Plant Production Science

Available online at http://zjar.journals.ekb.eg
http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

PLANT GROWTH, YIELD, AND TUBER QUALITY OF SOME POTATO CULTIVARS AS AFFECTED BY POTASSIUM SOURCES AS FOLIAR APPLICATION UNDER SANDY SOIL CONDITIONS

Talaat A.E. Mousa[1*], Samar A. Bardisi[1], H.E.M .Esmail[1] and G.A. Zayd[2]

1. Hort. Dept., Fac. Agric. Zagazig Univ., Egypt.

2. Hort. Res. Inst., ARC, Egypt.

Received: 25/12/2023; Accepted: 31/12/2023

ABSTRACT: In order to investigate the effects of spraying with various potassium sources, such as potassium silicate (KSil at 4.25 ml/l), potassium citrate (KCit at 1 g/l), potassium folvate (KF at 4.5 g/l), and potassium thiosulpahte (KTS at 1.25 ml/l), as well as the control (spraying with water) on the plant growth, N, P and K uptake by shoots, yield, and tuber quality of some potato cultivars, *i.e.*, Spunta, Santana, Cara, Lady rosetta, and Hermes, two field experiments were conducted at a private farm in El-Salhyia El-Gadida District, Sharkia Governorate during 2021 and 2022 summer seasons. Fertilizing Santana cultivar with KCit as foliar spray gave the tallest plants and recorded maximum values of number of leaves/plant, and concentrations of total chlorophyll (a+b) in leaf tissues, P and K uptake by shoots, whereas fertilizing Cara cultivar with the same source increased number of aerial stems/ plant at 90 days after planting, yield/plant and total yield /fad in both seasons. Moreover, fertilizing Cara with KSil as foliar application gave the highest values of N, P and K contents in tuber at harvesting time. Spraying Hermes cultivar with KSil increased specific gravity in tubers Meanwhile, Fertilizing Lady rosetta cultivar with KCit as foliar application increased the concentration of Vit. C in tubers.

Key words: Potato (*Solanum tuberosum*, L.), potato cultivars, potassium sources, foliar application, yield, tuber quality.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of most important food crops and can be used in human nutrition as a low-cost energy source. Additionally, it is an affordable food with significant content of starch, minerals, vitamin C and B, and amino acids and is highly appreciated worldwide (**Van Der Zaag and Horton, 1983**).

Spunta potato is one of the most widely grown varieties in the world. Oblong elongated with skin and yellow flesh, it stands out for its high yield and ability to produce large tubers. Santana potato has a light-yellow skin colour and crème colour of flesh. It is a medium early ripening variety with high yield. It has big long oval tubers, and It is extremely competent for processing due to the colour structure it takes when cooked. It is also excellent for producing high quality fries. Cara is an extremely high yielding Irish variety. These maincrop tubers are oval-round in shape, with smooth skin and a shallow eye. Beautifully coloured white and pink skin. Cara has soft, floury white flesh, therefore is good for baking and chipping. Lady rosetta is the potato variety with red skin, round, uniform tuber with relatively shallow for crisp quality production, either fresh or from storage. This variety is majorly used in the potato chips manufacturing around the world. Hermes is the potato variety with yellow skin, oval, low tuber number and high dormancy. It has high dry matter and good fry colour. It is also suitable for crisp quality production, either fresh or from storage.

*** Corresponding author: Tel. :**+20100 840 0059
E-mail address: Talatheteba@gmail.com

There were significant differences among potato cultivars as for vegetative growth (**Tantawy *et al.*, 2017; Kahlel and Sultan, 2019; Banjade *et al.*, 2019; Elsagan, 2020**) total chlorophyll in leaves (**Youseef *et al.*, 2017; Kahlel and Sultan, 2019; Othman *et al.*, 2019**), yield and it components (**Hussein and Hamideldin, 2014; Tantawy *et al.*, 2017; Alkharpotly *et al.*, 2018; Yousef 2021**) and tuber quality (**Hussein and Hamideldin, 2014; Baddour and Masoud, 2022; Mandour and Metwaly, 2022; Mystkowska *et al.*, 2023)**.

Potassium is an important nutrient for plant meristematic growth and physiological functions, including regulation of water and gas exchange in plants, protein synthesis, enzyme activation ، photosynthesis and carbohydrate translocation in plants. Potassium has favorable effects on metabolism of nucleic acids, proteins, vitamins and growth substances, energy transfer, phloem transport ،cation-anion balance and enabling their ability to resist pests and diseases (**Wang *et al.*, 2013**).

Potassium silicate K_2SiO_4 is a source of highly soluble silicon; it is used in agricultural production system primarily as a silicon fertilizer (**Abou-Baker *et al.*, 2011**). Potassium citrate ($C_6H_5K_3O_7$) is highly beneficial as a foliar application since it can readily mobilize into the internal tissues and translocate readily within the plant. Enhance citric acid cycle and energy production (ATP). Potassium fulvate ($K_{14}H_{11}KO_8$) is salt form of fulvic acids and has a functional role to improve plant growth and soil quality. Its response under reduced soil fertility is less reported, particularly in sand soil. Potassium thiosulfate ($K_2S_2O_3$) is a liquid fertilizer containing K and S.

Sandy, organic, leached, and eroded soils are the types of soil conditions that cause K deficit in agricultural plants (**Fageria *et al.*, 1997**). In addition, poor K utilisation efficiency in farming systems is significantly influenced by leaching of K, particularly in sandy soils (**Kayser and Isselstein, 2005**). It may be advantageous to introduce crops and genotypes that grow roots and take up more K from deep in the soil profile and transport it to aboveground plant parts because leaching of K can result in a large loss of K from the soil (**Wang *et al.*, 2000**).

Spraying potato plants with potassium at different sources had affected vegetative growth, leaf pigments, yield and tuber quality compared to unsprayed plants, as for potassium silicate **(Salim *et al.*, 2014; Ibrahim *et al.*, 2015; Abd El-Gawad *et al.*, 2017; Baddour and Masoud 2022; Mahdi *et al.*, 2023)** concerning potassium citrate **(Ali *et al.*, 2021; Gahwash and Bardisi, 2023)** on Jerusalem artichoke regarding potassium fulvate (**Mohaseb *et al.*, 2018; Ewais *et al.*, 2020)** and potassium thiosulpahte (**Abdel Naby *et al.*, 2018)**.

To achieve the highest productivity and the best specifications for the quality of potato tubers under sandy soil conditions, the goal of this work was to investigate how various potato cultivars responded to different potassium sources applied foliarly under a pivot irrigation system.

MATERIALS AND METHODS

Using a pivot irrigation system and sandy soil conditions, this work was done over the course of two consecutive summer seasons in 2021 and 2022 at a private farm in El-Salhyia El-Gadida District, Sharkia Governorate, to study how certain potato cultivars responded in terms of dry weight, yield, potassium use efficiency, and tuber quality to potassium sources applied as foliar application. The physical and chemical properties of the experimental soil are shown in Table 1.

This experiment included 25 treatments, which were the combinations between five potato cultivars (Spunta,Santana, Cara, Lady rosetta and Hermes) and four potassium sources treatments , i.e. spraying with potassium silicate (KSil) , potassium citrate (KCit), potassium folvate (KF) and potassium thiosulpahte (KTS) as well as control (without spraying) . These treatments were arranged in a split plot design with three replicates. Potato cultivars were randomly arranged in the main plots and potassium sources were randomly distributed in the sub plots. Tuber seeds of potato (whole tubers without cutting) were planted at 20 cm apart on January 27th and 25th in the 1st and 2nd seasons, respectively. The experimental unit area was 16.2 m^2. It contained three ridges with 6 m length each and 90 cm distance between

Table 1. The physical and chemical properties of the experimental soil at 2021 and 2022 seasons

Soil properties	2021 season	2022 season
Physical properties		
Clay (%)	6.82	5.64
Silt (%)	4.18	6.76
Sand (%)	89.00	87.60
Texture	Sandy	Sandy
Chemical properties		
E.C. (mmhos/cm)*	462 ppm	438 ppm
pH**	8.45	8.26
Organic matter (%)	< 0.17	0.18
Available N (mg/kg)	< 155	< 142
Available P_2O_5 (mg/kg)	< 9.80	< 8.91
Available K_2O (meq/100 g)	0.23	0.19
$CaCO_3$%	0.583	0.422
Available calcium (meq/100 g)	8.53	8.21
Available magnesium (meq/100 g)	0.72	0.76
Available Sodium (meq/100 g)	0.64	0.62
Iron (mg/kg)	< 4	< 5
Manganese (mg/kg)	1 >	1 >
Copper (mg/kg)	0.20 >	0.26 >
Zinc (mg/kg)	0.20 >	0.28 >
C/N Ratio	0.01 >	0.01 >

each two ridges. One ridge was used to measure the morphological and physiological traits and the other two ridges were used for yield determinations. In addition, one ridge was left between each two experimental plots without spraying as a gourd ridges to avoid the overlapping of spraying salutation.

