Response of potato plants to potassium silicate and calcium nitrate Nano fertilizers in winter season

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ABSTRACT

The field experiment was conducted at the Orabi Association Farms, a private farm in El-Kaluobia Governorate, Egypt, during the two consecutive winter seasons of 2022/2023 and 2023/2024 to assess the effects of the foliar application of potassium silicate and calcium nitrate, whether in Nano form or mineral fertilizers form on the growth, yield, and quality characteristics of potato (Hermes cv.). Six treatments were applied in the field experiment: potassium silicate Nano fertilizer at 100 and 1000 ppm, potassium silicate at 2000 ppm, calcium nitrate mineral fertilizer at 2000 ppm, and calcium nitrate Nano fertilizer at 1000 ppm. Based on the results, the Nano potassium silicate treatment at 100 ppm significantly improved the vegetative growth (plant length, number of main shoots, fresh and dry weight and chlorophyll content), total and marketable yield, quality of tubers and silicon and potassium contents of leaves. The study demonstrated that application of Nano fertilizers is recommended since they are low-cost and safe for environmental.

Keywords: Potassium silicate-Calcium nitrate-Nano fertilizers-Potato yield and quality.

INTRODUCTION

One of the principals and exportable vegetable crops grown in Egypt is the potato crop (*Solanum tuberosum* L.), which represents a significant place in Egyptian crop composition, exporting and processing. It offers cheap carbohydrates and a range of vitamins and nutrients that are essential in a human diet, making it a substantial source of national income in Egypt after rice and wheat. The cultivated area in Egypt with producing is about 6.9 million tons of potatoes, of which roughly 935881.42 tons are exported as fresh potatoes, according to (FAO, 2021).

Frost is the main problem with Egypt`s late autumn crops (winter agriculture), which are shipped to many European states. Potato plants need a moderate climate of 20–25˚C for optimal vegetative growth; however, the crop needs a cold climate of 15–20°C (Hijmans, 2003 and Rykaczewska, 2015). Certain plant species may be harmed by low temperatures, which could reduce their ability to survive and produce (Adhikari, et al., 2022). Lower temperatures cause a decrease in the activity of enzymes and other proteins, which diminishes plant growth (Zhang et al., 2020). Low temperatures affect many processes in these plants, such as those associated with defense, metabolism, secondary metabolic processes, and the synthesis of proteins and nucleic acids in plant cells (Aslam et al, 2022). Silica may help stressed plants regulate their osmotic balance and lessen oxidative damage, (Hajizadeh et al., 2021).

Nanotechnology has made unique applications of a wide range of materials with special features achievable. These molecules can interact effectively with plants. Among the special characteristics of nanoparticles with diameters ranging from 1 to 100 nm include a higher surface area to volume ratio, enhanced electrical conductivity, and elevated nutrient absorption effectiveness (Mahajan et al., 2011). These characteristics make fertilizer absorption simpler, lower cost and environmental protection (Mohammadi, 2015).

Abiotic stresses like cold can generate damaging molecules called active oxygen species, which require scavenging (Dreyer and Dietz, 2018). Fertilizers with SiO_2 nanoparticles greatly improve the antioxidant defense system (Taha et al., 2022). Nanoparticles (NPs) are regarded as a beneficial and promising technology for regulating crop productivity because of their capacity to strengthen plants against abiotic stress (Kandhol et al., 2022). The use of SiNPs can also improve the photosynthetic ability of sugarcane plants under chilling stress (Elsheery et al., 2020). Similarly, applying chitosan nanoparticles to cold-stressed banana plants helps lower ROS and increases Osmo protectant accumulation (Wang et al., 2021). Furthermore, on rice plants, the foliar application of ZnO NPs may reduce chilling stress through the antioxidative system and transcription factors involved in the chilling response (Song et al., 2021). Si-NPs have been shown to enhance plant performance and yield in adverse situations, (Rajput et al., 2021).

Therefore, this study was conducted to find out the effect of foliar applying with potassium silicate and calcium nitrate fertilizers in both mineral and NPs forms on the growth of potato plants, yield and tubers quality cultivated throughout the winter season.

MATERIALS AND METHODS

At the Orabi Association Farms, a private farm in the El-Kaluobia Governorate. The field experiment was carried out during the 2022–2023 and 2023–2024 growing seasons.

Complete seed potato tubers of Hermes cv. were planted in the first and second seasons, on 11 and 16 of November, respectively, and collected after 110–115 days to investigate how the application of potassium silicate and calcium nitrate mineral and nanoparticles on the yield, tuber quality and chemical composition of potatoes planted in the late winter. The chemical and physical analyses of the experimental soil are presented in **(Table 1)**. The average temperatures, relative humidity, precipitation and sunshine of location are shown in **Table (2)**. It was estimated at Egyptian Ministry of Agriculture & Land Reclamation, Agricultural Research Center, Central Lab. for Agricultural Climate.

