16 G-K	60.59 J-M	59.93 LM	58.07 N	57.12 N	59.37 E
Mean	62.56 A	62.08 A	61.54 B	60.72 C	60.07 D	
			Season 2023			
1% potassium silicate	62.69 B-G	62.14 E-I	61.57 G-J	60.91 I-K	60.26 K	61.51 D
2% potassium silicate	63.77 A-C	63.33 A-E	62.86 B-G	62.33 D-H	61.78 F-J	62.82 B
1% seaweed extract	63.21 A-E	62.75 B-G	62.21 D-I	61.63 G-J	61.03 H-K	62.17 C
2% seaweed extract	64.31 A	63.88 AB	63.50 A-D	63.04 A-F	62.53 C-G	63.45 A
Control	61.73 F-J	61.18 H-K	60.51 JK	58.66 L	57.69 L	59.95 E
Mean	63.14 A	62.66 AB	62.13 B	61.31 C	60.66 D	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.

In general, after 4 months of storage, the interaction between treatments and storage duration was significant. The treatment with 2% SWE and potassium silicate maintained the starch content without significant differences in two seasons, while the untreated control treatment gave the lowest percentages in the same storage period.

4. CONCLUSION

It might be concluded that potato plant cv. Spunta treated with SWE at 2% and potassium silicate at 2% enhanced vegetative growth indicators of plant, total yield and its components and tuber quality. Also, tubers obtained from these treatments may help in extending postharvest life of the potato tubers. This treatment plays an important role in lowering weight loss, suppressing pathogens infections and delaying softening and maintaining quality of tubers during storage, which all lead to enhancing keeping quality of the tubers as well as retaining its nutritional value for longer periods at 10ºC and 85% relative humidity (RH).

5. ACKNOWLEDGEMENT

The authors thank Prof. Dr. Said Abdullah Shehata thanked for his support and valuable advice and thanked the project "Development of Export Crops - Extending the Shelf Life of Fruits and Reducing Losses" for his support.

6. REFERENCES

AOAC (1990). Quality of Official Analytical Chemists, Washington DC. USA.

Abd El-Basir AE (2013). Role of some bio-stimulants and anti-stressors to mitigate high temperature damages on sweet pepper. Ph.D. Thesis, Fac. Agric., Suez Canal Univ., Ismailia, Egypt, 206 p.

Abd El-Gawad HG, Abu El-Azm NAI and Hikal MS (2017). Effect of potassium silicate on tuber yield and biochemical constituents of potato plants grown under drought stress conditions. Middle East J. Agric. Res., 6(3): 718-731.

Abdel-Latif AA, Ibrahim NM and Ismail SA (2019). Effect of foliar application of potassium silicate and some postharvest treatments on growth, productivity and storability of garlic. 14th Conf. Agric. Develop. Res., Fac. of Agric., Ain Shams Univ., March, 2019, Cairo, Egypt Special Issue, 27(1): 761 - 773.

Abd El-Moniem EA and Abd-Allah ASE (2008). Effect of green algae cells extract as foliar spray on vegetative growth, yield and berries quality of superior grapevines. Am. Euras. J. Agric. and Environ. Sci., 4(4):427-433.

Abou-El-Hassan S, Metwaly HA and Ali AM (2020). Efficiency of potassium and calcium compounds in gel formula to control early blight disease, improve productivity and shelf life of potato. Egypt. J. Agric. Res., 98 (1): 154-168.

Abou El-Yazied A, El-Gizawy AM, Ragab MI and Hamed ES (2012). Effect of seaweed extract and compost treatments on growth, yield and quality of snap bean. J. of American Sci., 8(6):1-20.

Afifi EHE (2016). Effect of some pre and postharvest treatments on storability of strawberry fruits. M.Sc. Thesis, Faculty of Agriculture, Ain Shams University, Egypt 149 pp.

Agarie S, Hanaoka N, Ueno O, Miyazaki A, Kubota F, Agata W and Kaufman PB (1998). Effects of silicon on tolerance to water deficit and heat stress in rice plants (*Oryza sativa* L.), monitored by electrolyte leakage. Prod. Sci., 1: 96-103.

Arthur GD, Stirk WA and Van Staden J (2003). Effect of a seaweed concentrate on the growth and yield of three varieties of Capsicum annuum. S. Afr. J. Bot., 69:207-211.