The sources of potato cultivars were HZPC Company (Holland) for Spunta cultivar, STET Company (Holland) for Santana cultivar, IPM Company (Scotland) for Cara cultivar, Danespo Company (Denmark) for Hermes cultivar and Majer Company (Holland) for Lady Rosetta cultivar.

Different potassium sources were potassium silicate (10.6% K_2O) in the form of Nova silica K at 4.25 ml/l (Al Waha Agri. Company, El Nubaria, El Beheira, Egypt), potassium citrate in the form of Cetro Saigo (45% K_2O) at 1 g/l (Saigo Chemicals Company, Kafr El Shekh, Egypt), potassium fulvate in the form of Exlans (10% K_2O and 70% potassium fulvate) at 4.5 g/l and potassium thiosulpahte (36% K_2O and 25% sulfur) at 1.25 ml/l were added as foliar spray into five times at 45, 55, 65, 75 and 85 days after planting.

During soil preparation 100 kg calcium mono super phosphate 15.5% P_2O_5, 25 kg potassium sulphate 50% K_2O and 50 kg ammonium sulphate 20.6% N were added per faddan. After planting, all treatments received 120 kg N/fad. (335, 74.20 and 20.65 kg /fad, in the form of ammonium nitrate 33.5% N, calcium nitrate 15.5% N and urea 46% N, respectively), 75 kg P_2O_5/fad. (44.12 and 61.47 kg/fad. in the form of phosphoric acid 85% P_2O_5 and mono ammonium phosphate 61% P_2O_5, respectively) and 90 kg K_2O (180 kg /fad. potassium sulphate) as well as 50 kg/fad. magnesium sulphate via fertigation every two days. Also, all treatments sprayed three times with mixture of microelements (4% Zn, 3% Fe, 0.3% Mo, 37.73% chelated materials , 2% Mn, 2% Mg, 3.97% S, 1% B, 1% Cu and 3% citric acid).

The normal agricultural practices were carried out as commonly followed in the district of this investigation.

Data Recorded

A random sample of five plants was randomly taken from every plot at 90 days after planting, in both seasons of study, for measuring the growth characters of potato plants expressed as follows: Plant height, number of both aerial stems and leaves/plant.

Photosynthetic pigments

Discs sample from the fourth upper leaf of potato plant was randomly taken from every experimental unit at 90 days after planting, in the two growing seasons, to determine total chlorophyll (a+b) according to the method described by **Wettestein (1957**).

Nitrogen, P and K uptake by shoots

Uptakes of N, P and K by shoots were calculated after nitrogen, phosphorus and potassium determination at 90 days after planting according to the methods described by **AOAC (2018)**.

Total yield

At harvesting time (15th June in both seasons) tubers from each plot were harvested and the following data were recorded: tuber yield per plant (g), and total yield (ton/faddan).

Tuber quality

Nitrogen, phosphorous and potassium contents were determined as previously mentioned in the dry weight of shoots.

Ascorbic acid (Vitamin C) were assayed according to **AOAC (2018)**.

Specific gravity

It was determined according to the method of **Murphy and Govern (1959).** The tubers were weighed in the air and then in water and specific gravity was calculated.

Statistical Analysis

The data were subjected to proper statistical analysis of variance according to **Snedecor and Cochran (1980**) and the differences among treatments were compared using Duncans' multiple range test (**Duncan, 1958**), where means had the different letters were statistically significant, while those means followed by the same letter were statistically insignificant.

RESULTS AND DISCUSSION

Plant Growth

Effect of cultivars

Data in Tables 2 to 4 indicate that there were significant differences among five cultivars with respect to plant height, number of aerial stems /plant, and number of leaves/ plant in both seasons. Santana cultivar gave the tallest plants (50.05 cm) as average of the two seasons and recorded maximum values of number of leaves / plant followed by Spunta cultivar at 90 days after planting in both seasons, whereas Cara cultivar gave the number of aerial main stem / plant. Hermes cultivar recorded the shortest plants (34.13 cm) as average of the two seasons and Lady rosetta cultivar gave the lowest values of number of leaves/plant, number of aerial stems /plant.

In general Cara cultivar gave the highest values of number of aerial stems /plant as average of the two seasons (4.47) followed by Spunta cultivar (3.2), Santana cultivar (2.96), Hermes cultivar (2.93) and LadyRosetta (2.08).

The differences among potato cultivars could be attributed to the genetic differences between cultivars. Differences among potato cultivars were also observed by **Abou El-Yazied and Selim (2007)**, **Mousa (2009)** and **Farrag *et al.* (2016)**. They found that there were significant differences among potato cultivars for plant height, number of leaves/plant, number of branches / plant and stem diameter.

Effect of potassium sources

Presented data in Tables 2, 3 and 4 indicate that spraying potato plants with potassium silicate (KSil) at 4.25 ml/, potassium citrate (KCit) at 1g /l , potassium folvate (KF) at 4.5 g/l and potassium thiosulphate (KTS) at 1.25 ml/l increased plant height, number of aerial stems / plant and number of leaves/ plant compared to unsprayed plants and spraying potato plants with KCit followed by KTS gave the highest values of plant height, number of aerial stems /plant and number of leaves/plant. In general spraying potato plants with KCit gave the highest values of number of aerial stems /plant as average of the two seasons (3.75) followed by KTS (3.30), KF (3.14), KSil (3.09) and unsprayed plants (2.37). This mans that spraying with different sources of potassium increased number of aerial stems /plant compared to unsprayed plants.