Table (1). The chemical and physical analyses of the experimental soil.

Parameter	Value
Particle size distribution (%):	
Clay	4.43
Silt	6.82
Fine sand	38.75
Coarse sand	50
Texture class	**Sandy**

Water parameters and bulk density

Depth	Field capacity (FC)		Wilting Point (WP)		Available water (AW)		Bulk density (BD)
	% by weight	Cm	% by weight	Cm	% by weight	Cm	gm./cm^3
0-15	12.2	28.7	2.3	5.4	9.9	23.3	1.57
15-30	11.1	26.6	2.2	5.3	8.9	21.4	1.6
30-45	10.3	25	2.5	6.1	7.8	19	1.62
45-60	8.2	20.4	2.7	6.7	5.5	13.7	1.66
		100.8		**23.5**	**23.5**	**77.3**	

Table (2). Location weather monthly data of average maximum and minimum temperatures, average relative humidity, precipitation and sunshine during 2022/2023 and 2023/2024 in Egypt- Qalyubiyah-Al Obour-Gamaiet Ahmed Orab.

Months	Minimum temperature (°C)	Maximum temperature (°C)	Average relative humidity (%)	Precipitation (mm)	Sunshine duration (Hours)
			2022- 2023		
22-Nov	13.29	25.20	60.38	0.40	10.62
22-Dec	11.35	23.00	63.53	15.80	10.23
23-Jan	8.27	20.48	68.54	20.50	10.45
23-Feb	6.39	18.89	69.79	10.70	11.12
Means	9.82	21.89	65.56	11.85	10.61
			2023-2024		
23-Nov	15.29	27.31	61.45	11.70	10.63
23-Dec	11.59	23.10	66.89	4.80	10.23
24-Jan	8.30	20.36	59.08	4.50	10.44
24-Feb	8.15	21.29	61.40	3.20	11.11
Means	10.83	23.02	62.21	6.05	10.61

The following foliar spray six treatments were involved of the experiment:

1- Control (tap water).
2- Nano-Potassium silicate at 100 ppm
3- Nano-Potassium silicate at 1000 ppm
4- Potassium silicate at 2000 ppm
5- Nano-Calcium nitrate at 1000 ppm
6- Calcium nitrate at 2000 ppm

The potato tuber (Hermes cultivar) comes from the Horticulture Research Institute, ARC, Giza, Egypt and the commercial source of Nano-compounds (biota) were used in the experiment provided by the Egyptian corporation for biotechnological research. The treatments were set up using a randomized complete design with three replicates and foliar spray treatments were applied at three times (30, 45, and 60 days after planting). Tubers were planted with a 25 cm distance between each row in a 17.5 m^2 plot that included five rows, each 0.70 m in width and 5 m in length. Furthermore, 20 m^3 of farmyard manure, 75 kg of P2O5/fed, and 150 kg of agricultural sulfur were mixed and applied throughout the soil preparation process. Six equal doses of ammonium nitrate (33.5% N), a nitrogen fertilizer, were delivered using the irrigation system at a rate of 180 kg N/fed.

At a rate of 96 kg K2O/fed, potassium sulfate (48 percent K_2O) was added as the potassium fertilizer. Once the soil was being prepared, the first dose of 100 kg of potassium sulfate was added. The remaining doses were then applied to the drip irrigation system in two equal doses. A drip irrigation system was used, and disease, insect, and cultural management programs were implemented in accordance with the guidelines provided to the Egyptian Ministry of Agriculture.

Data collected:

1-Growth parameters:

Seventy -five days after planting, a random sample of five plants was collected to determine the characters of vegetative growth, including stem length, the number of main stems per plant, fresh and dry weigh/plant. The average chlorophyll content was estimated using a Minolta SPAD unit chlorophyll meter.

2-Total yield and its component: -

Total yield of tubers per fed. and marketable tubers per plant was determined for each plot; tubers with no wounds, fractures, cuts, rotting, or insect infestations were considered suitable for marketing. Each plot's marketable tuber weight was determined. Tubers weighing 50 g or more were considered suitable for marketing.

- Average tuber weight (g) and number of tubers /plants were recorded as well as specific gravity of potato tubers was calculated according to the method of Kleinkopf and Wassermann (1987).

3-Chemical contents:

a- dry matter of potato tuber %

b- Starch content: it was determined as reported in A.O.A.C. (1990) procedure.

c- Mineral contents:

Silicon, nitrogen, calcium and potassium were determined in the digested dry matter of leaves as follows: -

1- Silicon concentration: It was determined according to Stefansson et al. (2007) using an inductively coupled plasma (ICP) spectrometer.

2- Total nitrogen: It was identified using Koch and McMeekin's (1924) methodology.

