EFFECT OF POTASSIUM SOURCES ON SOME POTATO CULTIVARS GROWN IN SANDY SOIL BY USING PIVOT IRRIGATION SYSTEM

Mousa, T. A.E **Samar, A. Bardisi** **H. E. M. Esmail** **G. A. Zayed**
MSc. student **Assist. Prof.** **Prof.** **Prof.**
[1]Hort. Dept., Fac. Agric. Zagazig University, Egypt. [2] Hort. Res. Inst., ARC, Egypt.
Corresponding author: Email: samarbardisi30@gmail.com

ABSTRACT

Study was carried out during two successive summer seasons of 2021 and 2022 at private filed in El-Salhyia El-Gadida District ,Sharkia Governorate, to study response of some potato cultivars to potassium sources as foliar application under sandy soil conditions using pivot irrigation system .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 .Spraying Cara cultivar with KCit increased number of tubers/ plant and total yield/ hectare, whereas spraying Spunta cultivar with KCit increased average tuber weight in both seasons .While, spraying Hermes cultivar with KSil as foliar spray increased DM, starch and total carbohydrates in tubers .Spunta cultivar with water only increased total sugars in tubers .In addition, the fertilization of Cara cultivar with KCit as a foliar application recorded a relative increase in the total yield of tubers amounting to about 72.50% as an average of the two seasons compared to the same cultivar without.

Key words: (*Solanum tuberosum,* L.), foliar spray, plant growth, yield and tuber quality

تاثير مصادر البوتاسيوم على بعض أصناف البطاطس النامية فى ارض رملية تحت نظام الرى المحورى

طلعت عبد الحميد السيد موسى سمر عبد الله برديسي هانى السيد محمد على اسماعيل جمال ابوستة زايد
[2]طالب ماجستير استاذ مساعد استاذ استاذ
قسم البساتين – كلية الزراعة – جامعة الزقازيق ، مصر [2] معهد بحوث البساتين .، مركز البحوث الزراعية ,الجيزة، مصر

المستخلص

اجري هذا العمل أثناء موسمى صيف 2021 و2022 فى مزرعة خضر خاصة بمنطقة الصالحية الجديدة, محافظة الشرقية, مصر لدراسة استجابة بعض اصناف البطاطا لمصادر البوتاسيوم تحت ظروف الارض الرملية ونظام الرى المحورى. اشتملت التجربة علي 25 معاملة عبارة عن التداخل بين خمس اصناف بطاطا (سبونتا, سانتانا, كارا, ليدى روزيتا, هيرميز) و 4 معاملات رش بمصادر البوتاسيوم (سليكات بوتاسيوم, سترات بوتاسيوم, فولفات بوتاسيوم, ثيوسلفات بوتاسيوم) بجانب معاملة المقارنة (الرش بالماء) وقد تم توزيع هذه المعاملات في نظام القطع المنشقة مرة واحدة في ثلاث مكررات حيث تم توزيع الأصناف في القطع الرئيسية، بينما تم توزيع معاملات الرش بمصادر البوتاسيوم عشوائيا في القطع تحت الرئيسة. ادى رش صنف البطاطا كارا بسترات البوتاسيوم الى زيادة عدد الدرنات على النبات ومحصول الهكتار, بينما ادى رش صنف البطاطا سبونتا بسترات البوتاسيوم الى زيادة متوسط وزن الدرنة. ادى رش صنف البطاطا هيرميز بسليكات البوتاسيوم الى زيادة محتوى الدرنات من المادة الجافة, النشا والكربوهيدرات الكلية, بيما ادى رش صنف البطاطا سبونتا بالماء (الكنترول) الى زيادة محتوى الدرنات من السكريات الكلية .ازداد محصول الصنف كارا بنسبة 72,50% (متوسط الموسمين) بالرش بسترات البوتاسيوم مقارنة برش نفس الصنف بالماء.