Table 2. Effect of cultivars, potassium sources and their interactions on plant height (cm) of potato plants at 90 days after planting during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	38.95 g	50.35 bc	51.68 abc	44.75 def	53.87 ab	**47.92 B**
Santana	43.04 fg	49.02 cde	55.72 a	49.41 bcd	53.52 ab	**50.14 A**
Cara	38.57 gh	42.66 fg	44.37 ef	41.02 fg	51.30 abc	**43.58 C**
Lady rosetta	34.16 hi	44.28 f	53.06 abc	41.43 fg	38.95 g	**42.37 C**
Herms	28.22 m	34.20 k	40.09 hij	31.64 l	39.33 hij	**34.69 D**
Mean (B)	**36.58 E**	**44.10 C**	**48.98 A**	**41.65 D**	**47.39 B**	
			2022 season			
Spunta	43.51 j	49.79 cd	52.73 ab	45.60 gh	52.54 ab	**48.83 B**
Santana	44.94 hi	50.02 cd	54.09 a	48.75 de	51.97 b	**49.95 A**
Cara	38.76 m	47.03 fg	47.79 ef	43.01 j	51.30 bc	**45.57 C**
Lady rosetta	34.16 o	42.88 j	50.15 cd	42.15 jk	40.85 kl	**42.03 D**
Herms	26.51 q	33.35 o	40.09 lm	30.78 p	37.15 n	**33.57 E**
Mean (B)	**37.57 E**	**44.61 C**	**48.97 A**	**42.05 D**	**46.76 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 3. Effect of cultivars, potassium sources and their interactions on number of aerial stems / plant of potato plants at 90 days after planting during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	2.45 kl	3.30 efg	3.50 de	3.50 de	3.15 fgh	**3.18 B**
Santana	2.35 l	2.85 hij	3.65 d	2.85 hij	3.35 ef	**3.01 C**
Cara	2.80 ij	4.35 c	5.60 a	4.45 c	5.30 b	**4.50 A**
Lady rosetta	1.65 n	2.00 m	2.90 hij	1.85 mn	2.30 l	**2.14 D**
Herms	2.70 jk	3.00 ghi	3.15 fgh	3.05 f-i	3.00 ghi	**2.98 C**
Mean (B)	**2.39 D**	**3.10 C**	**3.76 A**	**3.14 C**	**3.42 B**	
			2022 season			
Spunta	2.50 gh	3.25 cd	3.50 c	3.50 c	3.35 c	**3.22 B**
Santana	2.35 h	2.95 de	3.45 c	2.90 ef	2.90 ef	**2.91 C**
Cara	2.80 efg	4.50 b	5.45 a	4.75 b	4.70 b	**4.44 A**
Lady rosetta	1.55 j	1.95 i	2.90 ef	1.80 ij	1.95 i	**2.03 D**
Herms	2.60 fgh	2.79 efg	3.35 c	2.75 efg	3.00 de	**2.89 C**
Mean (B)	**2.36 C**	**3.08 B**	**3.73 A**	**3.14 B**	**3.18 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 4. Effect of cultivars, potassium sources and their interactions on number of leaves/ plant of potato plants at 90 days after planting during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	12.00 de	12.00 de	12.50 cd	12.50 cd	13.00 bcd	**12.40 B**
Santana	13.50 abc	14.50 a	14.50 a	14.00 ab	14.00 ab	**14.10 A**
Cara	11.00 ef	12.50 cd	13.50 abc	12.50 cd	13.50 abc	**12.60 B**
Lady rosetta	7.50 j	8.00 ij	10.0 fg	8.50 hij	9.50 gh	**8.70 C**
Herms	7.50 j	9.50 gh	10.00 fg	8.50 hij	9.00 ghi	**8.90 C**
Mean (B)	**10.30 C**	**11.30 B**	**12.10 A**	**11.20 B**	**11.80 A**	
			2022 season			
Spunta	11.50 hi	14.00 cd	15.00 ab	13.00 ef	15.50 a	**13.80 A**
Santana	13.00 ef	14.50 bc	14.50 bc	13.50 de	14.00 cd	**13.90 A**
Cara	11.50 hi	12.00 gh	13.00 ef	12.50 fg	13.00 ef	**12.40 B**
Lady rosetta	7.50 no	8.00 mn	9.00 kl	7.00 o	8.50 lm	**8.00 D**
Herms	7.50 no	9.50 jk	11.00 i	8.00 mn	10.00 j	**9.20 C**
Mean (B)	**10.20 E**	**11.60 C**	**12.50 A**	**10.80 D**	**12.20 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Potassium is one of the most essential nutrient required for plant development. It plays vital role in several physiological processes such as photosynthesis, translocation of photosynthates, control of ionic balance, regulation of plant stomata and transpiration, activation of plant enzymes and many other processes (**Trehan *et al.*, 2001**).

These results are in accordance with those reported by **El-Sirafy *et al.* (2008)** , **Dkhil *et al.* (2011)** , **Salim *et al.* (2014) and Ibrahim *et al.* (2015)**. They found that spraying potato with different potassium sources improved all plant growth parameters compared to unsprayed plants.

Effect of the interaction

Spraying Santana cultivar with KCit followed by KTS gave the tallest plants and recorded maximum values of number of leaves/ plant, whereas spraying Cara cultivar with KCit increased number of number of aerial stems /plant at 90 days after planting in both seasons (Tables 2, 3 and 4). Spraying Spunta, Santana, Cara, Lady rosetta and Hermes with different sources of potassium, *i.e.*, KCit, KSil, KF and KTS increased plant height, number of aerial stems/plant and number of leaves/plant compared to unsprayed the same cultivars with any potassium sources (water) in both seasons.

In this regard, **Zelelew *et al.* (2016)** showed that Zafira and Picasso responded positively up to the application of 150 kg K_2O/ha. While Ajiba had showed sharp and positive response in stem number production with increasing potassium levels only up to 75 kg K_2O/ha. Also, the highest values of leaves per plant) for Ajiba and Zafira respectively were recorded when they were treated with 75 kg of K_2O/ha. Also, **Baddour and Masoud (2022)** showed that the interaction between spraying spunta cultivar and spraying with potassium silicate showed a significant superiority in all vegetative growth than spraying Lady Rosita cultivar with potassium silicate.

Total Chlorophyll

Effect of cultivars

There were significant differences among five potato cultivars in the concentration of total chlorophyll (a+b) in leaf tissues at 90 days after planting in both seasons (Table 5).

Table 5. Effect of cultivars, potassium sources and their interactions on total chlorophyll a+b (mg/gm DW) in leaf tissues of potato plants at 90 days after planting during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	3.89 ijk	5.01 a-e	5.48 a	4.46 d-h	5.37 ab	**4.84 A**
Santana	4.56 d-g	4.88 a-e	5.42 ab	4.86 b-e	5.31 abc	**5.00 A**
Cara	3.64 jkl	4.25 f-i	4.98a-e	4.09 g-j	4.87 b-e	**4.36 B**
Lady rosetta	3.40 klm	4.42 e-i	5.02-d	4.13 g-j	4.72 c-f	**4.33 B**
Herms	2.81 m	3.63 jkl	4.00 g-k	3.16 lm	3.92 h-k	**3.50 C**
Mean (B)	**3.66 D**	**4.43 B**	**4.98 A**	**4.14 C**	**4.83 A**	
			2022 season			
Spunta	4.07 i-m	4.97b-g	5.26bc	4.55 d-k	5.23bcd	**4.81 B**
Santana	4.48 e-k	4.98b-g	5.84 a	4.86b-h	5.51b	**5.13 A**
Cara	3.87 k-n	4.69 c-j	5.11b-e	4.29 f-l	4.77 c-i	**4.54 C**
Lady rosetta	3.41 mno	4.27 g-l	5.00 b-f	4.20 h-l	4.96 b-g	**4.36 C**
Herms	2.64 p	3.32 nop	4.00 j-n	3.07 op	3.71 l-o	**3.34 D**
Mean (B)	**3.69 D**	**4.44 B**	**5.04 A**	**4.19 C**	**4.83 A**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

In general, Santana cultivar gave the highest values of the concentrations of total chlorophyll (a+b) in both seasons, followed by Spunta cultivar.

Differences among potato cultivars for leaf pigments were, also observed by **Youseef *et al.* (2017)** indicated that Potato cv. Spunta gave the highest concentration of total chlorophyll in leaf tissues without significant differences with Cara cv., whereas Accent cultivar gave the lowest concentrations of chlorophylls in both planting seasons. Also**, Othman *et al.* (2019)** found that Cara cultivar gave the highest concentration of total chlorophyll as compared other cultivars (Hermes, Spunta and Lady rosetta).

Effect of potassium sources

Data in Table 5 show that spraying with different sources of potassium, *i.e.*, KSil, KCit, KF and KTS increased the concentration of total chlorophyll (a+b) in leaf tissues compared to unsprayed plants and spraying with KCit gave the highest values.

Potassium plays a vital role in promoting the assimilation rate of CO_2 and photosynthetic capacity **(Mengel and Kirkby, 1987).**

Gardener *et al.* (1985) reported also, that potassium was found to serve a vital role in photosynthesis by increasing growth and leaf area index and hence, CO_2 assimilation and increasing the outward translocation of photosynthates. The obtained results are in agreement with those reported by **Abd El-Gawad *et al.* (2017)** showed that spraying potassium silicate at 2000 ppm gave the highest chlorophyll readings compared to spraying with 1000 and 3000 ppm potassium silicate or unsprayed plants. **Mohaseb *et al.* (2018)** indicated that the highest contents of chlorophyll (a+b) were recorded with the plants which sprayed with potassium humate than unsprayed plants. Also, **Gahwash and Bardisi (2023)** found that fertilization Jerusalem artichoke plants with 75% K_2O of the recommended rate (equal 54 kg K_2O/faddan) and spraying with KCit at1 ml/l or KSil at3 ml/l significantly increased total chlorophyll concentration in leaf tissues.