3- Calcium content: It was identified using an inductively Coupled Plasma (ICP) spectrometer according to A.O.A.C. (2016).

4- Potassium percentage: It was determined using a flame photometer, in accordance with Brown and Lilliland (1946).

4-Statistical analysis

The means of the data were compared by statistical analysis using Duncan's multiple range test, following the methodology outlined by Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

1-Growth characteristics:

The data presented in **Table (3)** revealed that spraying mineral and Nano fertilizers resulted in significant differences in growth parameters. Plant length showed the highest value when 2000 ppm of calcium nitrate was sprayed; in the first season, there were no appreciable variations when 100 ppm of Nano potassium silicate was applied, however, in the second season, only 100 ppm of Nano potassium produced the highest value. Data in the same table indicated an increment in number of the main shoot / plant by spaying 100 and 1000 ppm of Nano potassium silicate as well as 1000 ppm of Nano calcium nitrate in both growing seasons. Furthermore, the spraying 100 ppm of Nano potassium silicate revealed the maximum values of fresh weight in both tested seasons. On the other hand, during the first growing season, there were no significant differences in the dry weight of potato plants among all treatments; in contrast, during the second season, calcium nitrate (2000 ppm) and control had the lowest values. NPs can be absorbed and transported by plants after getting into contact with them; this can have a variety of impacts, including enhancing the growth of plants under abiotic stress and boosting antioxidant substances (Zhang et al., 2018; Pérez-Labrada et al., 2019**).** NPs may improve the activity of many antioxidant enzymes (Noohpisheh et al., 2021**)**, which could explain the increase in potato growth throughout the winter season. Our results are in the same line with the findings of Al-Selwey et al. (2023) who found that spraying SiO2-NPs considerably enhanced the growth parameters of potato plants.

Table (3). Effect of Nano and mineral fertilizers on growth characteristics of potato in 2022/2023 and 2023/2024 seasons.

Treatments (ppm)	Plant length (cm.)	No. main shoot/plant	Fresh weight (g)/plant	Dry weight (%)
		2022/2023		
Control	30.67 d	3.03 c	265.80 cd	25.07 a
Nano- potassium silicate 100	43.67 ab	4.67 ab	347.47 a	25.55 a
Nano- potassium silicate 1000	37.67 c	5.02 a	263.53 d	25.82 a
Potassium silicate 2000	42.67 b	3.67 bc	284.37 b	25.49 a
Nano- Calcium nitrate 1000	37.67 c	5.00 a	286.60 b	24.96 a
Calcium nitrate 2000	47.33 a	3 02 c	279.13 bc	24.89 a
		2023/2024		
Control	28.00 d	3.09 b	168.10 d	23.82 b
Nano- potassium silicate 100	44.67 a	5.33 a	264.20 a	27.47 a
Nano- potassium silicate 1000	37.33 b	4.02 ab	213.93 c	27.52 a
Potassium silicate 2000	35.00 bc	4.03 ab	235.90 b	26.51 a
Nano- Calcium nitrate 1000	31.00 cd	4.33 ab	270.00 a	26.93 a
Calcium nitrate 2000	32.33 cd	3.05 b	227.47 bc	13.97 b

Values in the same column followed by similar letters are not statistically different (Duncan test)

The results illustrated in **Fig (1)** showed that the spraying with 100 ppm of Nano-potassium silicate and 2000 ppm of normal potassium silicate as well as 1000 ppm of Nano-calcium nitrate exhibited the highest total chlorophyll in potato leaves in both tested seasons. These results are in the same line with the findings of Salim et al. (2014) who reported that foliar application of 2000 ppm potassium nitrate and potassium silicate to potato plants achieved optimum values of plant length, fresh shoot, dry shoot, and chlorophyll. SiO_2-NPs may strengthen resistance to abiotic stresses, help the antioxidant system during stressful situations, encourage plant growth, and preserve the water balance of cells (Qados, 2015). Furthermore, NPs increase CO_2 absorption, a basic mechanism of biomass creation that is vital to plant growth, and hence stimulate photosynthetic activity (Kataria et al., 2019). Application of nano-SiO_2 improves photosynthetic efficiency helping bean plants under drought stress (El-Sayed et al., 2021). As well as the decomposition of Nano calcium particles in the intercellular spaces of gerbera leaf released gaseous such as CO_2, may have contributed to the enhanced development traits of plants. This would have increased the level of CO_2 at the photosynthesis active of the plant leaves area and increased the efficiency of photosynthesis (Anitha et al., 2023).

Furthermore, applying potassium silicate directly improved the vegetative development properties of potatoes, as reported by Abd El-Gawad et al. (2017) and improved parameters for potato growth in every silicon treatment (Soltani et al., 2018). Similarly, Elsheery et al. (2020) found that the application of SiNPs can improve the photosynthetic abilities of sugarcane plants under cold stress. Applying potassium silicate is recommended as a source of silicon to support the chlorophyll content of wheat plants during various growth stages Abo Basha et al. (2024).

