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Effect of Mineral and Bio-Phosphorus Fertilization and Foliar Spraying With Some Growth Stimulants on Productivity and Tubers Quality of Potato Plant Grown In Winter Season

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Abstract

Forest is one of the critical factors limiting the productivity of potatoes (Solanum tuberosum L.) during winter season in Egypt. This field experiment was conducted at El Kanater Horticultural Research Station in Kaluobia Governorate, Egypt, during the two winter seasons of 2021/2022and 2022/2023 to investigated the effect of mineral and bi-phosphorus fertilizers treatments and foliar spraying with salicylic acid, potassium citrate and potassium silicate and their interaction on tubers yield and tubers quality of potato (Spunta cv.).: The experiment was laid out as (RCBD) in 4×4 factorial arrangement of phosphorus (phosphoric acid (40 l/fed) + phosphorene, phosphoric acid (60 l/fed) + phosphorene, phosphoric acid (80 l/fed) + phosphorene, and Control 400kg calcium superphosphate) and foliar spraying (tap water as control), potassium silicate at 2 g/l, potassium citrate at 3 g/l, and Salicylic acid 0.5 g/l.). Analysis of the data revealed that the interaction effect of phosphorus (phosphoric acid 80 l/fed+ phosphorene) and foliar spraying with potassium citrate 3g/l significantly improved the tubers yield/ plant, tubers yield/ fed, number of tubers, potato tuber physical properties (tuber length, tuber diameter, tuber weight) and potato tuber chemical properties (total carbohydrate, Starch, Total protein ana Dry matter).

Key words: Potassium silicate, Potassium citrate, Salicylic acid, phosphoric acid, phosphorene, potato Spunta cv.

Introduction

Potato (*Solanum tuberosum* L.) is an important food crops after wheat, corn and rice across the world **(Vreugdenhil, 2007)**. It is considered a favorite food for a large segment of the world's population, which can be eaten fried, grilled, boiled, or in the form of baked goods. It may also be shared on the table with many other foods in cooked form because of its nutritional value, as the tubers contains about 79% water, 17% carbohydrates (88% is starch), 2% protein, and contains negligible fat. A 100-gram of fresh potato tuber provides 77 kilocalories of food energy and it is a rich source of vitamin B6 (23%) and 24% of vitamin C **(Laws, 2015)**. The world total cultivated area in 2022 reached about 18.13 million hectares, with fresh tubers production of 276.12 million tons, while the total Egyptian cultivated area in in 2022 reached 262.91 thousand hectares, with total production of tubers reached about 6.91 million tons **(FAOSTAT 2022)**.

Potato plants are generally characterized by their high response to fertilization, as the yield and quality of tubers increase significantly with the application of optimal fertilizer doses. Accordingly, fertilization with macro- and microelements is considered an imperative necessity to improve tuber yield and quality. Many elements also play an important role in resisting many biotic and abiotic stresses. Potassium silicate is considered as an agronomical essential element because of its beneficial effects of Si, including enhancement of growth and quality, photosynthesis stimulation, transpiration reduction and increasing plant resistance to biotic and abiotic stresses, are well-established in several agricultural crops **(Kamenidou, et al., 2008)**. Potassium silicate is a source of highly soluble potassium and silicon so it is used in agricultural production system primarily as a silicon amendment source and has utilized of supplying small amounts of potassium help to improve the quality of yield **(Tarabih et al., 2014)**.

Zewail et al., (2011) found that foliar application of potassium citrate (KC) increased yield and yield components of faba bean plants.

Spraying SA increased average tuber number / plant, yield / plant, marketable yield and total yield / fad as well as protein content in tubers **(Asem, et al., 2020)**.

Phosphorus plays a vital role in building process and energy transferring, as it participates in enzymatic construction and the formation of amino

acids. It was found that application of P increased the days to reach flowering. Aboveground and underground biomass yields of potato were significantly influenced by N and P fertilization **(Zelalem et al 2009)**. Also, **Eleiwa et al (2012)** reported that application of NPK levels significantly increased the dry weight of potato. Also, NPK application significantly increased the tuber yield and the yield parameters of potato at harvest. In addition, **Qiu, et al., (2022)** evaluated different P rates significantly improved tuber yield.

Based on the above-mentioned effect of each individual factor, the present study aims to evaluate the role of potassium source, salicylic acid and phosphorous fertilizers on tuber yield and tuber quality of potato (Spunta cv.).