Effect of the interaction

Spraying Santana cultivar with KCit gave the highest concentrations total chlorophyll (a+b) in

leaf tissues in both seasons (Table 5). Similar result was obtained with **Baddour and Masoud (2022)** indicated that the highest total chlorophylls in leaves of potato were obtained with the interaction between spraying Spunta cultivar and spraying with potassium silicate than spraying Lady rosetta cultivar with potassium silicate.

Nitrogen, P and K Uptake by Shoots

Effect of cultivars

Respecting N, P and K uptake by shoots, data in Tables 6, 7 and 8 show that Santana cultivar increased N, P and K uptake by shoots, followed by Spunta cultivars. These results were due to the genetically differences among the cultivars and could be confirmed with the results of shoot dry weights which showed the same trend.

The variability among the studied cultivars might be due to the heredity differences. The obtained results are confirmed with the results of **Tantawy *et al*. (2017)** showed that the highest uptake of N, P and K by shoots of potato plants were obtained by Spunta cultivar than Diamond cultivar. also, **Othman *et al.* (2019)** found that Cara cultivar recorded the highest nitrogen contend in leaves, followed by Lady Rosetta as compared to Spunta and Hermes cultivars. In this concern, **Mystkowska *et al*. (2023)** indicated that Oberon variety recorded the highest contents and uptake of phosphorus and potassium by shoots as compared to Malaga variety.

Effect of potassium sources

Spraying potato plants grown in sandy soil with KCit followed by KTS gave the highest values of N, P and K uptake by shoots (Tables 6, 7 and 8).

Potassium promotes protein synthesis and N uptake, resulting in improved leaf growth. Also, potassium helps plants retain their osmotic potential, which improves water uptake and root permeability while serving as a guard cell. Additionally, it improves the effectiveness of water consumption (**Marschner, 1995**).

These results are in accordance with those reported by **Abd El-Gawad *et al*. (2017)** showed that spraying potassium silicate at 2000 ppm recorded the highest values of nitrogen and potassium uptake, total soluble carbohydrates and protein and free amino acids in the plant leaves compared to spraying with 1000 and 3000 ppm potassium silicate or unsprayed plants. **Mohaseb *et al.* (2018)** indicated that spraying potato plants with potassium humate gave the maximum N contents and its uptake by plants than unsprayed plants. **Ali *et al.* (2021)** indicated that the highest values of N, P and K uptake as well as total carbohydrates in leaves were recorded when sprayed potato plants with potassium citrate, followed by Monopotassium phosphate and then potassium silicate.

Effect of the interaction

Data in Tables 6, 7 and 8 show that fertilizing Hermes cultivars with KCit as foliar spray increased N uptake by shoots , whereas spraying Santana cultivars with KCit increased P and K uptake by shoots.

In this regard, **Baddour and Masoud (2022)** indicated that the highest N, P and K contents in potato were obtained with the interaction between spraying spunta cultivar and spraying with potassium silicate than spraying Lady Rosita cultivar with potassium silicate.

Total Yield

Effect of cultivars

With respect to yield/plant, data in Table 9 indicate that Cara and spunta cultivars gave the best yieldplant (0.946 and 1.047 kg for Cara and 0.893 and 1.011 kg for Spunta) followed by Santana cultivar (0.856 and 0.918 kg, whereas Lady rosetta cultivar gave lowest (0.722 and 0.753 kg) in the 1st and 2nd seasons, respectively.

As for total yield/fad., data in Table 10 indicate that Cara cultivar gave the highest values of total yield (18.932 and 20.954 ton) followed by Spunta cultivar (17.871 and 20.230 ton), whereas Lady rosette cultivar gave the lowest values (14.447 and 15.059 ton) in the 1st and 2nd seasons, respectively.

In general, under sandy soil conditions, during summer plantations Cara cultivar gave the highest total yield/fad., (as average of the two seasons (19.943 ton) followed by Spunta cultivar (19.051 ton), Santana (17.753 ton), Hermes (16.977 ton) and Lady rosetta (14.752 ton).

Table 6. Effect of cultivars, potassium sources and their interactions on nitrogen uptake by shoots (mg/ plant) of potato plants at 90 days after planting during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	461.13 lm	660.90 e	806.40 b	550.90 hij	770.40 bc	**649.95 AB**
Santana	549.80 ij	643.50 ef	766.70 bc	594.90 gh	722.00 d	**655.38 A**
Cara	495.90 kl	610.00 fg	752.30 cd	549.50 ij	764.00 bcd	**634.34 B**
Lady rosetta	395.90 n	520.80 jk	656.80 e	464.00 lm	594.50 ghi	**526.40 C**
Herms	426.80 mn	629.30 efg	878.90 a	532.50 jk	758.20 cd	**645.14 AB**
Mean (B)	**465.91 E**	**612.90 C**	**772.22 A**	**538.36 D**	**721.82 B**	
			2022 season			
Spunta	498.87 hi	667.00 de	806.60 ab	573.80 fg	789.50 ab	**667.15 A**
Santana	520.80 gh	661.10 de	836.90 a	595.90 ef	705.60 cd	**664.06 A**
Cara	522.80 gh	706.70 cd	757.00 bc	603.40 ef	774.40 abc	**672.86 A**
Lady rosetta	362.20 j	492.10 hi	664.10 de	440.20 i	578.40 fg	**507.40 B**
Herms	436.10 i	628.90 ef	844.40 a	561.00 fgh	788.20 ab	**651.72 A**
Mean (B)	**468.15 E**	**631.16 C**	**781.80 A**	**554.86 D**	**727.22 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 7. Effect of cultivars, potassium sources and their interactions on phosphorus uptake by shoots (mg/ plant) of potato plants at 90 days after planting during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	61.47 l	87.10 f	111.00 a	76.20 hi	105.80 b	**88.313 B**
Santana	77.20 gh	86.50 f	107.40 b	88.10 f	101.40 c	**92.120 A**
Cara	58.30 m	66.80 k	91.00 e	68.30 k	79.00 g	**72.680 D**
Lady rosetta	39.30 p	55.40 n	68.20 k	51.30 o	60.90 l	**55.020 E**
Herms	51.70 o	73.30 j	98.00 d	74.60 ij	88.20 f	**77.160 C**
Mean (B)	**57.593 E**	**73.820 C**	**95.120 A**	**71.700 D**	**87.060 B**	
			2022 season			
Spunta	67.07 g	88.30 d	107.40 b	76.40 ef	100.40 c	**87.913 B**
Santana	76.50 ef	89.20 d	120.20 a	90.00 d	106.60 bc	**96.500 A**
Cara	57.50 h	75.30 ef	93.30 d	72.80 fg	79.20 e	**75.620 C**
Lady rosetta	35.70 j	55.20 hi	71.10 fg	51.00 i	60.20 h	**54.640 D**
Herms	53.80 hi	75.30 ef	90.80 d	76.70 ef	90.50 d	**77.420 C**
Mean (B)	**58.113 E**	**76.660 C**	**96.560 A**	**73.380 D**	**87.380 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 8. Effect of cultivars, potassium sources and their interactions on potassium uptake by shoots (mg/ plant) of potato plants at 90 days after planting of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	716.0 n	998.2 ghi	1234.5 bc	903.4 jk	1155.6 de	**1001.5 C**
Santana	952.7 ij	1100.6 ef	1286.2 ab	1033.3 fgh	1181.9 cd	**1110.9 A**
Cara	750.8 mn	903.5 j	1156.4 de	842.9 kl	1108.4 def	**952.4 D**
Ladyrosetta	590.0 o	810.8 lm	976.2 hij	733.2 n	947.0 ij	**811.4 E**
Herms	767.1 lmn	1066.1 fg	1316.0 a	941.3 ij	1132.9 de	**1044.7 B**
Mean (B)	**755.3 E**	**975.8 C**	**1193.9 A**	**890.8 D**	**1105.2 B**	
			2022 season			
Spunta	768.8 kl	1009.6 ghi	1217.1 bc	945.3 hij	1146.2 cde	**1017.4 BC**
Santana	903.3 j	1136.5 de	1366.6 a	1050.5 fg	1221.0 bc	**1135.6 A**
Cara	740.4 l	1013.2 gh	1184.2 cd	907.1 j	1111.8 ef	**991.3 C**
Ladyrosetta	549.4 m	739.7 l	936.3 ij	732.7 l	823.9 k	**756.4 D**
Herms	751.6 kl	1055.9 fg	1266.7 b	946.4 hij	1175.5 cde	**1039.2 B**
Mean (B)	**742.7 E**	**991.0 C**	**1194.2 A**	**916.4 D**	**1095.7 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 9. Effect of cultivars, potassium sources and their interactions on yield/plant (kg) of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	0.731 lmn	0.899 gh	1.052 b	0.823 ij	0.962 cde	**0.893 B**
Santana	0.664 p	0.862 hi	0.983 cd	0.830 ij	0.944 def	**0.856 C**
Cara	0.684 op	0.932 efg	1.166 a	0.905 fgh	1.046 b	**0.946 A**
Lady rosetta	0.526 r	0.712 mno	0.889 gh	0.693 nop	0.792 jk	**0.722 E**
Herms	0.614 q	0.775 kl	0.999 c	0.750 klm	0.877 h	**0.803 D**
Mean (B)	**0.643 E**	**0.836 C**	**1.017A**	**0.800 D**	**0.924B**	
			2022 season			
Spunta	0.899 h-k	1.040 c-f	1.133 bc	0.937 ghi	1.049 c-f	**1.011 A**
Santana	0.786 lmn	0.925 g-j	1.015 d-g	0.887 h-l	0.981 e-h	**0.918 B**
Cara	0.766 mn	1.113 bcd	1.336 a	0.865 i-m	1.159 b	**1.047 A**
Lady rosetta	0.593 o	0.731 n	0.902 h-k	0.734 n	0.805 k-n	**0.753 C**
Herms	0.744 n	0.826 j-n	1.073 b-e	0.881 h-l	0.950 f-i	**0.894 B**
Mean (B)	**0.757 E**	**0.927 C**	**1.091A**	**0.860 D**	**0.988 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