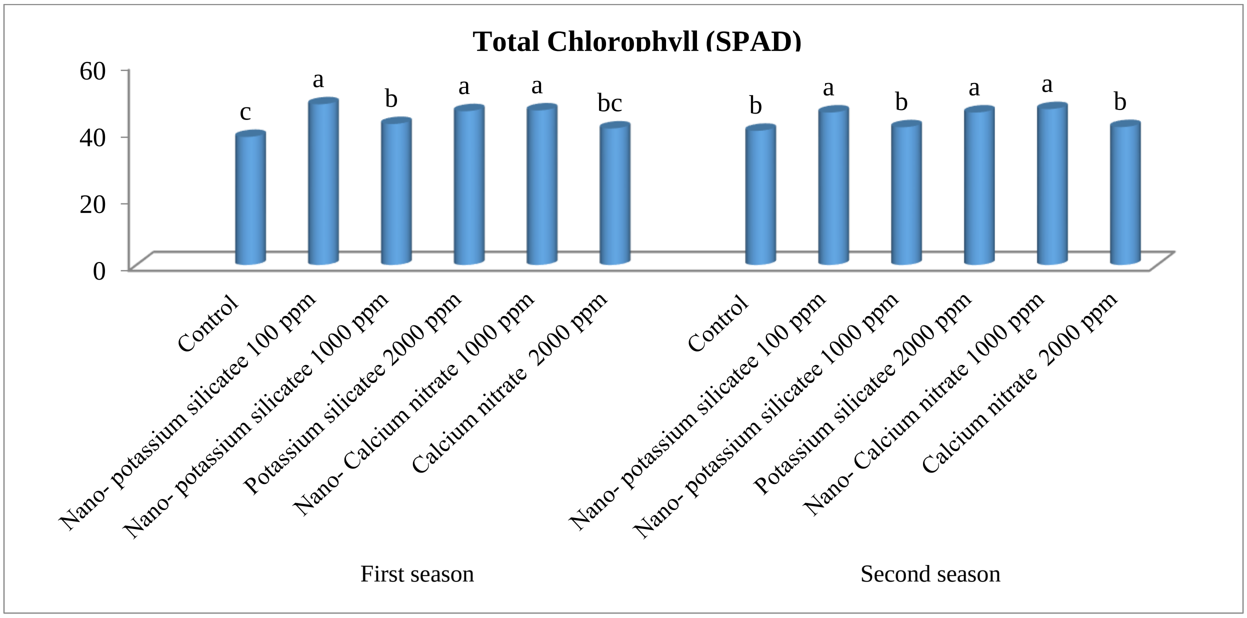

Fig. (1). Effect of Nano and mineral fertilizers on total chlorophyll (SPAD) of potato in 2022/2023 and 2023/2024 seasons.

2- Yield and its components:

The data displayed in **Fig (2)** shows that the foliar application of Nano potassium silicate at 100 ppm and potassium silicate 2000 ppm during the first season had an effective impact on the total tuber yield per feddan. Moreover, the application of 100 ppm potassium silicate Nano increased the total yield per fadden in comparison to the other treatments in the second season.