الكلمات المفتاحية: البطاطا، الرش الورقى، نمو النبات، المحصول وجودة الدرنات

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INTRODUCTION

Potato (*Solanum tuberosum,* L.) is one of the most important vegetables in Egypt for both local consumption and exportation. It has a considerable importance as an export crop to the European and Arab markets and one of the national income resources. Thus, academics in the region are focusing on developing novel approaches to cultivate this strategically important crop in different environments (7, 11, 12, 13, 40). The total potato cultivated area in Egypt during 2020 was 235.543 hectare (150.334, 65.109 and 20.040 ha. for winter , summer and autumn seasons , respectively which produced 6.785.871 tons with average 28.809 ton/ha. (6) Respecting , potato cultivars, the total cultivated area during 2020 for Spunta, Cara, Lady Rosetta and Hermes were about 20.376, 33.867, 57.575 and 2.438 ha. which, produced 612.271, 866. 837, 1.347.525 and 66.269 ton with average 30.036, 25.585, 23.395 and 27.165 ton/ha., respectively. Spunta , Cara, Santana and Lady Rosetta cultivars cultivating during winter, summer and autumn seasons ,whereas Hermes cultivar cultivating in summer season. There were significant differences among potato cultivars as for shoot dry weight (16, 21, 31, 42), yield and it components (10, 28, 43) and tuber quality (15, 28 , 34, 40). Horticultural crops need potassium in large quantities, especially at tuberlization filing stages. Potassium fertilizer application could be made in several ways by banding, fertigation or by spraying liquid fertilizers on to the leaves . Also, 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 (46). Potassium silicate K_2SiO_4 is a source of highly soluble silicon; it is used in agricultural production system primarily as a silicon fertilizer (5) . 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. Poor K utilization efficiency in farming systems is significantly influenced by leaching of K, particularly in sandy soils .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 (45). Some authors showed that spraying potato plants with different sources of potassium such as potassium silicate, potassium citrate, potassium fulvate and potassium thiosulpahte significantly increased shoot dry weight, leaf pigments , yield and its components and tuber quality compared to unsprayed plants, as for potassium silicate (2, 14, 29, 34, 41) , concerning potassium citrate (8, 25) found that fertilization Jerusalem artichoke) regarding potassium fulvate (23, 35) and potassium thiosulpahte (3). Therefore, the aim of this study was to study the response of some potato cultivars to different potassium sources as foliar application under the pivot irrigation system in order to obtain the highest productivity and the best specifications for the quality of potato tubers under sandy soil conditions.

MATERIALS AND METHODS

This work was carried out during two successive summer seasons of 2021 and 2022 at private Farm in El-Salhyia El-Gadida District, Sharkia Governorate, to study response of some potato cultivars (dry weight, yield, potassium use efficiency and tuber quality) to potassium sources as foliar application under sandy soil conditions using pivot irrigation system. The physical and chemical properties of the experimental soil are shown in Table 1.

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 >

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 sown 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 6m length each and 90 cm distance between 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 238 kg calcium mono super phosphate 15.5 % P_2O_5, 59.5 kg potassium sulphate 50 % K_2O and 59.5 kg ammonium sulphate 20.6 % N were added per hectare. After planting, all treatments received 285.6 kg N/ha.(797.3, 176.596 and 49.147 kg /ha., in the form of ammonium nitrate 33.5 % N, calcium nitrate 15.5 % N and urea 46 % N , respectively), 178.5 kg P_2O_5/ha. (105 and 146.29 kg/ha. in the form of phosphoric acid 85% P_2O_5 and mono ammonium phosphate 61 % P_2O_5, respectively) and 214.2 kg K_2O (428.4 kg /ha. potassium sulphate) as well as 119 kg/ ha. Magnesium sulphate via fertigation every two day 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

Dry weight of shoots: A random sample of five plants was randomly taken from every plot at 90 days after planting, in both seasons of study, for measuring dry weight of shoots (aerial stems + leaves).

Yield and its Components :At harvesting time (15th June in both seasons) tubers from each plot were harvested and the following data were recorded: Number of tubers/plant, average tuber weight (g), and total yield per ha^{-1}. (ton) . The total plants /ha=57.000 plants approximately.