Materials and Methods

The current study was conducted at El Kanater Horticultural Research Station in Kalyubia Governorate to study the effect of mineral and bio phosphorus fertilizers treatments and foliar spraying with salicylic acid, potassium citrate and potassium silicate and their interaction on tubers yield and tubers quality of the Spunta potato cultivar that grown in the Nile lug during the two growing seasons 2021/2022 and 2022/2023. The experimental soil was a clay loam with pH of 7.94.

Experimental Procedures

Soil analysis of experimental sites

Before sowing, soil samples were randomly taken to measure physical and chemical properties. A random sample was taken from surface layer up to 30 cm depth. It was air-dried, crushed, and tested for physical and chemical properties. Chemical and physical properties of the experimental soil are shown in Table 1.

Table 1. The experimental soil physical and chemical properties as the average of 2021/2022 and 2022/2023 seasons.

Physical Soil Analysis

Particle size distribution			Texture	pH	EC Ds.m^{-1}	Organic matter
Sand %	Silt %	Clay %				
19.02	26.78	54.20	Clay-Loamy	7.94	1.07	1.21%

Chemical Soil Analysis

Available macro nutrients (mg/kg)			Cations meq.l^{-1}				Anions meq.l^{-1}			
N	P	K	Na^{+}	K^{+}	Mg^{++}	Ca^{++}	So_{4-}	Cl	HCo_{3-}	Co_{3--}
22.50	9.10	64.00	3.91	0.84	1.65	3.36	1.79	3.82	4.15	-

Experimental work

Potato **s**eeds of Spunta cultivars were obtained from Agricultural Research Center**,** Giza, Egypt. Tubers used in this study were uniform in shape and free from physiological and disease infection. Seeds were planted after completing curing process. Planting was done on 1st of November, in both seasons under surface irrigation system. Seeds were planted, in rows each row was 4 matters long and 80 cm apart.

Treatments

Phosphorus fertilizers treatments:

1- phosphoric acid (40 l/fed) + phosphorene.
2- phosphoric acid (60 l/fed) + phosphorene.
3- phosphoric acid (80 l/fed) + phosphorene.
4- Control (400kg calcium superphosphate.

- Foliar spraying treatments:

1- Potassium silicate (2 g/l).
2- Salicylic acid (0.5 g/l).
3- Potassium citrate (3 g/l)
4- Control (Tap water).

During the two growing seasons, all tested treatments were applied three times; after 50, 65 and 80 days from planting. Also, all experimental plots received the recommended dosage of nitrogen and potassium fertilizers.

Experimental Design

The field experiments was arranged in a in a split plot design with three replicates where, the soil application treatments allocated in the main plots while the foliar spraying treatments were randomly distributed in the sub plots.

During soil preparation, 60 kg P_2O_5fed^{-1} (as calcium super phosphate (15.5% P_2O_5) and 20 m^3 fed^{-1} of chicken manure were added. All experimental unites received equal amount of 120, 60, and 96 units of N, P_2O_5 and K_2O , per feddan ,respectively. Ammonium nitrate was the source of nitrogen where; potassium sulphate was the source of potassium. Calcium Super Phosphate at the rate of 60 P_2O_5 units were added during soil preparation and phosphoric acid (15

P_2O_5 units) were fustigated. All amounts of N and K were added as soil application throughout growing season until 85 days after planting. Harvesting was done after 115 days from planting.

All agricultural practices were carried out, including the application of herbicide, ridging, fertilization and pest control according to the technical recommendations for the crop issued by the Egyptian Ministry of Agriculture and Land Reclamation.

Data recorded

Tuber's physical properties

1. Average tuber weight (g); it was determined as the average weight of all tubers of five randomly chosen plants each experimental sub-sub -plot then divided by 5 to calculate average tuber weight.

2. Tuber length (mm); it was determined as the average length of 10 tubers each experimental sub-sub -plot by using ruler.

3. Tuber diameter (mm); it was determined as the average diameter of 10 guarded tubers each experimental sub-sub -plot using Vernier caliper.

Yield and its components

1. Number of tubers/plant; it was the average number of tubers for the five randomly chosen plants from each experimental sub-sub-plot.

2. Tuber's yield/plant (g); it was calculated as the average weight of all tubers of five guarded plants chosen randomly from each experimental sub-sub -plot then divided by 5 to calculate tuber's yield/plant.

3. Tuber's yield/feddan (tons); the tuber yield per feddan was estimated by multiplying the average plant yield of tubers by the number of plants per feddan.

Tuber's quality characteristics

1. Tuber's starch content (%)

Starch was estimated according to the method described by **Malik and Srivastava (1979)**

2. Tuber's total sugars content (%):

3. Tuber's dry mattr%

Five fresh tubers were randomly chosen from each treatment and artificially dried at 70 ^{o}C for until reach a constant weight. The five dried tubers were weighed and the average dried tuber was estimated.

tuber's mineral contents.