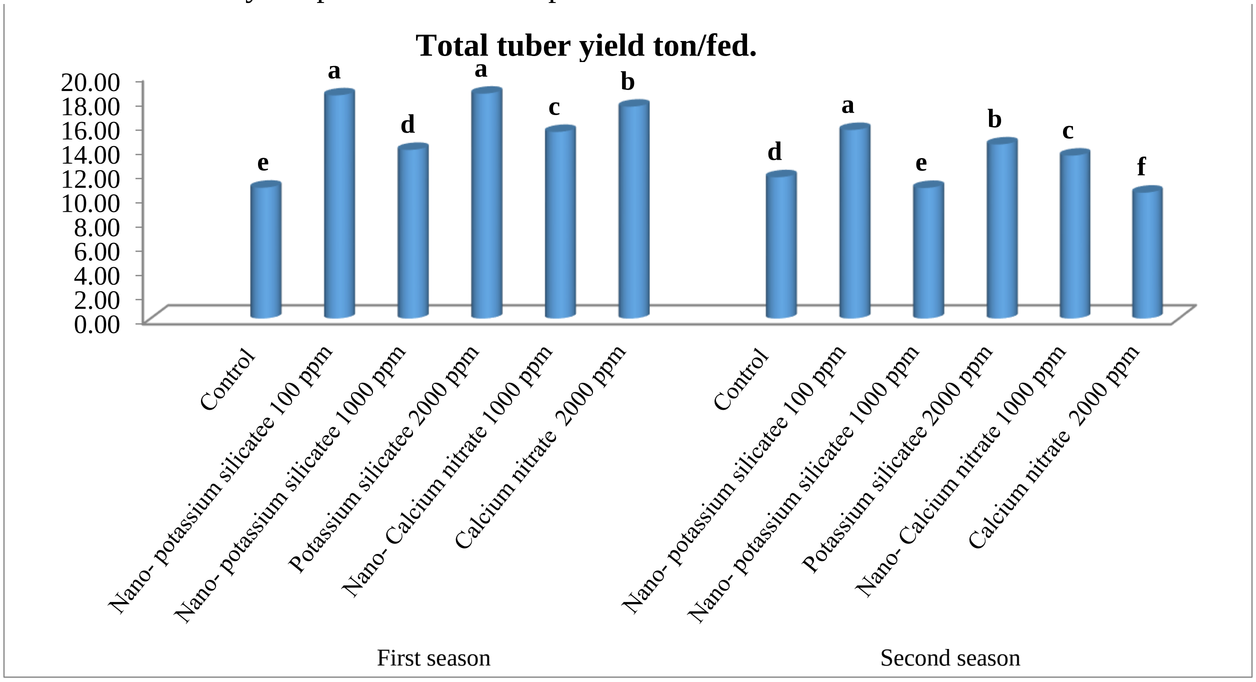

Fig. (2). Effect of Nano and mineral fertilizers on total yield per fadden of potato in 2022/2023 and 2023/2024 seasons.

Marketable yield of tubers per feddan increased substantially by foliar spraying 100 ppm Nano potassium silicate followed by 2000 ppm potassium silicate in both testing seasons **(Table 4).** Our results are in harmony with those of El-Hedek (2013) and

Abd El-Gawad et al. (2017) they revealed that applying silicon foliar spray along with potassium silicate treatment increased photosynthesis in potato plants resulted in higher tuber yield. An important impact of applied Nano fertilizer on crop productivity has been observed for several crops, such as peanut, (Xiumei et al., 2005), apple Ranjbar et al, (2018) and cucumber Cid-López et al., (2021). Application of SiO2 NPs boosted tomato fruit yield by 14.55% when compared to the control, according to study by Magín et al. (2022). Similarly, wheat plots that received foliar spraying of potassium silicate produced the highest grain, straw, and biological yield (Abo Basha et al., 2024).

Table (4). Effect of Nano and mineral fertilizers on marketable yield and components of potato in 2022/2023 and 2023/2024 seasons.

Treatments (ppm)	Marketable yield (ton/fed.)	No. tuber/plant	Average of tuber weight (g)
		2022/2023	
Control	7.84 f	6.20 e	105.96 d
Potassium silicate Nano 100	16.87 a	7.53 b	182.22 a
Potassium silicate Nano 1000	9.94 e	7.17 c	132.67 c
Potassium silicate 2000	16.20 b	9.00 a	171.41 ab
Calcium nitrate Nano 1000	12.88 d	6.81 d	173.49 ab
Calcium nitrate 2000	13.33 c	7.27 c	158.67 b
		2023/2024	
Control	10.67 e	6.52 c	120.32 b
Potassium silicate Nano 100	13.62 a	7.89 a	155.68 a
Potassium silicate Nano 1000	12.17 d	6.07 d	146.85 a
Potassium silicate 2000	13.19 b	7.69 a	137.54 ab
Calcium nitrate Nano 1000	12.58 c	7.16 b	137.03 ab
Calcium nitrate 2000	9.87 f	5.79 d	127.72 b

Values in the same column followed by similar letters are not statistically different (Duncan test)

Table (4) clearly shows that foliar application of 2000 ppm potassium silicate significantly increased the number of tubers per plant in the first season, followed with 100 ppm nanoparticles of potassium silicate in comparison to the other treatments. Furthermore, the highest values of tuber number per plant in the second season were achieved by foliar spray with 2000 ppm potassium silicate and 100 ppm potassium silicate nanoparticles. Applying 100-ppm potassium silicate Nano particles treatment is the most effective treatment to increase the average tuber weight followed by treatments with spaying 2000 ppm potassium silicate and 1000 ppm calcium nitrate Nano particles in both tested seasons. Madejón et al. (2006) found that the application of calcium in the nano size form improved several elements of the plant's growth and yield. Potassium fertilization has been shown to improve potato production indicators through several physiological processes, such as ionic balancing, stomatal and activity of enzymes, and osmotic management. These processes all directly affect plant development, which in turn affects tuber formation and yield (Bishwoyog and Swarnima, 2016). These results are similar to those of Shabana et al. (2023) who reported that spraying potassium silicate to potato plants minimizes the adverse effects of salt in irrigation water by enhancing the quantity and quality of tuber yield.