Tuber Quality : Dry matter (%) :One hundred grams of the grated mixture were dried at 105 ^{0}C till constant weight and DM (%) was recorded. Total carbohydrate (%):It was determined colorimetrically in dry tubers as (g/100g) according to the methods described by (1). Starch content*:* It was determined by the method described by (1).Total sugars (%): It was determined according to the method described by (30).

Statistical analysis

The data were subjected to proper statistical analysis of variance according to (26) and the differences among treatments were compared using Duncans' multiple range test (19), 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 indicates that there were significant differences among five cultivars with shoot dry weight in both seasons. Santana cultivar produced the highest shoot dry weight/ plant followed by Spunta cultivar at 90 days after planting in both seasons. While Hermes cultivar recorded the lowest shoot dry weight. In general Santana cultivar gave the highest shoot dry weight (46.90 g), followed by Spunta cultivar (43.84g), Cara cultivar (40.75 g), Hermes cultivar (39.89 g) and Lady Rosetta (31.09 g) as average of the two seasons. The differences among potato cultivars could be attributed to the genetic differences between cultivars. Differences among potato cultivars were also observed by (4,20,23,33) all in potato. They found that there were significant differences among cultivars for shoot dry weight.

Table 2. Effect of cultivars, potassium sources and their interactions on number of shoot dry weight (g/plant) at 90 days after planting of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	35.26 ijk	45.58 cde	49.78 ab	40.51 gh	48.76 abc	43.97 B
Santana	41.97 fg	44.38 ef	50.44 a	44.73 def	49.45 ab	46.19 A
Cara	34.92 jk	38.61 ghi	46.44 b-e	37.13 hij	44.16 ef	40.25 C
Lady Rosetta	25.54 n	32.96 kl	36.29 ijk	28.64 mn	35.60 ijk	31.80 D
Hermes	30.93 lm	40.08 gh	48.03 a-d	37.50 hij	44.08 ef	40.12 C
Means (B)	33.72 E	40.32 C	46.19 A	37.70 D	44.41 B	
			2022 season			
Spunta	36.98 h-k	45.07 cde	47.73 bc	41.28 e-h	47.56 bc	43.72 B
Santana	40.69 e-i	45.28 cde	52.97 a	44.14 cde	50.04 ab	46.62 A
Cara	35.09 jkl	42.57 d-g	46.44 bcd	38.93 f-j	43.26 c-f	41.25 C
Lady Rosetta	23.99 o	30.19 mn	36.29 ijk	27.86 no	33.63 klm	30.39 D
Hermes	30.93 lmn	38.82 f-j	45.40 b-e	38.16 g-k	45.04 cde	39.67 C
Means (B)	33.53 E	40.38 C	45.76 A	38.07 D	43.90 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

Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Effect of potassium sources

Presented data in Tables 2 indicates 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 shoot dry weight compared to unsprayed plants and spraying potato plants

with KCit followed by KTS produced the highest value of shoot dry weight/ plant. In general spraying potato plants with KCit gave the highest values gave the highest shoot dry weight as average of the two seasons (45.97 g), followed by KTS (44.15 g), KSil (40.35 g), KF (37.88 g) and unsprayed plants (33.62 g). The increases in shoot dry weight due to spraying plants with KCit were about 36.72 % as average of the two seasons than unsprayed plants. This means that spraying with different sources of potassium increased dry weight of shoots and number of aerial stems /plant compared to unsprayed plants. Potassium is one of the most essential nutrients 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 (44).These results are in accordance with those reported by (19, 22, 29, 41) all on potato. They found that spraying potato with different potassium sources improved shoot dry weight compared to unsprayed plants.