The varietals differences among the studied cultivars may be due to the heredity differences and also, may be due to the differences among them in their yield attributes. Similar findings were reported by **Mousa (2009)**, **Farrag *et al.* (2016)**, **Youseef *et al.* (2017)**, **Elsagan (2020)**, **Al-Zebari *et al.* (2022)** all on potato. They showed that there were significant differences among potato cultivars regarding yield and its components.

Effect of potassium sources

Data in Tables 9 and 10 show that fertilizing potato plants with different potassium sources as foliar application during summer plantations had a significant effect on yield/plant and total yield/faddan in both seasons.

Spraying with plants KSil, KCit, KF and KTS increased yield / plant and total yield/fad., compared to spraying with water only, which gave the lowest values. KCit as foliar application gave the highest values of yield/plant and total yield/fad., followed by spraying with KTS in both seasons.

In general spraying potato plants grown in sandy soil during summer plantations with KCit as foliar application gave the highest values of total yield/fad., as average of the two seasons (21.09 ton), followed by spraying KTS (19.12 ton/fad), KSil (17.63 ton), KF (16.6 ton) and unsprayed plants (14.01 ton).

The increases in total yield due to spraying with KCit were about 58.09 and 44.13% and about 43.52 and 30.54 for spraying with KTS over unsprayed plants in the 1st and 2nd seasons, respectively.

Since K plays a crucial role in this regard as it influences cell division, tuberous root initiation and thickening, photosynthesis, the formation of carbohydrates, the translocations of sugars, mineral nutrients, and photosynthetic matter, as well as enzyme activity, the synthesis and accumulation of starch have a positive impact on potato tuber formation **(Byju and George, 2005)**.

The source of potassium fertiliser has an impact on potato yield parameters in addition to potassium rate (**Bansali and Trehan 2011**). Additionally, foliar application of K at 1% helped to produce potatoes with great tuber quality and a higher yield. Therefore, in addition to applying K to the soil, foliar spraying is advised (**Khan *et al*., 2010**).

In this regard, similar results were obtained by **Salim *et al*. (2014)**, **Ibrahim *et al.* (2015)**, **Abd El-Gawad *et al*. (2017)**, **Abdel Naby *et al*. (2018)**, **Mohaseb *et al*. (2018) and Ali *et al.* (2021)** indicated that that the highest values of total tuber yield/ha were obtained when sprayed potato plants with Monopotassium phosphate followed by potassium citrate, and then potassium silicate. Also **Mahdi *et al.* (2023)** indicated that spraying potato plants with potassium silicate at 3 ml /l was the best for increasing total yield as compared to spraying with potassium sulphate or unsprayed plants.

Effect of the interaction

Spraying potato cultivars, Spunta, Santana, Cara Lady rosetta and Hermes with different sources of potassium, *i.e.*, and KSil, KCit, KF and KTS increased yield/plant, and total yield/ fad., compared to unsparing the same cultivars in both seasons (Tables 9 and 10). Spraying Cara cultivar with KCit, followed by KTS increased yield/plant and total yield /faddan.

In this connection, **Zelelew *et al*. (2016)** indicated that Ajiba cultivar gave the highest tuber weight/plant and total yield /ha than Zafira and Picasso when fertilized with 300 kg K_2O/ha.

In the same line, **Baddour and Masoud (2022)** indicated that the highest total yield /ha of potato were obtained with the interaction between spraying spunta cultivar and spraying with potassium silicate than spraying Lady rosetta cultivar with potassium silicate.

Nitrogen, P and K Contents in Tuber at Harvesting Time

Effect of cultivars

Data in Tables 11, 12 and 13 show that there were significant differences among five potato cultivars concerning N, P and K contents in tubers in both seasons. Cara, Santana and Hermes cultivars gave the highest N, P and K contents in tuber at harvesting time, respectively.

The differences among the cultivars in their chemical constituents were found by **Kahlel and Sultan (2019)** and **Mystkowska *et al*. (2023)** on potato.