3-Chemical contents:

The results in **Table (5)** show that the dry matter content of potato tubers significantly increased in the two tested seasons by spraying 2000 ppm of common potassium silicate and 100 and 1000 ppm potassium silicate nanoparticles. These results confirm those of Abd El-Gawad et al. (2017) who found that applying potassium silicate as a foliar spray at 2000 ppm significantly increased the dry matter content of potato tubers. The potato tubers treated with 1000 ppm potassium silicate nanoparticles and 2000 ppm calcium nitrate resulted in higher starch content than the tubers treated with the other treatments during the first season. Additionally, spraying 100, 1000 ppm potassium silicate nanoparticles and 2000 ppm of common potassium silicate resulted in a substantial increase in starch concentration in the second season as compared to the control treatment. The application of Si-NPs reduced the negative effects of salinity and raised tomato starch parameter by 77% Alam et al. (2022). SiNP can be applied topically to sweet potatoes as a supplement to boost tuber biomass, decrease sugar tuber production, and improve carbohydrate metabolism. Data in **Table (5)** clearly shows that spraying 100, 1000 ppm of potassium silicate nanoparticles and 2000 ppm of calcium nitrate resulted in the highest specific gravity of the tuber in the second season compared to the rest of the treatment. On the other hand, there were no significant differences in the specific gravity of potato tubers during the first season, despite the impact of mineral and Nano fertilizer treatments on the specific gravity content in the tuber.

Table (5). Effect of Nano and mineral fertilizers on dry matter, starch and specific gravity contents of potato tubers in 2022/2023 and 2023/2024 seasons.

Treatments (ppm)	Dry matter (%)	Starch (%)	Specific gravity
		2022/2023	
Control	22.54 c	16.22 c	1.11 a
Potassium silicate Nano 100	23.26 a-c	16.62 b	1.19 a
Potassium silicate Nano 1000	23.76 a	17.35 a	1.17 a
Potassium silicate 2000	22.82 a-c	16.28 bc	1.12 a
Calcium nitrate Nano 1000	22.73 bc	16.27 bc	1.12 a
Calcium nitrate 2000	23.70 ab	17.18 a	1.17 a
		2023/2024	
Control	23.47 b	16.99 bc	1.16 b
Potassium silicate Nano 100	23.60 ab	17.63 ab	1.17 ab
Potassium silicate Nano 1000	24.86 a	18.06 a	1.19 a
Potassium silicate 2000	23.69 ab	17.57 ab	1.16 b
Calcium nitrate Nano 1000	21.57 c	14.96 d	1.12 c
Calcium nitrate 2000	23.18 b	16.58 c	1.14 a

Values in the same column followed by similar letters are not statistically different (Duncan test)

3.1. Protein% of leaves:

Results shown in **Fig. (3)** demonstrate that the addition of treatments with 100 or 1000 ppm Nano particles of potassium silicate during the first season had a substantial impact on the protein percentage of potato leaves. However, the application of Nano potassium silicate at 100 ppm produced the highest value for the protein percentage of leaves in the second season. Nucleic acid and protein synthesis are two of the main plant processes that are impacted by low temperatures (Aslam et al., 2022). The potato leaves treated with SiO_2-NPs showed an increasing pattern in total protein levels and the antioxidant activity of all the enzymes studied when compared to the control plants (Al-Selwey et al., 2023). Compared to the control plant, the potassium silicate NP-treated sweet potato tuber showed an increase in protein and invertase enzyme levels of 5.0 µg/mg (Zalan et al., 2024).