Effect of the interaction

Spraying Santana cultivar with KCit followed by KTS produced the tallest plants and recorded maximum value of shoot dry weight, whereas spraying at 90 days after planting in both seasons (Table 2).Spraying Spunta, Santana , Cara, Lady Rosetta and Hermes with different sources of potassium , i.e., KCit, KSil, KF and KTS increased shoot dry weight/ plant compared to the same cultivars with control (spraying with water) in both seasons.In this regard, (15) showed that the interaction between spraying Spunta cultivar and spraying with potassium silicate showed a significant superiority in all vegetative growth, i.e., plant height , fresh weigh and dry weight / shoots than spraying Lady Rosetta cultivar with potassium silicate.

Yield and its components

Effect of cultivars: There were significant differences among five cultivars in number of tubers/ plant , average tuber weight and total yield /ha. in both seasons (Tables 3 , 4, 5). As for number of tubers / plant, data in Table 3 show that Cara cultivar gave the highest number of tubers/ plant (10.88 and 11.67), followed by Hermes cultivars (9.50 and 10.11), whereas Lady Rosetta cultivar produced the lowest values (8.37 and 8.92) in the 1st and 2nd seasons, respectively. Data in Table 4 shows that Spunta cultivar recorded maximum values of average tuber weight (98.53 and 103.19 g) followed by Santana cultivar (92.75 and 93.07 g), whereas Lady Rosetta cultivar recorded minimum values (85.65 and 84.05 g) in the 1st and 2nd seasons, respectively. As for total yield /ha. data in Table 5 indicate that Cara cultivar produced the highest values of total yield/ha. (45.058 and 49.870 ton) followed by Spunta cultivar (42.533 and 48.147ton), whereas Lady rosette cultivar produced the lowest values (34.384 and 35.840 ton/ha.) in the 1st and 2nd seasons, respectively. Spunta cultivar recorded maximum average tuber weight as average two seasons (100.86 g), followed by Santana cultivar (92.91 g), Cara cultivar (87.93g), Hermes cultivar (86.11 g) and Lady Rosetta cultivar (84.85 g). In general, under sandy soil conditions , during summer plantations Cara cultivar produced the highest total yield /ha. as average of the two seasons (47.464 ton) followed by Spunta cultivar (45.341 ton), Santana (42.252 ton), Hermes (40.405 ton) and Lady Rosetta (35.109 ton). The varietals differences among the studied cultivars could be due to the heredity differences and also, could be due to the differences among them in their yield attributes. Similar findings were reported by (14, 21, 24, 39, 47) all on potato. They showed that there were significant differences among potato cultivars regarding yield and its components.

Table 3. Effect of cultivars, potassium sources and their interactions on number of tubers/ plant of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	8.07 m	9.14 ij	9.74 ef	8.96 jk	9.27 hi	9.04 D
Santana	8.03 m	9.32 ghi	9.86 e	9.09 ij	9.68 ef	9.20 C
Cara	9.11 ij	11.12 c	11.77 a	11.03 c	11.39 b	10.88 A
Lady Rosetta	7.12 n	8.24 lm	9.54 fg	8.15 m	8.82 k	8.37 E
Hermes	8.42 l	9.54 fg	10.35 d	9.41 gh	9.77 ef	9.50 B
Means (B)	8.15 E	9.47 C	10.25 A	9.33 D	9.79 B	
			2022 season			
Spunta	9.31 i	9.98 e-h	10.07 d-g	9.60 hi	9.98 e-h	9.79 C
Santana	9.22 i	9.83 gh	10.40 d	9.60 hi	10.21 d-g	9.85 C
Cara	10.36 de	11.73 b	12.64 a	11.64 b	12.02 b	11.67 A
Lady Rosetta	7.93 k	8.69 j	10.07 d-g	8.60 j	9.31 i	8.92 D
Hermes	9.31 i	10.07 d-g	10.93 c	9.93 fgh	10.31 def	10.11 B
Means (B)	9.233 E	10.06 C	10.82 A	9.87 D	10.37 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, Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Table 4. Effect of cultivars, potassium sources and their interactions on average tuber weight (g) of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	90.60 fg	98.35 c	108.05 a	91.85 f	103.80 b	98.53A
Santana	82.75 hij	92.45 ef	99.65 bc	91.35 f	97.55 cd	92.75 B
Cara	75.77 kl	83.80 hij	99.10 c	82.05 hij	91.47 f	86.43 C
Lady Rosetta	73.85 l	86.40 gh	93.20 def	85.05 hi	89.75 fg	85.65 CD
Hermes	72.90 l	81.25 ij	96.55 cde	79.65 jk	89.75 fg	84.02 D
Means (B)	79.17 E	88.45 C	99.31A	85.99 D	94.46 B	
			2022 season			
Spunta	96.55 cde	104.20 b	112.50 a	97.60 cd	105.10 b	103.19 A
Santana	85.25 j	94.15 ef	97.55 cd	92.35 fg	96.05 cde	93.07 B
Cara	73.90 m	94.90 def	105.70 b	74.30 m	96.40 cde	89.04 C
Lady Rosetta	74.75 m	84.10 jk	89.60 gh	85.30 j	86.50 ij	84.05 D
Hermes	79.90 l	82.05 kl	98.15 c	88.75 hi	92.15 fg	88.20 C
Means (B)	82.07 E	91.88 C	100.70 A	87.66 D	95.24 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, Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Effect of potassium sources