Artyszak A (2018). Effect of silicon fertilization on crop yield quantity and quality-A Literature Review in Europe. Plants, 7 (54): 1- 17.

Atala SA, Saad M EL-M and Saleh MA (2019). Effect of hot water and chitosan treatments for improving the quality and increasing storability of globe artichoke. Annals of Agric. Sci., Moshtohor, 57(2): 469 - 482.

Awad EMM, Yossef NS and El-Shall ZS (2006). Effect of foliar spraying with seaweed extracts and inorganic fertilizers levels on growth, yield and quality of potato crop. J. Agric. Sci. Mansoura Univ., 31(10):6549-6559.

Banaras M, Bosland PW and Lownds NK (2005). Effects of harvest time and growth conditions on storage and post-storage quality of fresh peppers (*Capsicum annuum* L.). Pak. J. Bot., 37 (2):337-344.

Cheour FJC, Willemot J, Arul J, Desjardins J, Mathlouf PM, Charest FM and Gosselin A (1990). Foliar application of calcium chloride delays postharvest ripening of strawberry. J. Amer. Soc. Hort. Sci., 115 (5):785-792.

Claassen PAM, Budde MAW and Van Calker MH (1993). Increase in phosphorylase activity during cold-induced sugar accumulation in potato tubers. Potato Res., 36: 205-217.

Craigie JS (2011). Seaweed extract stimuli in plant science and agriculture. J. Appl. Phycol., 23: 371-393.

Crusciol CA, Pulz AL, Lemos LB, Soratto RP and Lima GP (2009). Effects of silicon and drought stress on tuber yield and leaf biochemical characteristics in potato. Crop Sci., 49: 949- 954.

Dkhil BB, Denden M and Aboud S (2011). Foliar potassium fertilization and its effect on growth, yield and quality of potato grown under loam sandy soil and semi-arid conditions. International Journal of Agricultural Research, 6(7): 593-600.

Epstein E (2001). Silicon in plants: Facts vs. concepts. In L.E. Datnoff, G.H. Snyder, and G.H. Korndörfer (ed.) Elsevier, N. Y., 1-15.

Gad El-Hak SH, Ahmed AM and Moustafa YMM (2012). Effect of foliar application with two antioxidants and humic acid on growth, yield and yield components of peas (*Pisum sativum* L.). Journal of Horticultural Science & Ornamental Plants, 4 (3):318-328.

Gad EL-Rab NA (2018). Effect of some pre and postharvest treatments on yield, quality and storability of snap beans. Ph.D. Thesis, Fac. Agric., Cairo Univ., Cairo, Egypt, 252 p.

Garbaye J and Churin JL (1996). Effect of ectomycorrhizal inoculation at planting on growth and foliage quality of Tilia tomentosa. J. Arboric., 22(1):29-33.

González A, Castro J, Vera J and Moenne A (2013). Seaweed oligosaccharides stimulate plant growth by enhancing carbon and nitrogen assimilation, basal metabolism, and cell division. J. Plant Growth Regul., 32: 443- 448.

Haider MW, Ayyub CM, Pervez MA and Asad HU (2012). Impact of foliar application of seaweed extract on growth, yield and quality of potato (*Solanum tuberosum* L.). Soil and Environment, 31 (2):157-162.

Hamed ES (2012). Effect of seaweed extract and compost treatments on growth, yield and quality of snap bean. Ph.D. Thesis, Fac. of Agric., Ain Shams, Univ., Egypt.

Hammash F and El Assi N (2007). The influence of pre storage waxing and wrapping on quality attributes of stored 'Shamouti' orange. Acta Hortic., 740:133-140.

Helaly AA (2016). Efficiency of using seaweed extracts under varying levels of NPK on growth and yield components of sweet potato (*Ipomoea batatas* L.). Ph.D. thesis Fac. Agric., Alexandria, Univ., Egypt.

Helaly AA (2021). Green seaweed extract: A complementary bio-fertilizer and bio-stimulator for growth and yield of sweet potato plants. Scientific Journal of Agricultural Sciences, 3 (1): 1-14.

Hou L, Szwonek E and Shangjun X (2006). Advances in silicon research of horticultural crops. Veg. Crop Res. Bull., 64: 5-17.