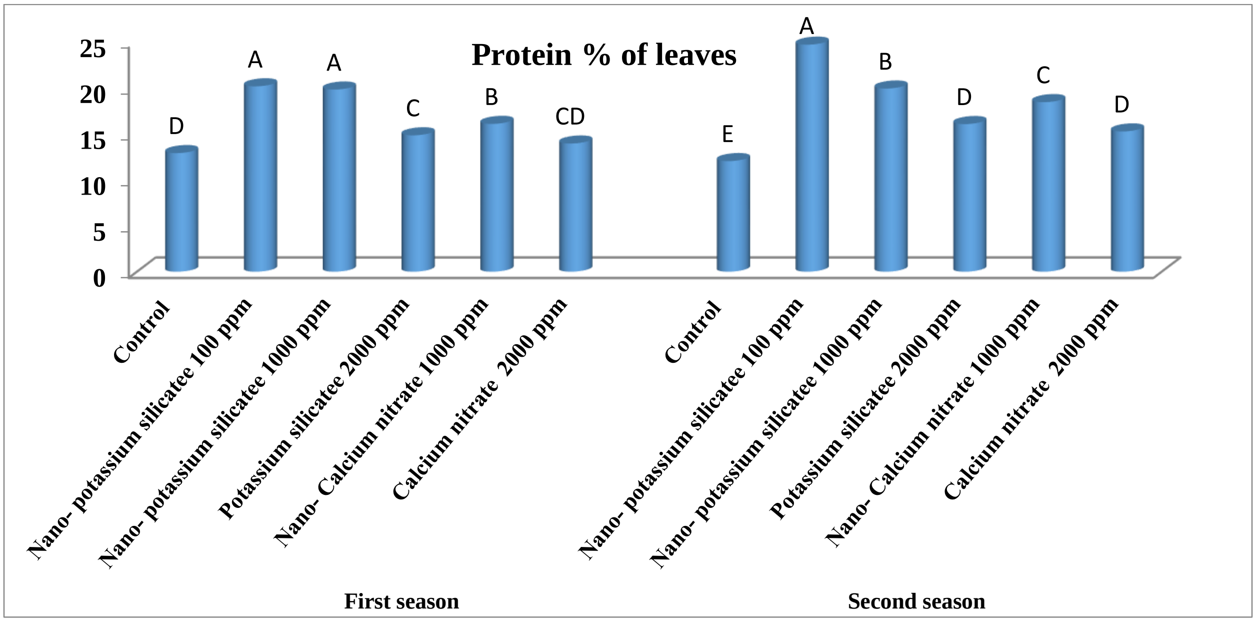

Fig. (3). Effect of Nano and mineral fertilizers on protein % of leaves of potato in 2022/2023 and 2023/2024 seasons.

3.2. Mineral contents:-

Results shown in **Fig. (4)** demonstrate that foliar Nano fertilization of 100 ppm potassium silicate and 2000 ppm potassium silicate resulted in a significant impact on leaves silicon content in the first seasons. However, in the second season, the highest value of silicon content of leaves was obtained when spraying of Nano fertilization of 100 ppm potassium silicate. This may be directly related to the beneficial effects of Nano fertilizers on root system efficiency, nutrient status, and their uptake. SiO_2 NPs have a great effect on growth because they improve several xylem sap transport characteristics and boost the plant's capacity to absorb nutrients and water, (Janmohammadi et al., 2016).

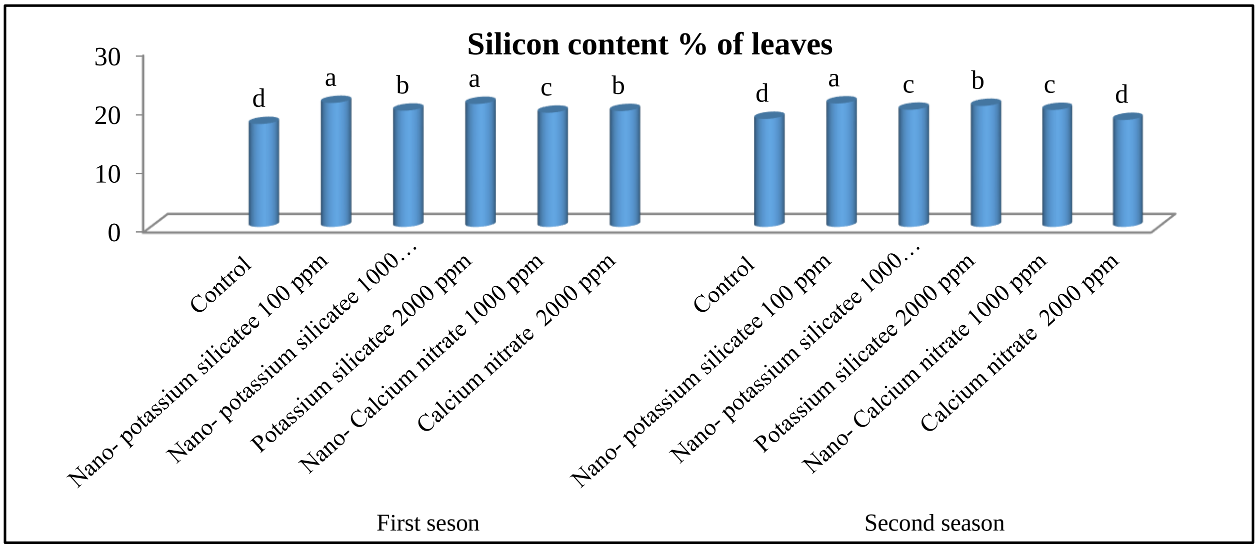

Fig. (4). Effect of Nano and mineral fertilizers on silicon content of potato leaves in 2022/2023 and 2023/2024 seasons.