Table 10. Effect of cultivars, potassium sources and their interactions on total yield/ton/ faddan (kg) of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	14.623 lmn	17.978 fgh	21.048 b	16.460 ij	19.245 cde	**17.871 B**
Santana	13.290 p	17.233 hi	19.651 cd	16.607 ij	18.886 def	**17.133 C**
Cara	13.683 op	18.637 efg	23.328 a	18.100 fgh	20.912 b	**18.932 A**
Ladyrosetta	10.516 r	14.239 mno	17.783 gh	13.863 nop	15.832 jk	**14.447 E**
Herms	12.276 q	15.503 kl	19.986 c	14.990 klm	17.537 h	**16.058 D**
Mean (B)	**12.878 E**	**16.718 C**	**20.359 A**	**16.004 D**	**18.482 B**	
			2022 season			
Spunta	17.978 ijk	20.798 def	22.658 bc	18.739 hij	20.978 def	**20.230 B**
Santana	15.720 mno	18.510 hij	20.290 efg	17.731 ijk	19.613 fgh	**18.373 C**
Cara	15.312 mno	22.264 bcd	26.721 a	17.297 jkl	23.175 b	**20.954 A**
Ladyrosetta	11.855 p	14.617 o	18.045 ij	14.672 o	16.106 lmn	**15.059 D**
Herms	14.877 no	16.525 klm	21.456 cde	17.626 jk	19.001 ghi	**17.897 C**
Mean (B)	**15.148 E**	**18.543 C**	**21.834 A**	**17.213 D**	**19.775 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 11. Effect of cultivars, potassium sources and their interactions on nitrogen contents (%) in tuber at harvesting time of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	1.59 mn	2.07 c	1.89 e	1.66 jk	1.93 d	**1.82 B**
Santana	1.45 p	1.68 j	1.57 n	1.52 o	1.61 lm	**1.56 C**
Cara	1.63 kl	2.25 a	2.11 b	1.72 hi	1.94 d	**1.93 A**
Lady rosetta	1.41 q	1.73 h	1.62 lm	1.00 r	1.69 ij	**1.49 D**
Herms	1.68 j	1.96 d	1.85 f	1.75 h	1.81 g	**1.81 B**
Mean (B)	**1.55 C**	**1.93 A**	**1.80 B**	**1.53 D**	**1.79 B**	
			2022 season			
Spunta	1.56 r	2.11 d	1.92 f	1.63 no	1.97 e	**1.83 C**
Santana	1.43 s	1.72 k	1.62 o	1.58 q	1.66 l	**1.60 E**
Cara	1.65 lm	2.22 a	2.15 c	1.77 i	1.98 e	**1.95 A**
Lady rosetta	1.39 t	1.75 j	1.64 mn	1.60 p	1.72 k	**1.62 D**
Herms	1.71 k	2.19 b	1.92 f	1.79 h	1.83 g	**1.88 B**
Mean (B)	**1.54 E**	**1.99 A**	**1.85 B**	**1.67 D**	**1.83 C**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 12. Effect of cultivars, potassium sources and their interactions on phosphorus contents (%) in tuber at harvesting time of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	0.239 klm	0.268 b-e	0.249 g-l	0.241 klm	0.257 d-i	**0.250 C**
Santana	0.248 h-l	0.282 ab	0.263 c-g	0.251 g-l	0.271 bcd	**0.263 AB**
Cara	0.233 m	0.253 f-k	0.242 j-m	0.237 lm	0.248 h-l	**0.242 D**
Lady rosetta	0.241 klm	0.293 a	0.266 cdef	0.256 e-j	0.281 ab	**0.267 A**
Herms	0.245 i-m	0.273 bc	0.256 e-j	0.249 g-l	0.262 c-h	**0.257 BC**
Mean (B)	**0.241 D**	**0.273 A**	**0.255 C**	**0.246 D**	**0.263 B**	
			2022 season			
Spunta	0.242 h	0.273 bc	0.255 ef	0.246 gh	0.262 de	**0.255 C**
Santana	0.250 fg	0.287 a	0.267 cd	0.258 e	0.278 b	**0.268 A**
Cara	0.231 i	0.262 de	0.247 gh	0.242 h	0.255 ef	**0.247 D**
Lady rosetta	0.233 i	0.276 b	0.272 bc	0.261 de	0.274 bc	**0.263 B**
Herms	0.231 i	0.267 cd	0.248 fgh	0.243 gh	0.249 fgh	**0.247 D**
Mean (B)	**0.237 E**	**0.273 A**	**0.257 C**	**0.250 D**	**0.263 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 13. Effect of cultivars, potassium sources and their interactions on potassium contents (%) in tuber at harvesting time of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	3.57 kl	4.11 de	3.91 fgh	3.68 jk	4.02 def	**3.85 C**
Santana	3.12 o	3.91 fgh	3.67 jk	3.34 mn	3.85 ghi	**3.57 D**
Cara	3.31 n	3.82 hi	3.59 kl	3.47 lm	3.67 jk	**3.57 D**
Lady rosetta	3.74 ij	4.15 cd	3.98 efg	3.85 ghi	4.06 de	**3.95 B**
Herms	3.98 efg	4.41a	4.27 bc	4.12 d	4.38ab	**4.23 A**
Mean (B)	**3.54 E**	**4.08 A**	**3.88 C**	**3.69 D**	**3.99 B**	
			2022 season			
Spunta	3.51 o	4.15 de	3.88 hij	3.72 klm	4.08 ef	**3.86 C**
Santana	3.18 q	3.94 ghi	3.76 kl	3.42 o	3.88 hij	**3.63 D**
Cara	3.29 p	3.79 jk	3.66 mn	3.51 o	3.62 n	**3.57 E**
Lady rosetta	3.68 lmn	4.22 cd	4.02 fg	3.93 ghi	4.14 de	**3.99 B**
Herms	3.86 ij	4.38 ab	4.31 bc	3.97 gh	4.44 a	**4.19 A**
Mean (B)	**3.50 E**	**4.09 A**	**3.92 C**	**3.71 D**	**4.03 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Effect of potassium sources

Data tabulated in Tables 12, 13 and 14 show that KSil as foliar application gave the highest contents of N, (1.96%), P (0.273%) and K (4.08%) in tubers as average of the two seasons as compared to the other treatments.

These results are in accordance with those reported by **El-Sirafy *et al*. (2008**) indicated that the highest values of N, P and K contents in tuber were obtained with the plants which sprayed with K_2O than unsprayed plants in both seasons.

Effect of the interaction

The interaction between potato cultivars and fertilizing with potassium at different sources had significant effect on N, P and K contents in tuber at harvesting date in both seasons (Tables 11, 12 and 13).

Fertilizing Cara, Santana and Hermes with KSil as foliar application produced the highest values of N (2.24%), P (0.285%) and K (4.40%) as average of the two seasons.

Tuber Quality

Effect of cultivars

Data in Table 14 show that, different potato cultivars reflected a significant differences between them regarding Specific gravity in tubers in both growing seasons. Hermes cultivar gave the highest value of specific gravity in tubers (1.142 and 1.135 g/gm^3) followed by Lady rosette cultivar (1.068 and 1.079 g/cm^3), whereas Cara cultivar gave the lowest specific gravity in tuber (0.964 g/cm^3) in the both seasons. As for Vit C in tuber data in Table 15 show that Lady rosetta cultivar gave the highest value of Vit C (18.98 mg/100 g FW), followed by Hermes cultivar (17.57 mg/100 g FW) as average of the two seasons.

The genetic makeup of each cultivar accounted for the majority of the variances in nutritional value between the five cultivars. The differences in the tuber quality of potato cultivars were also noted by **Alkharpotly *et al*. (2018)** indicated that the highest specific gravity in tubers was recorded with the cultivar Lady rosetta than the cultivar 'Caruso'. However, 'Caruso' tubers had higher value in the ascorbic acid contents. And **Mandour and Metwaly (2022)** mentioned that the cultivar of Lady Rosetta potato scored higher specific gravity than Spunta cultivar.

Effect of potassium sources

Fertilizing potato plants grown in sandy soil and summer plantations with different sources of potassium had significant effect on tubers specific gravity and Vit C at harvesting time in both seasons (Tables 14 and 15). The best treatment for increasing specific gravity in tubers was KSil as foliar application (1.101 and 1.116 g/cm^3) followed by using KTS (1.079 and 1.088 g/cm^3) in the 1st and 2nd seasons, respectively. Spraying with KCit gave the highest concentration of Vit C (17.86 mg/100 g FW) in tubers as average of the two seasons. While spraying potato plants with water only recorded the lowest specific gravity and Vit C in tubers in both seasons.

One of the ways to assess the quality of a potato tuber is by its specific gravity. According to **Al-Moshileh and Errebi (2004**), K fertilisation has a positive correlation with specific gravity. The obtained results are in agreement with those reported by **Ibrahim *et al.* (2015)** showed that plants foliar application of 2000 ppm potassium silicate showed the highest values of tuber specific gravity than the other treatments spraying with 1000 ppm or unsprayed plants . In addition, **Abdel Naby *et al*. (2018)** found that spraying potato plants with MegaPot (commercial fertilizer (MegaPot) as a source of nitrogen, potassium and sulphur (9% N, 40% K2O and 15.69% S) at the rate of 1.5 g/liter water) significantly increased vitamin-C in tubers as compared to unsprayed treatment. Also, **Mohaseb *et al*. (2018)** indicated that the highest values tuber vitamin-C content was obtained by spraying potato plants with potassium humate compared to unsprayed plants

Effect of the interaction

The highest specific gravity in tubers was obtained with fertilizing Hermes cultivar with KSil as foliar application (1.191 and 1.200 g/cm^3), followed by Hermes cultivar with KTS as foliar spray (1.183 and 1.199 g/cm^3) in the 1st and 2nd seasons, respectively. On the other hand spraying spunta cultivar with water only gave the lowest specific gravity value (0.842 and 0.859 g/cm^3) in the 1st and 2nd seasons, respectively (Table 14). As for Vit C contents**,** Lady rosetta cultivar with KCit as foliar application increased Vit C (19.40 mg /100 g FW) in tubers as average