Kaluwa K, Bertling I, Bower JP and Tesfay SZ (2010). Silicon application effects on ‘Hass’ avocado fruit physiology. South African Avocado Growers Association, Year Book, 33 pp.

Kanto T, Miyoshi A, Ogawa T, Maekawa K and Aino M (2004). Suppressive effect of potassium silicate on powdery mildew of strawberry in hydroponics. J. Gen. Plant Pathol., 70:207-211.

Kassem HA, Al- Harbi AR and Dhaif Allah MS (2014). Effect of salicylic acid and/or calcium chloride on potato tubers and quality and storage potential. Mitteilungen Klosterneuburg, 64(5): 187-199.

Kazami D, Tsuchiya T, Kobayashi Y and Ogura N (2001). Effect of storage temperature on quality of potato tubers. Journal of Japanese Society Food Science Technology, 47(11):851 - 856.

Khan MA, Goyal V and Jain N (2017). Impact of orthosilicic acid formulation on yield and disease incidence of potatoes. In Proceedings of the 7th International Conference on Silicon in Agriculture, Bangalore, India. 24-28 October, pp. 137.

Khan W, Usha PR, Subramanian S, Jithesh MN, Rayorath P, Hodges DM, Critchley AT, Craigie JS and Prithiviraj B (2009). Seaweed extracts as biostimulants of plant growth and development. J. Plant Growth Regul., 28:386-399.

Kolodziejczyk M (2016). Effect of nitrogen fertilization and microbial preparations on quality and storage lossed in edible potato. Acta Agrophysica, 23(1):67-78.

Kuyu CG, Tola YB and Abdi GG (2019). Study on post-harvest quantitative and qualitative losses of potato tubers from two different road access districts of Jimma zone, South West Ethiopia. Heliyon, 5: 1- 7.

Levene H (1960). Robust tests for equality of variances. In Ingram Olkin, Harold Hotelling, Etalia, Stanford University Press, pp: 278-292.

Liang YC, Chen XH, MA TS, Qian ZJ and Liu LR (1993). Effect of Si on the growth, yield and quality of tomato. Jiangsu Agric. Sci., 4:48-50.

Marschner P (2012). Marschner's mineral nutrition of higher plants, 3rd ed., Academic Press, London, UK. pp. 178-189.

Miceli A, Vetrano F and Moncada A (2021). Influence of Ecklonia maxima extracts on growth, yield, and postharvest quality of hydroponic leaf lettuce. Horticulturae, 7 (440): 1- 24.

Mohamed MAA, Abd El-khalek AF and Elmehrat HG (2017). Improving mango fruits (Zibda cv) quality and storability by preharvest application with potassium silicate, chitosan and calcium chloride. Egyptian Journal of Horticulture, 44(1):17-32.

Mohamed OO (2014). Impact of preharvest foliar spray with some safely substances on yield and storability of fresh cut green pea seeds (*Pisum sativum* L.) during storage. Zagazig J. Agric. Res., 41(6):1-18.

Muthoni J and Nyamongo DO (2009). A review of constraints to ware Irish potatoes production in Kenya. Journal of Horticulture and Forestry, 1(7): 98-102.

Page D, Marty I, Bouchet JP, Gouble B and Causse M (2008). Isolation of genes potentially related to fruit quality by subtractive selective hybridization in tomato. Postharvest Biol. Technol., 50: 117-124.

Papenfus HB, Stirk WA, Finnie JF and Van Staden J (2012). Seasonal variation in the polyamines of Ecklonia maxima. Bot. Mar., 55: 539-546.

Pilon C, Soratto RP, Broetto F and Fernandes AM (2014). Foliar or soil applications of silicon alleviate water-deficit stress of potato plants. Crop Ecology & Physiology, 106(6): 2325- 2334.

Rizk FA, Rageb ME, Shaheen AM, Mahmoud SH, Soliman MM and Omar NM (2018). Enhancing the productivity of potato crop by using seaweeds extract. Middle East J. Agric. Res., 7(2): 269-277.

Ronga D, Biazzi E, Parati K, Carminati D, Carminati E and Tava A (2019). Microalgal biostimulants and biofertilisers in crop productions. Agronomy, 9 (4): 1 – 22.