1. nitrogen content.
2. phosphorus content.
3. potassium content.
4. Total carbohydrates content

tuber's nitrogen contents were assayed according to **Chapman and Pratt (1961)** and **Cottenie*et al.* (1982**) using the micro kjeldahl apparatus. Phosphorus was determined spectrophotometers by **cottenie *et al*(1982**). Potassium was determined photometrically, using flame photometer according to **Jackson (1965).**

3.2. Statistical analysis

The data were subjected and analyzed by using **two-way** ANOVA followed by LSD test through SPSS 16 (version 4). The treatments means were compared using least significant difference (LSD) tested at 5% level of probability as described by **Gomez and Gomez (1984)**.

Results

1. Effect of soil application with different levels of phosphoric acid+ phosphorine and foliar spraying with potassium silicate, salicylic acid and potassium citrate as well as their interaction on potato tuber yield.

The results in Tables 2, 3 and 4 confirmed that potato tuber yield significant affected by soil application and foliar spraying treatments as well as their interaction in both seasons.

Table 2. Effect of soil application with different levels of phosphoric acid+ phosphorene on potato tuber yield traits during winter season of 2021/2022 and 2022/2023.

Factors	Number of	Tuber yield/plant (g)	Tuber yield/fed (tons)
1st season2021/2022			
Pa (80 l/fed) +phosphorene	6.83 a	709.15 a	11.35 a
Pa (60 l/fed) + phosphorene	6.50 b	649.93 b	10.40 b
Pa (40 l/fed) + phosphorene	6.17 c	598.57 c	9.58 c
Control PRD(400kg calcium superphosphate).	5.75 d	540.01 d	8.64 d
LSD at 5%	**0.24**	**17.43**	**0.28**
2nd season2022/2023			
Pa (80 l/fed) +phosphorene	6.17 a	757.94 a	12.13 a
Pa (60 l/fed) + phosphorene	5.67 ab	705.03 ab	11.28 ab
Pa (40 l/fed) + phosphorene	5.33 bc	628.73 bc	10.06 bc
Control PRD(400kg calcium superphosphate).	5.00 c	566.18 c	9.06 c
LSD at 5%	**0.53**	**82.64**	**1.32**

Values followed by the same letter in the same column are not statistically different

a. Effect of soil application treatments:

All tuber yield traits were higher under all tested soil applications treatments than control in both seasons (Table 2). The results showed significant increase in number of tubers/plant, tuber yield/plant and tuber yield/fed with the increase of phosphoric acid rate in both seasons. The highest number of tubers/plant (6.83 and 6.17), tuber yield/plant (709.15 and 757.94 g) and tuber yield/fed (12.35 and 12.13 tons) were recorded in potato plants that treated with 80 kg phosphoric acid + phosphorene in the two seasons of the study, respectively, followed by Potato plants that treated with 60 kg phosphoric acid + phosphorene. On the other hand, potato plants the treated with the recommended dose of P had the lowest values in both season.

b- Effect of Foliar spraying treatments:

The presented data in Table 3 revealed significantly differences among all foliar spraying treatments in increasing number of tubers/plant, tuber yield/plant and tuber yield/fed in both seasons. All foliar spray treatments increased potato tuber yield more than the control treatment in both seasons. Potato plants that sprayed with potassium citrate recorded the highest number of tubers/plant (6.50 and 6.17), tuber yield/plant (691.23 and 774.74 g) and tuber yield/fed (11.06 and 12.40 tons) in booth seasons, respectively, followed by Potato plants that sprayed with potassium silicate then potato plants that sprayed with salicylic acid. On the other side, potato plants in the control treatment recorded the lowest values in both seasons.

Table 3. Effect of foliar spraying with potassium silicate, salicylic acid and potassium citrate on potato tuber yield traits during winter season of 2021/2022 and 2022/2023.

treatments	Number of tuber/plant	Tuber yield/plant (g)	Tuber yield/fed (tons)
1st season2021/2022			
Control (C)	6.17	566.36 c	9.06 c
Potassium Silicate (PS)	6.42	648.69 ab	10.38 ab
Salicylic acid (SA)	6.17	591.38 bc	9.46 bc
Potassium Citrate (PC)	6.5	691.23 a	11.06 a
LSD 5%	**0.74 (ns)**	**74.7**	**1.2**
2nd season2022/2023			
Control (C)	5.08 c	590.50 c	9.45 c
Potassium Silicate (PS)	5.67 ab	670.07 b	10.72 b
Salicylic acid (SA)	5.25 bc	622.57 bc	9.96 bc
Potassium Citrate (PC)	6.17 a	774.74 a	12.40 a
LSD 5%	**0.54**	**77.92**	**1.25**