Data in Tables (3,4 and 5) shows that fertilizing potato plants with different potassium sources as foliar application during summer plantations had a significant effects on yield and its components in both seasons. Spraying with plants KSil, KCit, KF and KTS increased number of tubers/ plant, average tuber weight and total yield /ha. compared to spraying with water only, which produced the lowest values. KCit as foliar application gave the highest values of number of tubers/ plant, average tuber weight and total yield /ha., 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 produced the highest values of total yield /ha. as average of the two seasons (50.194 ton) followed by spraying KTS (45.506 ton), KSil (41.959 ton), KF (39.508 ton) and unsprayed plants (33.344 ton). Also, spraying with KCit recorded maximum values of average tuber weight as average of the two seasons (100 g),

followed by spraying with KTS (94.85 g), spraying with KSil (90.16 g), spraying with KF (86.82 g) and spraying with water (80.62 g). The increases in total yield due to spraying with KCit were about 58.09 and 44.13% and were 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. (18). The source of potassium fertilizer had an impact on potato yield parameters in addition to potassium rate (17). 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 (32). In this regard, similar results were obtained by (2, 3, 8, 29, 36, 39, 41) indicated that the highest values of number of tubers/plant , average tuber weight and 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. (33) indicated that spraying potato plants with potassium silicate at 3ml /l was the best for increasing tuber numbers/ plant, average tubers weight and total yield as compared to spraying with potassium sulphate or unsprayed plants.

Table 5. Effect of cultivars, potassium sources and their interactions on total yield / ton/ha. of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	34.803 lmn	42.788 fgh	50.094 b	39.175 ij	45.803 cde	42.533 B
Santana	31.630 p	41.015 hi	46.769 cd	39.525 ij	44.949 def	40.777 C
Cara	32.566 op	44.356 efg	55.521 a	43.078 fgh	49.771 b	45.058 A
Lady Rosetta	25.028 r	33.889 mno	42.324 gh	32.994 nop	37.680 jk	34.384 E
Hermes	29.217 q	36.897 kl	47.567 c	35.676 klm	41.738 h	38.218 D
Means (B)	30.650 E	39.789 C	48.454 A	38.090 D	43.987 B	
			2022 season			
Spunta	42.788 ijk	49.499 def	53.926 bc	44.599 hij	49.928 def	48.147 B
Santana	37.414 mno	44.054 hij	48.290 efg	42.200 ijk	46.679 fgh	43.728 C
Cara	36.443 mno	52.988 bcd	63.596 a	41.167 jkl	55.157 b	49.871 A
Lady Rosetta	28.215 p	34.788 o	42.947 ij	34.919 o	38.332 lmn	35.840 D
Hermes	35.407 no	39.330 klm	51.065 cde	41.950 jk	45.222 ghi	42.595 C
Means (B)	36.052 E	44.132 C	51.965 A	40.967 D	47.065 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 , Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