Salim BB, Abd El-Gawad HG and Abou El-Yazied A (2014). Effect of foliar spray of different potassium sources on growth, yield and mineral composition of potato (*Solanum tuberosum* L.). Middle East Journal of Applied Sciences, 4(4): 1197-1204.

Sarhan TZ (2011). Effect of humic acid and seaweed extracts on growth and yield of potato plant (*Solanum tubersum* L.) Desire cv Mesopotamia. J. Agric., 39: 19-27.

Selvan GG and Sivakumar K (2013). Effect of foliar spray from seaweed liquid fertilizer of Ulva reticulata (Forsk.) on Vigna mungo L. and their elemental composition using SEM- energy dispersive spectroscopic analysis. APJR., 2 : 119-125.

Shehata SA, Saad MEL-M, Saleh MA and Atala SA (2018). Effect of foliar spray with potassium silicate on growth, yield, quality and storability of cucumber fruits. Annals of Agric. Sci. Moshtohor, 56 (2): 385 – 396.

Shehata SA, Saad MEL- M, Saleh MA and Atala SA (2019). Effect of some biostimulants materials on growth, yield, quality and storability of sweet pepper. Annals of Agric. Sci., Moshtohor, 57(1): 77 – 88.

Shehata SA, Said ZA, Attia MM and Rageh MA (2015). Effect of foliar application of micronutrients, magnesium and wrapping films on yield, quality and storability of green bean pods. Fayoum J. Agric. Res. & Dev., 30(1):121-139.

Shetty R, Jensen B, Shetty NP, Hansen M, Hansen CW, Starkey KR and Jorgensen HJL (2012). Silicon induced resistance against powdery mildew of roses caused by Podosphaera pannosa. Plant Pathol., 61: 120 - 131.

Shi Y, Zhang Y, Hanr W, Feng, Hu Y, Guo J and Gong H (2016). Silicon enhances water stress tolerance by improving root hydraulic conductance in *Solanum lycopersicum* L. Front. Plant Sci., 7: 1 - 15.

Snedecor GW and Cochran WG (1980). Statistical methods. 8th Ed., Iowa State Univ. Press, Ames, Iowa, USA., 476 p.

Soltani M, Kafi M, Nezami A and Taghiyari HR (2018). Effects of silicon application at nano and micro scales on the growth and nutrient uptake of potato mini tubers (*Solanum tuberosum* var. Agria) in greenhouse conditions. BioNanoScience, 8: 218-228.

Stefánsson A, Gunnarsson I and Giroud N (2007). New methods for the direct determination of dissolved inorganic, organic and total carbon in natural waters by Reagent-Free Ion Chromatography and inductively coupled plasma atomic emission spectrometry. Anal. Chim. Acta, 582 (1): 69-74.

Stirk WA, Tarkowská D, Tureˇcová V, Strnad M and Van Staden J (2014). Abscisic acid, gibberellins and brassinosteroids in Kelpak®, a commercial seaweed extract made from Ecklonia maxima. J. Appl. Phycol., 26: 561-567.

Talebi S, Majd A, Mirzai M and Abedini M (2015). The study of potassium silicate effects on qualitative and quantitative performance of potato (*Solanum tuberosum* L.). Biological Forum An International Journal, 7(2): 1021-1026.

Tarabih ME, El-Eryan EE and El-Metwally MA (2014). Physiological and pathological impacts of potassium silicate on storability of Anna apple fruits. American Journal of Plant Physiology, 9(2): 52-67.

Tesfay SZ, Bertling I and Bower JP (2011). Effects of postharvest potassium silicate application on phenolics and other anti-oxidant systems aligned to avocado fruit quality. Postharvest Biol. Technol., 60: 92-99.

Thirumaran G, Arumugam M, Arumugam R and Anantharaman P (2009). Effect of seaweed liquid fertilizer on growth and pigment concentration of Abelmoschus esculentus L. Taub. Am Euras. J. Agron., 2 (2): 50 -56.

Tigist M, Workneh TS and Woldetsadik K (2013). Effects of variety on the quality of tomato stored under ambient conditions. J. Food Sci. Technol., 50 (3): 477- 486.