Values followed by the same letter in the same column are not statistically different

c- Effect of interaction:

Data in Table 4 showed that tuber yield traits varied in their response to foliar spraying treatment under the different soil application treatments in both seasons. All interactions of soil application and foliar spraying treatments exceeded the control treatment in increase all tuber yield traits in both seasons. Across all soil application treatments potassium citrate foliar spraying superior at potassium silicate and salicylic acid in increasing number of tubers/plant, tuber yield/plant and tuber yield/fed in both seasons. Potato plants that sprayed with potassium citrate under the highest rate of phosphoric acid (80kg/fed) recorded the highest number of tubers/plant (7.00 and 6.67), tuber yield/plant (778.67 and 877.10 g) and tuber yield/fed (12.46 and 14.03 tons) in the first and second seasons, respectively, followed by Potato plants that sprayed with potassium citrate under the moderate level of phosphoric acid (60 kg/fed) in both season. On the other hand, potato plants in the control treatment had the lowest number of tubers/plant (5.67 and 4.67), tuber yield/plant (489.50 and 500.73 g) and tuber yield/fed (7.83 and 8.01 tons) in both seasons, respectively.

Table 4. Effect of the interaction of soil application with different levels of phosphoric acid+ phosphorine and foliar spraying with potassium silicate, salicylic acid and potassium citrate on potato tuber yield traits during winter season of 2021/2022 and 2022/2023.

Factors		Number of	Tuber yield/plant (g)	Tuber yield/fed (tons)
		1st season2021/2022		
Pa (80 l/fed) phosphorine	**C**	6.67 ab	643.70 b-f	10.30 b-f
	PS	7.00 a	742.27 ab	11.88 ab
	SA	6.67 ab	671.97 a-d	10.75 a-d
	PC	7.00 a	778.67 a	12.46 a
Pa (60 l/fed) phosphorine	**C**	6.33 ab	589.37 e-h	9.43 d-h
	PS	6.67 ab	678.73 a-d	10.86 a-d
	SA	6.33 ab	615.10 c-g	9.84 c-g
	PC	6.67 ab	716.53 abc	11.46 abc
Pa (40 l/fed) + phosphorine	**C**	6.00 ab	542.87 fgh	8.69 fgh
	PS	6.33 ab	629.33 c-f	10.07 c-f
	SA	6.00 ab	560.07 e-h	8.96 e-h
	PC	6.33 ab	662.00 b-e	10.59 b-e
Control PRD(400kg calcium superphosphate).	**C**	5.67 b	489.50 h	7.83 h
	PS	5.67 b	544.43 fgh	8.71 fgh
	SA	5.67 b	518.40 gh	8.29 gh
	PC	6.00 ab	607.70 d-g	9.72 d-g
LSD 5%		**1.06**	**107.27**	**1.72**
		2nd season2022/2023		
Pa (80 l/fed)+ phosphorene	**C**	5.67 bcd	704.87 bc	11.28 bc
	PS	6.33 cde	720.27 bc	11.52 bc
	SA	6.00 abc	729.53 bc	11.67 bc
	PC	6.67 a	877.10 a	14.03 a
Pa (60 l/fed) +phosphorene	**C**	5.33 cde	642.73 cd	10.28 cd
	PS	5.67 bcd	697.43 cd	11.16 c
	SA	5.33 cde	666.27 cd	10.66 cd
	PC	6.33 ab	813.67 ab	13.02 ab
Pa (40 l/fed) + phosphorene	**C**	4.67 e	513.67 e	8.22 f
	PS	5.67 bcd	677.63 cd	10.84 cd
	SA	5.00 de	570.40 de	9.13 def
	PC	6.00 abc	753.20 bc	12.05 bc
Control PRD(400kg calcium superphosphate).	**C**	4.67 e	500.73 e	8.01 f
	PS	5.00 de	584.93 de	9.36 def
	SA	4.67 e	524.07 e	8.39 ef
	PC	5.67 bcd	655.00 cd	10.48 cd
LSD 5%		**0.78**	**111.88**	**1.79**

Values followed by the same letter in the same column are not statistically different

2- Effect of soil application with different levels of phosphoric acid+ phosphorene and foliar spraying with potassium silicate, salicylic acid and potassium citrate as well as their interaction on potato tuber physical properties.