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 number of tubers/ plant, average tuber weight and total yield /ha. compared to unspraying the same cultivars in both seasons (Tables 3 , 4, 5). Spraying Cara cultivar with KCit, followed by KTS increased number of tubers/ plant and total yield /ha., whereas spraying spunta cultivar with KCit, followed by Cara cultivar with KCit increased average tuber weight in both seasons. In the same line , (15) indicated that the highest average tuber weight, number of tuners/ plant and total yield /ha of potato were obtained with the interaction between spraying spunta cultivar and spraying with potassium silicate than spraying Lady Rosita cultivar with potassium silicate.

Tuber quality

Effect of cultivars There were significant differences among five cultivars (Spunta, Santana, Cara, Lady Rosetta and Hermes) with respect to dry matter (DM%), starch, total carbohydrates and total sugars in tubers in both seasons (Tables, 6 , 7, 8, 9). Hermes cultivar recorded maximum DM%, starch and total carbohydrates in tubers , followed by Lady Rosetta cultivars, whereas Spunta

cultivar recorded maximum value of total sugars in tubers, followed by Santana cultivar in both seasons. In general, Hermes cultivar produced the highest values of DM, starch and total carbohydrates (23.35 % , 18.60% and 19.60%) as average of the two seasons, followed by Lady Rosetta (22.26 %, 17.51 and 19.30 %) as average of the two seasons, whereas Spunta cultivar gave the highest value of total sugars (1.289 %) followed by Santana cultivar (1.223 %) as average of the two seasons. This means that potatoes cultivars (Spunta and Santana) produced the highest total sugars, whereas cultivars (Hermes and Lady Rosetta) produced the highest DM%, starch and total carbohydrates. There were positive correlation among DM, starch and total carbohydrates in tubers. 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 (47) found that potato Cara and Spunta potato cultivars recorded the maximum total carbohydrate and DM contents (%) in tubers; whereas Spunta cv. recorded the highest tubers starch content percentage. Also, Alkharpotly et al. (10) indicated that the highest specific gravity and starch in tubers were recorded with the cultivar 'Lady Rosetta ' than the cultivar 'Caruso'. However, 'Caruso' tubers had higher value in the ascorbic acid contents and reducing sugars. and Mandour and Metwaly (34) mentioned that the cultivar of Lady Rosetta potato scored higher DM%, specific gravity and starch contents than Spunta cultivar.

Effect of potassium sources

Fertilizing potato plants with different potassium sources as foliar feeding increased DM, starch and total carbohydrates in tubers compared to spraying with water only in both seasons (Tables 6 , 7 and 8), whereas unsprayed potato plants increased total sugars in tubers (Table 9). Potassium source in the form of KSil as foliar application produced the highest DM (21.24 %) , starch (17.83 %) , total carbohydrates (18.69 %) as average of the two seasons and unsprayed plants with potassium (water only gave the highest value of total sugars in tuber (1.268 %) as average of the two seasons. 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 potato yield (42), and other crops (37, 38) This may be because potassium activates several enzymes involved in carbohydrate metabolism, proteins synthesis, especially the production of proteins and sugars, as well as photosynthesis, and helps in the translocation of carbohydrates from leaves to tubers and its accumulation in storage tubers, as mentioned by (9, 22). Data showed a significant increase due to foliar application with potassium silicate for total carbohydrate and total sugar. These results are going in agreement with those reported by (2) showed that the highest values of dry matter content and total carbohydrates in tubers were recorded with the plants which sprayed with potassium silicate at 2000 ppm as compared to spraying with 1000 and 3000 ppm potassium silicate or unsprayed plants.