Vulavala VKR, Elbaum R, Yermiyabu U, Fogelman E, Kuma A and Ginzberg I (2016). Silicon fertilization of potato: Expression of putative transporters and tuber skin quality. Planta, 243: 217–229.

Wadas W (2023). Nutritional value and sensory quality of new potatoes in response to silicon application. Agriculture, 13 (542): 1- 11.

Waller RA and Duncan DB (1969). A buyes rule for the symmetric multiple comparison problems. Amer. State. Assoc. J., 64:1484-1503.

Wang M, Zheng Q, Shen Q and Guo S (2013). The critical role of potassium in plant stress response. Int. J. Mol. Sci., 14(4): 7370-7390.

Wills R, Mcglasson B, Graham D and Joyce D (1998). Postharvest: An introduction to the physiology and handling of fruit, vegetables and ornamentals. Ed.: CAB International, Wallingford, UK. Zagazig J. Agric. Res., 17:877 - 882.

Zaki MEl-S, Mohamed MHM and Halawa SS (2021). Effect of preharvest propagation method, nitrogen fertilizer sources and soil addition with some growth stimulants on storability of potato plants stored under room temperature conditions. 5th International Conference on Biotechnology Applications in Agriculture (ICBAA), Benha University, 8 April 2021, Egypt (Conference Online). Bio-fertilizers: 669-682.

Zhang X and Schmidt RE (2000). Hormone-containing products' impact on antioxidant status of tall fescue and creeping bentgrass subjected to drought. Crop Sci., 40:1344-1349.

Zodape ST (2001). Seaweeds as a biofertilizer. J. Sci. Ind. Res., 60: 378- 382.

الملخص العربى

تأثير الرش الورقي بسليكات البوتاسيوم ومستخلص الطحالب البحرية على نمو النبات و الانتاجية وصفات الجودة و القدرة التخزينية لدرنات البطاطس.

محمود عاطف صالح[1]، شيرين عطا عطاالله[1] و إيناس عبد الله برديسى[2]

[1]قسم بحوث تداول الخضر، معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر

[2]قسم البساتين، كلية الزراعة، جامعة الزقازيق، مصر.

أجري هذا البحث لدراسة تأثير الرش الورقي بسليكات البوتاسيوم بتركيز ١% و٢% ومستخلص الطحالب البحرية بتركيز ١% و٢% على صفات النمو الخضري، والمحصول ومكوناته، و الجودة والقدرة التخزينية لدرنات البطاطس صنف سبونتا خلال موسمى ٢٠٢٢ و ٢٠٢٣. وتشير النتائج إلى ان الرش الورقى بمستخلص الطحالب البحرية بتركيز ٢ % و سليكات البوتاسيوم بتركيز ٢% حسنت معنوياً صفات النمو الخضري (ارتفاع النبات، ومساحة الورقة، وعدد الأوراق لكل نبات، والوزن الطازج والجاف للنبات، ومحتوى الكلوروفيل فى الأوراق (SPAD) ، والمحصول ومكوناته (المحصول الكلى للدرنات ووزن الدرنات لكل نبات و متوسط وزن الدرنة)، والصفات الطبيعية والكيماوية للدرنة (طول الدرنة ، ونسبة المادة الجافة، ومحتوى الكربوهيدرات الكلية والنشا) مقارنة بالمعاملات الأخرى أو النباتات الغير معاملة (الكنترول). أعطت معاملة سليكات البوتاسيوم بتركيز ٢% أعلى القيم من محتوى السليكون والبوتاسيوم في الأوراق والدرنات كما حسنت من صلابة الدرنة، وكانت معاملة مستخلص الطحالب البحرية بتركيز ٢% هي الأكثر فاعلية في تحسين صفات النمو الخضري والمحصول الكلي ومكوناته وجودة الدرنات. كما أن هذه المعاملة ادت الى إطالة عمر درنات البطاطس بعد الحصاد حيث أعطت أقل فقد وزن مع المحافظة على صفات الجودة كما اعطت مظهر جيد للدرنات بعد ٤ أشهر من التخزين على درجة حرارة ١٠ °م بدون حدوث اى تلف.

الكلمات المفتاحية: البطاطس ، مستخلص الطحالب البحرية ، سليكات البوتاسيوم ، النمو الخضري ، المحصول ، الجودة ، القدرة التخزينية.