The obtained results in Tables 5, 6 and 7 revealed that potato tuber physical properties significant affected by soil application and foliar spraying treatments as well as their interactions in both seasons.

a- Effect of soil application treatments:

potato tuber physical properties traits were higher under all tested soil applications treatments than control in both seasons (Table 5). The results confirmed significant increase in all potato tuber physical properties with the increase of phosphoric acid rate in both seasons. The highest tuber length

(9.94 and 11.36 cm), tuber diameter (6.82 and 7.85 cm) and tuber weight (103.63 and 124.42 g) were recorded in potato plants that treated with 80 kg phosphoric acid + phosphorene in the two seasons of the study, respectively, followed by Potato plants that treated with 60 kg phosphoric acid + phosphorene. On the other hand, potato plants the treated with the recommended dose of P had the lowest values in both seasons, respectively.

Table 5. Effect of soil application with different levels of phosphoric acid+ phosphorene on potato tuber physical properties during winter season of 2021/2022 and 2022/2023.

Factors	Tuber length (cm)	Tuber diameter (cm)	Tuber weight (g)
1st season2021/2022			
Pa (80 l/fed) + phosphorene	9.94 a	6.82 a	103.63 a
Pa (60 l/fed) + phosphorene	8.85 b	6.03 b	99.87 b
Pa (40 l/fed) + phosphorene	7.98 c	5.53 c	96.92 c
Control PRD(400kg calcium superphosphate).	7.33 d	5.14 d	93.75 d
LSD at 5%	**0.13**	**0.23**	**1.41**
2nd season2022/2023			
Pa (80 l/fed) + phosphorene	11.36 a	7.85 a	124.42 a
Pa (60 l/fed) + phosphorene	10.28 b	7.05 b	120.63 b
Pa (40 l/fed) + phosphorene	9.41 c	6.47 c	117.12 c
Control PRD(400kg calcium superphosphate).	8.75 d	6.03 d	114.67 d
LSD at 5%	**0.14**	**0.15**	**1.62**

Values followed by the same letter in the same column are not statistically different

b-Effect of Foliar spraying treatments:

The data in Table 6 showed significantly differences among all foliar spraying treatments in increasing tuber length, tuber diameter and tuber weight in both seasons. All foliar spraying treatments increased potato tuber physical properties more than the control treatment in both seasons. Potato plants that sprayed with potassium citrate recorded the highest tuber length (10.18 and 11.62 cm), tuber diameter (6.99 and 7.94 cm) and tuber weight (106.24 and 126.91 g) in both, respectively, followed by Potato plants that sprayed with potassium silicate then potato plants that sprayed with salicylic acid. On the other hand, potato plants in the control treatment had the lowest values in both seasons.

Table 6. Effect of foliar spraying with potassium silicate, salicylic acid and potassium citrate on potato tuber physical properties during winter season of 2021/2022 and 2022/2023.

Treeatments	Tuber length (cm)	Tuber diameter (cm)	Tuber weight (g)
1st season2021/2022			
Control (C)	7.19 d	5.07 d	91.59
Potassium Silicate (PS)	8.94 b	6.03 b	100.78
Salicylic acid (SA)	7.78 c	5.44 c	95.56
Potassium Citrate (PC)	10.18 a	6.99 a	106.24
LSD 5%	**0.13**	**0.22**	**0.81**
2nd season2022/2023			
Control (C)	8.63 d	6.03 d	112.12 d
Potassium Silicate (PS)	10.37 b	7.11 b	121.55 b
Salicylic acid (SA)	9.19 c	6.32 c	116.26 c
Potassium Citrate (PC)	11.62 a	7.94 a	126.91 a
LSD 5%	**0.14**	**0.16**	**0.76**

Values followed by the same letter in the same column are not statistically different

c- Effect of interaction:

Data presented in Table 7 indicated that tuber physical properties traits varied in their response to foliar spraying treatment under the different soil application treatments in both seasons. All interactions of soil application and foliar spraying treatments exceeded the control treatment in increase all tuber physical properties traits in both seasons.

Across all soil application treatments potassium citrate foliar spraying superior at potassium silicate and salicylic acid in increasing tuber length, tuber diameter and tuber weight in both seasons. Potato plants that sprayed with potassium citrate under the highest rate of phosphoric acid (80kg/fed) recorded the highest tuber length (12.00 and 13.43 cm), tuber diameter (8.20 and 9.15 cm) and tuber weight (111.27 and 131.83 g) in the first and second seasons, respectively, followed by Potato plants that sprayed with potassium citrate under the moderate level of phosphoric acid (60 kg/fed) in both season. In contrast, potato plants in the control treatment under all used treatment had the lowest tuber length (5.87 and 7.30 cm), tuber diameter (4.11 and 5.07 cm) and tuber weight (86.27 and 107.07 g) in both seasons, respectively.