Table 14. Effect of cultivars, potassium sources and their interactions on specific gravity (g/cm^3) in tuber at harvesting time of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	0.842 n	1.056 gh	0.991 j	0.902 m	1.040 hi	**0.966 D**
Santana	0.964 k	1.110 cd	1.056 gh	0.994 j	1.085 ef	**1.041 C**
Cara	0.894 m	1.031 i	0.969 k	0.937 l	0.991 j	**0.964 D**
Lady rosetta	1.010 j	1.121 c	1.075 fg	1.040 hi	1.096 de	**1.068 B**
Herms	1.075 fg	1.191 a	1.153 b	1.112 cd	1.183 a	**1.142 A**
Mean (B)	**0.957 E**	**1.101 A**	**1.048 C**	**0.997 D**	**1.079 B**	
			2022 season			
Spunta	0.859 s	1.064 ghi	1.015 lm	0.923 q	1.048 ij	**0.981 D**
Santana	0.948 p	1.121 de	1.048 ij	1.004 lmn	1.102 ef	**1.044 C**
Cara	0.888 r	1.023 kl	0.988 no	0.948 p	0.977 o	**0.964 E**
Lady rosetta	0.994 mno	1.139 d	1.085 fg	1.061 hij	1.118 de	**1.079 B**
Herms	1.042 jk	1.200 a	1.164 c	1.072 gh	1.199 b	**1.135 A**
Mean (B)	**0.946 E**	**1.116 A**	**1.060 C**	**1.001 D**	**1.088 B**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

Table 15. Effect of cultivars, potassium sources and their interactions on ascorbic acid (mg /100 g FW) in tuber at harvesting time of potato plants during summer seasons of 2021 and 2022

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Mean (A)
			2021 season			
Spunta	16.11 n	16.63 i-l	16.94 g-j	16.34 lmn	16.59 jkl	**16.52 D**
Santana	16.18 mn	16.91 h-k	17.06 fgh	16.46 lmn	16.85 h-k	**16.69 D**
Cara	16.54 klm	17.35 def	17.64 d	16.98 ghi	17.16 e-h	**17.13 C**
Ladyrosetta	18.36 c	19.14 ab	19.35 a	18.84 b	19.06 ab	**18.95 A**
Herms	16.97 ghi	18.08 c	18.16 c	17.29 d-g	17.44 de	**17.58 B**
Mean (B)	**16.83 E**	**17.62 B**	**17.83 A**	**17.18 D**	**17.42 C**	
			2022 season			
Spunta	16.07 n	16.71 i-l	17.03 ghi	16.41 lmn	16.53 j-m	**16.55 E**
Santana	16.24 mn	16.96 ghi	17.14 fgh	16.49 klm	16.89 g-j	**16.74 D**
Cara	16.48 klm	17.48 def	17.73 d	17.02 ghi	17.15 fgh	**17.17 C**
Ladyrosetta	18.31 c	19.24 ab	19.45 a	18.95 b	19.12 ab	**19.01 A**
Herms	16.84 h-k	18.12 c	18.19 c	17.21 efg	17.53 de	**17.57 B**
Mean (B)	**16.78 E**	**17.70 B**	**17.90 A**	**17.21 D**	**17.44 C**	

KSli= potassium silicate 10.6% K_2O at 4.25 ml/l, KCit= potassium citrate (45% K_2O) at 1 g/l , KF= potassium folvate (10% K_2O) at 4.5 g/l and KTS= potassium thiosulphate (36.5% K_2O) at 1.25 ml/l

of the two seasons (Table 15). These results are in harmony with previous findings **by Baddour and Masoud (2022)** indicated that the interaction between spraying spunta cultivar and spraying with potassium silicate recorded the best tuber quality.

REFERENCES

Abd El-Gawad, H.G., A.I.N. Abuelazm, M.S. Hikal, A. El-Gawad, N.A.I. Abu El-Azm and M.S. Hikal (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, 718–731.

Abdel Naby, H.M., E.L. El-Gamily and A.A.A. Gab Allah (2018). Response of Potato Plants to Sources and Rates of Potassium Fertilizer. J. Plant Prod., Mansoura Univ., 9 (1): 67-71.

Abou El-Yazied, A. and S.M. Selim (2007). Effect of reducing N, P mineral fertilization levels combined with biofertilizer on growth, yield and tuber quality of potato plants. J. Agric. Sci. Mansoura Univ., 32 (4):2957- 2982.

Abou-Baker, A.H., M. Abd-Eladl and M.M. Abbas (2011). Use of silicate and different cultivation practices in alleviating salt stress effect on bean plants. Aust. J. Basic and Appl. Sci., 5(9):769-781.

Ali, M.M.E., S.A. Petropoulos, D.A.H. Selim, M. Elbagory, M.M. Othman, A.E.D. Omara and M.H. Mohamed (2021). Plant growth, yield and quality of potato crop in relation to potassium fertilization. 11, 675. https://doi. org/10.3390/ agronomy11040675.

Alkharpotly, A., A. Roshdy and E. Mady (2018). Potato growth and yield attributes as affected by boron and selenium foliar application. J. Plant Prod., Mansoura Univ., 9 (11): 901- 911.

Al-Moshileh, A.M. and M.A. Errebi (2004). Effect of various potassium sulphate rates on growth, yield and quality of potato grown under sandy soil and arid conditions. Potassium and Fertigation development in West Asia and North Africa. Rabat, Morocco: IPI Regional Workshop, 24-28.

Al-Zebari, Y.I., A.M S. Kahlel and S.Y.H. Al-Hamdan (2021). Response of four potato (*solanum tuberosum* l.) varieties to four nano fertilizers. Earth and Environ. Sci., 761:1-10.

AOAC (2018). Association of official analytical chemists. Official Methods of Analysis, 21st Ed. AOAC Int., Washington, D.C; USA.

Baddour, A.G. and A.S.O. Masoud (2022). Response of two potato cultivars to organic fertilization and potassium foliar application. J. Soil Sci. and Agric. Eng., Mansoura Univ., 13 (2): 51 – 58.

Banjade, S., S.M. Shrestha, N. Pokharel, D. Pandey and M. Rana (2019). Evaluation of growth and yield attributes of commonly grown potato (*Solanum Tuberosum*) varieties at Kavre, Nepal. Int. J. Sci. Res. Pub., 9(11): 134-142.

Bansali, S. and S. Trehan (2011). Effect of potassium on yield and processing quality attributes of potato. Karnataka J. Agric., 24 (1): 48-54.

Byju, G. and J. George (2005). Potassium nutrition of sweet potato. Adv. Hort. Sci., 19: 221 - 239.

Dkhil, B.B., M. Denden and S. Aboud (2011). Foliar potassium fertilization and its effect on growth, yield and quality of potato grown under loam-sandy soil and semi-arid conditions. Int. J. Agric. Res., 6: 593-600.

Duncan, D.B. (1958). Multiple Range and Multiple F-Test. Biometrics, 11: 1-5.

Elsagan, M.A.M. (2020). Evaluation of some potato cultivars productivity by using seedling. Mid. East J. Agric. Res., 9 (4): 758-771.

El-Sirafy, Z.M., Kh.A. Abbady, A.M. El-Ghamry and R.A. El-Dissoky (2008). Potato yield quality, quantity and profitability as affected by soil and foliar potassium application. Res. J. Agric. and Biol. Sci., 4 (6): 912-922.

Ewais, M.A., L.A. Abd El-Rahman and D.A. Sayed (2020). Effect of foliar application of boron and potassium sources on yield and quality of potato (*Solanum tuberosum* L.). Middle East J. Appl. Sci., 10(1): 120-137.

Fageria, N.K., V.C. Ballgar and C.A. Jones (1997). Growth and nutrition of filed crops 2nd Ed. Marcel Dekker, Inc. New York, 85

Farrag, K., M.A.A. Abdrabbo and S.A.M. Hegab (2016). Growth and productivity of potato under different irrigation levels and mulch types in the North West of the Nile Delta, Egypt. Mid. East J. Appl. Sci., 6: 774–786.

Gahwash, M.N. and E. A. Bardisi (2023). Effect of planting date and spraying with different potassium sources on growth, productivity and tuber quality of jerusalem artichoke. Future J. Biol., 2 (2023) 32-55.