It is evident from **Table (6)** that application of 100 ppm Nano fertilizer of potassium silicate achieved the greatest effect on nitrogen content of leaves as compared to the control treatment in both tested seasons. Application at 1000 Nano fertilizer of potassium silicate had a significant effect on nitrogen leave content in the first season. The results shown in **Table (6)** showed also that the potassium content of potato leaves throughout the two growth seasons was significantly impacted by the foliar application of 100 ppm potassium silicate Nano fertilizer. Potassium is highly involved in potato plant growth and development and can assist plants in adapting to abiotic stressors such as extreme temperatures (Naumann et al., 2020). Furthermore, the calcium content of potato leaves was significantly affected by the foliar application of 1000 ppm calcium nitrate Nano fertilizer across the two growing seasons. In potato plants cultivated in water deficit, the foliar spray of SiO_2-NPs (50 mgL[1]) encouraged the accumulation of mineral ions, leading to increased nitrogen and potassium (Al-Selwey et al., 2023).

Table (6). Effect of Nano and mineral fertilizers on silicon, nitrogen, potassium and calcium contents of potato leaves in 2022/2023 and 2023/2024 seasons.

Treatments (ppm)	N%	K%	Ca %
		Season; 2022/2023	
Control	**2.06 d**	**0.94 d**	**4.58 d**
Potassium silicate Nano 100	**3.17 a**	**2.05 a**	**4.58 d**
Potassium silicate Nano 1000	**3.23 a**	**2.03 a**	**3.95 e**
Potassium silicate 2000	**2.37 c**	**2.01 a**	**4.68 c**
Calcium nitrate Nano 1000	**2.57 b**	**1.75 c**	**5.92 a**
Calcium nitrate 2000	**2.23 cd**	**1.93 b**	**5.08 b**
		Season; 2023/2024	
Control	**1.92 e**	**0.97 f**	**4.55 c**
Potassium silicate Nano 100	**3.95 a**	**1.91 a**	**3.61 e**
Potassium silicate Nano 1000	**3.17 b**	**1.08 e**	**4.15 d**
Potassium silicate 2000	**2.56 d**	**1.16 d**	**4.41 c**
Calcium nitrate Nano 1000	**2.95 c**	**1.30 b**	**5.41 a**
Calcium nitrate 2000	**2.44 d**	**1.22 c**	**4.76 b**

Values in the same column followed by similar letters are not statistically different (Duncan test)

It is well known that when plants are exposed to NPs fertilizers, their morphology changes, changing the way roots grow of wheat and Soya Bean (Dimkpa et al., 2015), this can have the impact of producing root hair growth, which may enhance nutrient absorption (Adams et al., 2017). Alsaeedi et al. (2019) reported that the application of Si NPs resulted in 41% increase in K absorption and concentration in cucumber of leaves. Additionally, the application of SiO_2 NPs enhanced and positively impacted the absorption and concentration of macronutrients in tomato roots and leaves (González-Moscoso et al., 2021).

Conclusion:

The growth, total and marketable yield, quality tuber attributes (dry matter, starch content, and specific gravity), leaves protein, silicon, and potassium content of potato plants were all positively enhanced by the foliar application of potassium silicate NPs at a concentration of 100 ppm. Potato plants can withstand the winter cold due to Nano fertilizers, which also lessens the damage and hence the cost caused by mineral fertilizers.

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الملخص العربي

استجابة نباتات البطاطس لأسمدة سيليكات البوتاسيوم ونترات الكالسيوم النانوية في الموسم الشتوي

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أجريت تجربة حقلية بمزرعة خاصة بمحافظة القليوبية بمصر خلال العروة الشتوية لموسمي 2023/2022 و2024/2023 بهدف تقييم تأثير الرش الورقي بسليكات البوتاسيوم ونترات الكالسيوم النانويه والمعدنية علي النمو والمحصول وجودة درنات البطاطس للصنف هيرميس. تم رش نباتات البطاطس بست معاملات في تجربة حقليه بسماد سيليكات البوتاسيوم النانوي بمعدل 100 و1000 جزء في المليون، والأسمدة المعدنية من سيليكات البوتاسيوم بمعدل 2000 جزء في المليون ونترات الكالسيوم بمعدل 2000 جزء في المليون، وأسمدة نترات الكالسيوم النانوية بمعدل 1000 جزء في المليون.

وبناء علي النتائج: أدت المعاملة بسيليكات البوتاسيوم النانويه عند 100 جزء في المليون إلي تحسين النمو الخضري والثمري بشكل كبير مثل طول النبات، عدد الأفرع الرئيسية، الوزن الطازج والجاف للنبات، محتوى الكلوروفيل، المحصول الكلي والتسويقي، وجودة الدرنات، ومحتوى السيليكون والبوتاسيوم بشكل ملحوظ في الأوراق.

توصي الدراسة برش نباتات البطاطس بسيليكات البوتاسيوم النانوية بتركيز 100 جزء في المليون لتحسين معايير النمو والمحصول الكلي والتسويقي وجودة درنات البطاطس وهذه الدراسة تعمل علي تقليل كميات وأسعار وأضرار الأسمدة المعدنية وآمنه للبيئة.