Table 7. Effect of the interaction of soil application with different levels of phosphoric acid+ phosphorene and foliar spraying with potassium silicate, salicylic acid and potassium citrate on potato tuber physical properties during winter season of 2021/2022 and 2022/2023.

treatments		Tuber length (cm)	Tuber diameter (cm)	Tuber weight (g)
1st season				
Pa (80 l/fed) +phosphorene	**C**	8.80 fg	6.06 e	96.67 g
	PS	10.03 c	6.89 c	106.03 c
	SA	8.93 f	6.15 e	100.57 e
	PC	12.00 a	8.20 a	111.27 a
Pa (60 l/fed)+ phosphorene	**C**	7.53 i	5.22 hi	93.03 h
	PS	9.20 e	6.06 e	101.90 e
	SA	8.00 h	5.53 gh	96.93 g
	PC	10.67 b	7.31 b	107.60 b
Pa (40 l/fed) + phosphorene	**C**	6.57 l	4.91 i	90.40 i
	PS	8.63 g	5.69 fg	99.27 f
	SA	7.27 j	5.04 i	93.27 h
	PC	9.43	6.48 d	104.73 d
Control PRD(400kg calcium superphosphate).	**C**	5.87 m	4.11 j	86.27 j
	PS	7.90 h	5.46 gh	95.90 g
	SA	6.90 k	5.02 i	91.47 i
	PC	8.63 g	5.95 ef	101.37 e
LSD 5%		**0.18**	**0.31**	**1.16**
2nd season				
Pa (80 l/fed) +phosphorene	**C**	10.23 f	7.35 d	117.27 h
	PS	11.47 c	7.84 c	126.90 c
	SA	10.30 f	7.06 ef	121.67 f
	PC	13.43 a	9.15 a	131.83 a
Pa (60 l/fed) phosphorene	**C**	8.97 h	6.17 hi	113.87 i
	PS	10.63 e	7.28 de	123.00 e
	SA	9.43 g	6.49 g	117.50 h
	PC	12.10 b	8.27 b	128.17 b
Pa (40 l/fed) + phosphorene	**C**	8.00 k	5.53 k	110.27 k
	PS	10.07 f	6.91 f	119.57 g
	SA	8.70 i	5.99 ij	113.57 i
	PC	10.87 d	7.44 d	125.07 d
Control PRD(400kg calcium superphosphate).	**C**	7.30 l	5.07 l	107.07 l
	PS	9.30 g	6.40 gh	116.73 h
	SA	8.33 j	5.75 jk	112.30 j
	PC	10.07 f	6.91 f	122.57 ef
LSD 5%		**0.19**	**0.24**	**1.1**

Values followed by the same letter in the same column are not statistically different

3- Effect of soil application with different levels of phosphoric acid+ phosphorene and foliar spraying with potassium silicate, salicylic acid and potassium citrate as well as their interaction on potato tuber chemical properties.

The obtained results in Tables 8, 9 and 10 showed that potato tuber contents of total carbohydrate, starch, total protein and dry matter significant affected by soil application and foliar spraying treatments as well as their interaction in both seasons.

a-Effect of soil application treatments:

All soil applications treatments exceeded the recommended dose of P in increasing tuber contents of total carbohydrate, starch, total protein and dry matter increased step by step with the increase of phosphoric acid rate in both seasons. Potato plants that treated with 80 kg phosphoric acid + phosphorene recorded the highest potato tuber contents of total carbohydrate (18.20 and 19.29%), starch (13.66 and 15.13%), total protein (16.11 and 17.48%) and dry matter (17.50 and 18.50%) in the two seasons of the study, respectively, followed by Potato plants that treated with 60 kg phosphoric acid + phosphorene. In the contrast of this, potato plants the treated with the recommended dose of P only had the lowest values in both seasons.

Table 8. Effect of soil application with different levels of phosphoric acid+ phosphorene on potato tuber chemical properties during winter season of 2021/2022 and 2022/2023.