Gardener, F.D., R.B. Pearce and R.L. Mitchell (1985). Physiology of crop plants. The Iowa state Univ. Press. Ame., 327.

Hussein, O.S. and N. Hamideldin (2014). Effects of spraying irradiated alginate on *Solanum tuberosum* L. plants: growth, yield and physiological changes of stored tubers. J. Agric. Vet. Sci., 7 (1): 75-79.

Ibrahim, M.F., H.G. Abd El-Gawad and A.M. Bondok (2015). Physiological impacts of potassium citrate and folic acid on growth, yield and some viral diseases of potato plants. Mid. East J. Agric. Res., 4 (3): 577-589.

Kahlel, A.M.S. and F.I. Sultan (2019). Response of four potato cultivars to soil application with organic and amino acid compounds. Res. on Crops, 20 (1): 101-108.

Kayser, M. and J. Isselstein (2005). Potassium cycling and losses in grassland systems: a review. Grass and Forage Sci., 60 (3):213-224.

Khan, M.Z., M.E. Akhtari, M.N. Safdar, M.M. Mahmood, S. Ahmad and N. Ahmed (2010). Effect of source and level of potash on yield and quality of potato tubers. Pak. J. Bot., 42 (5): 3137-3145.

Mahdi, R.S., A.I. Manea and I.A. Aubied (2023). Effect of bio-fertilizer and potassium spraying on the growth and yield of potatoes for autumn season. 5th Int. Conf. Agric. and Environ. Sci., 1158: 042050.

Mandour, M.A. and H.A. Metwaly (2022). interactive effects of selenium and salicylic acid on growth, yield attributes and improves early blight resistance of two potato cultivars. J. Hort. Sci. and Ornamental Plants, 14 (1): 21-31.

Marschner, H. (1995). Mineral Nutrition of Higher Plants. 2nd Ed., Acad. Press Limited, San Diego.

Mengel, K. and E.A. Kirkby (1987). Principles of plant nutrition. 4th Ed., Int. Potash Inst., Norblafen-Bern, Switzerland.

Mohaseb, M.I., H.A. Khafagy, M.S. Mahrous and S.M. Abdel-Azeem (2018). Effect of humic substances addition and foliar spraying with biostimulants on growth, yield and quality of potato (*Solanum Tuberosum*). Ann. Agric. Sci., Moshtohor, 56 (4):1121-1132.

Mousa, M.A.A. (2009). Effect of zinc plus manganese foliar application on potato performance and quality. Assiut J. Agric. Sci., 40 (1): 17-35.

Murphy, H.G. and M.J. Govern. (1959). Factors affecting the specific gravity of white potato in main Agr. Exp. Sta. Bull., 583.

Mystkowska, I., K. Zarzecka, M. Gugała, A. Ginter and A. Sikorska (2023) Impact of care and nutrition methods on the content and uptake of selected mineral elements in *Solanum tuberosum*. Agron., 13 (690): 1-15.

Othman, B.A., E.M. Handak, A.S.M. Abo-Senna and A.M. Ragab (2019). Evaluation of some potato cultivars against potato Virus Y (PVYNTN) infection. Mid. East J. Appl. Sci., 9 (3): 781-794.

Salim, B.B.M., H.G. Abd El-Gawad and A. Abou El-Yazied (2014). Effect of foliar spray of different potassium sources on growth, yield and mineral composition of potato (*Solanum tuberosum* L.). Mid. East J. Appl. Sci., 4(4): 1197-1204.

Snedecor, G.W. and W.G. Cochran (1980). Statistical Methods. 7th Ed. Ames, Iowa U.S.A: Iowa State Univ., 507.

Tantawy, A.S., Y.A. Salama, S.A. Saleh and A.A. Ghoname (2017). Enhancing yield and quality of two potato cultivars by using boron foliar application. Midd. East J. Appl. Sci., 7 (3): 510-518.

Trehan, S., S. Roy and R. Sharma (2001). Potato variety differences in nutrient deficiency symptoms and responses to NPK. Better Crops Int., 15: 18-21.

Van Der Zaag, D.E. and D. Horton (1983). Potato production and utilization in world perspective with special reference to the tropics and sub-tropics. Potato Res., 26: 323–362

Wang, J.G., F.S. Zhang, X.L. Zhang and Y.P. Cao (2000). Release of potassium from K-bearing minerals: effect of plant roots under P deficiency. Nutr. Cycl Agroecosys, 56:45–52.

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

Wettestein, D. (1957). Chlorophyll. Lethale under Submikroskopische Formwechsel der Plastiden. Exp. Cell Reso, 12: 427-506.

Youseef, M.E.A., I.A.S. Al-Easily and Dalia A.S. Nawar (2017). Impact of biochar addition on productivity and tubers quality of some potato cultivars under sandy soil conditions. Egypt. J. Hort., 44*(*2): 199 -217.

Yousef, S.Y.A. (2021). Effect of radiation mutants on genetic stability of the productivity and quality of some potato cultivars under drought stress conditions. Ph.D. Thesis, Fac. Agric., Zagazig Univ., Egypt.

Zelelew, D.Z., S. Lal, T.T. Kidane and M.G. Biniam (2016). Effect of potassium levels on growth and productivity of potato varieties. Ame. J. Plant Sci., 7:1629-1638.

تاثير بعض أصناف البطاطس ومصادر البوتاسيوم على نمو النبات، المحصول وجوده الدرنات تحت ظروف الارض الرمليه

طلعت عبد الحميد السيد موسى[1] - سمر عبدالله برديسي[1]

هانى السيد محمد على اسماعيل[1] - جمال ابوستة زايد[2]

1- قسم البساتين - كلية الزراعة - جامعة الزقازيق ، مصر

2- معهد بجوث البساتين .، مركز البحوث الزراعية ،الجيزة، مصر

أجريت تجربتان حقليتان في مزرعة خاصة بالصالحية الجديدة، بمحافظة الشرقية خلال موسمي صيف 2021 و 2022 بهدف دراسة تأثير الرش بمصادر مختلفة من البوتاسيوم مثل (سيليكات البوتاسيوم بمعدل 4.5 مل/لتر وسيترات البوتاسيوم بمعدل 1 جم/لتر وفولفات البوتاسيوم بمعدل 4.5 جم/لتر وثيوسلفات البوتاسيوم بمعدل 1.25 مل/لتر) وكذلك معامله المقارنه (الرش بالماء) على نمو النبات، الممتص من النيتروجين والفسفور والبوتاسيوم بواسطه عرش النبات والمحصول، وجودة درنات بعض أصناف البطاطس (سبونتا وسانتانا وكارا وليدي روزيتا وهيرميس). أعطى تسميد صنف سانتانا بسترات البوتاسيوم رشاً ورقياً أطول النباتات وأعلى قيم لعدد الأوراق/ نبات، وتركيز الكلوروفيل الكلي (أ+ب) في أنسجة الأوراق، الممتص من النيتروجين والفوسفور والبوتاسيوم بواسطه عرش النبات، بينما أدى تسميد الصنف كارا بنفس المصدر إلى زيادة عدد السيقان الرئيسية/النبات عند 90 يوما من الزراعة في كلا الموسمين و أعلى إنتاجية/نبات والمحصول الكلى للفدان. علاوة على ذلك، أعطى تسميد الكارا بسليكات البوتاسيوم عن طريق الرش الورقى أعلى قيم لمحتويات النيتروجين والفوسفور والبوتاسيوم في الدرنات عند الحصاد. على جانب أخر أدى رش الصنف هيرميس بسليكات البوتاسيوم إلى زيادة الوزن النوعي للدرنات، بينما أدى تسميد صنف ليدى روزيتا بسترات البوتاسيوم من خلال الرش الورقي إلى زيادة فيتامين ج في الدرنات.

المحكمـــــون:

1- أ.د. الســـيد الســـيد ابو الخير رئيس بحوث - معهد بحوث البساتين - مركز البحوث الزراعية.

2- أ.د. أحمد عبدالله محمود محسن أستاذ الخضر - قسم البساتين كليه الزراعه جامعه الزقازيق.