Factors	Total carbohydrate (%)	Starch (%)	Total protein (%)	Dry matter (%)
1st season2021/2022				
Pa (80 l/fed) + phosphorene	18.20 a	13.66 a	16.11 a	17.50 a
Pa (60 l/fed) + phosphorene	17.29 b	13.02 b	15.02 b	17.00 b
Pa (40 l/fed) + phosphorene	16.23 c	12.42 c	13.95 c	15.80 c
Control PRD(400kg calcium superphosphate).	14.84 d	11.96 d	12.83 d	15.54 c
LSD 5%	**0.35**	**0.13**	**0.37**	**0.3**
2nd season2022/2023				
Pa (80 l/fed) + phosphorene	19.29 a	15.13 a	17.48 a	18.50 a
Pa (60 l/fed) + phosphorene	18.17 b	14.75 b	16.17 b	17.51 b
Pa (40 l/fed) + phosphorene	17.13 c	13.69 c	15.50 c	16.48 c
Control PRD(400kg calcium superphosphate).	15.83 d	12.70 d	14.11 d	16.14 d
LSD 5%	**0.23**	**0.06**	**0.06**	**0.12**

Values followed by the same letter in the same column are not statistically different

b- Effect of Foliar spraying treatments:

The results presented in Table 9 indicated significantly difference among all foliar spraying treatments in potato tuber contents of total carbohydrate, starch, total protein and dry matter. All foliar spraying treatments increased tuber chemical traits more than the control treatment in both seasons. Potato plants that sprayed with potassium citrate recorded the highest potato tuber contents of total carbohydrate (17.87 and 18.96%), starch (13.50 and 15.10%), total protein (15.95 and 17.13%) and dry matter (17.23 and 18.14%) in both seasons, respectively, followed by Potato plants that sprayed with potassium silicate then potato plants that sprayed with salicylic acid. On the other hand, potato plants in the control treatment recorded the lowest potato tuber values in both seasons.

Table 9. Effect of foliar spraying with potassium silicate, salicylic acid and potassium citrate on potato tuber chemical properties.

Factors	Total carbohydrate (%)	Starch (%)	Total protein (%)	Dry matter (%)
1st season				
Control (C)	15.49 d	11.97 d	12.96 d	15.68 d
Potassium Silicate (PS)	16.95 b	13.01 b	14.92 b	16.65 b
Salicylic acid (SA)	16.25 c	12.59 c	14.08 c	16.27 c
Potassium Citrate (PC)	17.87 a	13.50 a	15.95 a	17.23 a
LSD 5%	**0.26**	**0.12**	**0.25**	**0.15**
2nd season				
Control (C)	16.18 d	13.15 d	14.49 d	16.20 d

Potassium Silicate (PS)	18.10 b	14.32 b	16.22 b	17.39 b
Salicylic acid (SA)	17.17 c	13.71 c	15.42 c	16.89 c
Potassium Citrate (PC)	18.96 a	15.10 a	17.13 a	18.14 a
LSD 5%	**0.15**	**0.08**	**0.17**	**0.19**

Values followed by the same letter in the same column are not statistically different

c- Effect of interaction:

Results in Table 10 declared that potato tuber chemical traits varied in their response to foliar spraying treatment under the different soil application treatments in both seasons. All interactions of soil application and foliar spraying treatments exceeded the control treatment in increase all tuber chemical traits in both seasons. Across all soil application treatments potassium citrate foliar spraying superior at potassium silicate and salicylic acid in increasing potato tuber contents of total carbohydrate, starch, total protein and dry matter in the two seasons. Potato plants that sprayed with potassium citrate under the highest rate of phosphoric acid (80kg/fed) recorded the highest potato tuber contents of total carbohydrate (19.36 and 20.52%), starch (14.52 and 16.11%), total protein (17.25 and 18.71%) and dry matter (18.11 and 19.25%) in the first and second seasons, respectively, followed by Potato plants that sprayed with potassium citrate under the moderate level of phosphoric acid (60 kg/fed) in both seasons. On the other side, potato plants in the control treatment had the lowest potato tuber contents of total carbohydrate (13.57 and 14.31%), starch (11.12 and 11.87%), total protein (11.36 and 12.56%) and dry matter (14.79 and 15.19%) under all tested treatments in both seasons, respectively.

Table 10. Effect of the interaction of soil application with different levels of phosphoric acid+ phosphorene and foliar spraying with potassium silicate, salicylic acid and potassium citrate on potato tuber chemical properties during winter season of 2021/2022 and 2022/2023.

Factors		Total carbohydrate (%)	Starch (%)	Total protein (%)	Dry matter (%)
1st season2021/2022					
Pa (80 l/fed) phosphorine	**C**	17.27 f	12.86 e	14.91 d	16.84 e
	PS	18.18 bc	13.91 b	16.41 b	17.62 bc
	SA	17.97 cd	13.36 c	15.86 c	17.43 c
	PC	19.36 a	14.52 a	17.25 a	18.11 a
Pa (60 l/fed) phosphorine	**C**	16.11 hi	12.18 g	13.14 f	16.13 fg
	PS	17.67 de	13.12 d	15.75 c	17.18 d
	SA	16.84 g	12.91 e	14.62 de	16.92 e
	PC	18.52 b	13.87 b	16.56 b	17.75 b
Pa (40 l/fed) + phosphorine	**C**	14.99 k	11.71 i	12.42 g	14.96 j
	PS	16.75 g	12.75 e	14.37 e	15.93 g
	SA	15.81 i	12.12 gh	13.31 f	15.48 h
	PC	17.36 ef	13.09 d	15.69 c	16.81 e
Control PRD(400kg calcium superphosphate).	**C**	13.57 m	11.12 j	11.36 h	14.79 j
	PS	15.18 jk	12.25 g	13.14 f	15.87 g
	SA	14.36 l	11.96 h	12.51 g	15.26 i
	PC	16.25 h	12.52 f	14.31 e	16.25 f
LSD 5%		**0.37**	**0.18**	**0.36**	**0.21**
2nd season2022/2023					
Pa (80 l/fed) phosphorine	**C**	18.17 e	14.16 h	16.21 f	17.52 e
	PS	19.64 b	15.32 c	17.98 b	18.85 b
	SA	18.81 c	14.94 e	17.01 cd	18.36 c
	PC	20.52 a	16.11 a	18.71 a	19.25 a
Pa (60 l/fed) phosphorine	**C**	16.48 h	13.69 j	14.69 j	16.56 g
	PS	18.59 d	15.07 d	16.81 de	17.93 d
	SA	17.98 ef	14.53 g	15.93 g	17.14 f

Pa (40 l/fed) + phosphorine	**PC**	19.63 b	15.72 b	17.25 c	18.41 c
	C	15.75 i	12.86 l	14.51 j	15.52 j
	PS	17.81 f	13.93 i	15.62 h	16.47 g
	SA	16.36 h	13.14 k	15.12 i	16.12 hi
Control PRD(400kg calcium superphosphate).	**PC**	18.59 d	14.81 f	16.73 e	17.79 d
	C	14.31 j	11.87 n	12.56 l	15.19 j
	PS	16.36 h	12.96 l	14.46 j	16.31 gh
	SA	15.54 i	12.21 m	13.62 k	15.93 i
	PC	17.11 g	13.77 j	15.81 gh	17.12 f
LSD 5%		**0.22**	**0.12**	**0.25**	**0.27**

Values followed by the same letter in the same column are not statistically different

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تاثير التسميد الفوسفاتى المعدنى والحيوى والرش الورقى ببعض منشطات النمو على المحصوول الدرنى وصفات الجودة لنباتات البطاطس النامية فى العروة الشتوى

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معهد بحوث البساتين – مركز البحوث الزراعية

قسم البساتين كلية الزراعة جامعة بنها

يعتبر الصقيع من اخطر العوامل التى تحد من انتاجية البطاطس فى العروة الشتوى لذلك تم اجراء تجربة حقلية بمحطة بحوث القناطر الخيرية بمحافظة االقليوبية خلال الموسمين الشتويين 2021/2022و2022/2023 لدراسة تاثيرالتسميد الفوسفاتى المعدنى والحيوى والرش الورقى بسترات البوتاسيوم، سليكات البوتاسيوم وحامض السالسيليك على المحصول الدرنى وصفات الجودة للدرنلت الناتجة لنباتات البطاطس صنف اسبونتا.وقد كانت معاملات التسميد االفوسفاتى 80لترحامض فوسفوريك +السماد الحيووى الفوسفورين و 60لترحامض فوسفوريك +السماد الحيووى الفوسفورين و 40لترحامض فوسفوريك +السماد الحيووى الفوسفورين مقارنة مع الكنترول (المعدل الموصى به 400كجم سوبر فوسفات الكاليسوم) وكذلك الرش الورقى لكلا من سترات البوتاسيوم تركيز 3جرام/لتر، سليكات البوتاسيوم بتركيز 2جرام/لتر وحامض السالسيليك بتركيز .5 جرام /لتر بالاضافة لمعاملة الكنترول .كما يمكن تلخيص أهم النتائج التى تم الحصول عليها على النحو التالى:- سجلت نباتات البطاطس التي عوملت بحمض الفوسفوريك 80 كجم + السماد االلحيوى الفوسفورين والرش بسترات البوتاسيوم بتركيز 2جرام/للتر الى الحصول على اعلى عدد الدرنات/نبات ومحصول الدرنات/نبات ومحصول الدرنات/فدان وأعلى طول وقطر ووزن للدرنة و أعلى محتوى درنات البطاطس من الكربوهيدرات الكلية والنشا والبروتين الكلي والمادة الجافة في الموسمين الأول والثاني

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