Table 6. Effect of cultivars, potassium sources and their interactions on dry matter (%) in tuber at harvesting time of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	18.54 no	19.44 h-k	19.08 j-m	18.84 lmn	19.33 i-l	19.04 D
Santana	18.80 mno	19.59 hij	19.15 i-m	19.04 k-n	19.40 h-k	19.19 D
Cara	18.28 o	20.97 g	19.63 hi	19.42 h-k	19.86 h	19.63 C
Lady Rosetta	21.05 g	22.78 cde	22.62 def	22.14 f	22.49 ef	22.21 B
Hermes	22.90 cde	23.65 a	23.29 abc	23.08 bcd	23.58 ab	23.30 A
Means (B)	19.91 D	21.28 A	20.75 B	20.50 C	20.93 B	
			2022 season			
Spunta	18.60 mn	19.59 h-k	19.16 jkl	18.87 lm	19.42 ijk	19.13 D
Santana	18.84 lm	19.67 hij	19.14 klm	19.08 klm	19.46ijk	19.24 CD
Cara	18.20 n	20.09 h	19.76 hi	19.46 ijk	19.92 hi	19.48 C
Lady Rosetta	21.11 g	22.81 de	22.76 def	22.27 f	22.57 ef	22.30 B
Hermes	22.96 cde	23.81 a	23.38 abc	23.20 bcd	23.66 ab	23.40 A
Means (B)	19.94 D	21.19 A	20.84 B	20.58 C	21.00 AB	

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, Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Table 7. Effect of cultivars, potassium sources and their interactions on starch (%) in tuber at harvesting time of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	14.33 n	17.11 e	16.07 jkl	15.54 m	15.89 klm	15.78 D
Santana	15.94 jkl	16.71 fgh	16.47 hi	15.93 kl	16.56 ghi	16.32 C
Cara	15.71 lm	16.92 efg	16.56 ghi	15.99 jkl	16.84 e-h	16.40 C
Lady Rosetta	16.25 ijk	18.12 cd	18.04 cd	16.31 ij	17.86 d	17.31 B
Hermes	16.96 ef	19.86 a	18.41 c	18.03 d	18.96 b	18.44 A
Means (B)	15.83 D	17.74 A	17.11 B	16.36 C	17.22 B	
			2022 season			
Spunta	14.48 o	17.41 efg	16.35 j-m	15.53 n	16.78 h-k	16.11 D
Santana	16.00 mn	16.82 hij	16.77 h-k	16.22 lm	16.79 h-k	16.52 C
Cara	16.31 klm	16.89 hi	17.00 ghi	16.84 hi	16.72 h-k	16.75 C
Lady Rosetta	16.53 i-l	18.57 c	18.51 c	17.16 fgh	17.86 de	17.72 B
Hermes	17.62 ef	19.91 a	18.64 c	18.29 cd	19.38 b	18.76 A
Means (B)	16.18 D	17.92 A	17.45 B	16.80 C	17.50 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 , Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Table 8. Effect of cultivars, potassium sources and their interactions on total carbohydrates (%) in tuber at harvesting time of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	17.34 i-l	17.99 g	17.67 g-j	17.47 h-k	17.89 gh	17.67 C
Santana	16.75 m	17.56 g-k	17.23 jkl	17.01 lm	17.46 h-k	17.20 D
Cara	16.97 lm	17.69 ghi	17.30 i-l	17.20 klm	17.53 h-k	17.33 D
Lady Rosetta	18.75 f	19.79 bc	19.28 de	18.91 ef	19.67 bcd	19.28 B
Hermes	19.02 ef	20.27 a	19.49 cd	19.28 de	20.06 ab	19.62 A
Means (B)	17.76 D	18.66 A	18.19 B	17.97 C	18.52 A	
			2022 season			
Spunta	17.26 kl	18.11 g	17.79 ghi	17.51 ijk	17.95 gh	17.72 C
Santana	16.81 m	17.70 g-j	17.31 jkl	17.06 lm	17.54 h-k	17.28 D
Cara	17.03 lm	17.77 ghi	17.29 jkl	17.24 kl	17.58 h-k	17.38 D
Lady Rosetta	18.83 f	19.88 abc	19.34 de	18.97 ef	19.61 bcd	19.32 B
Hermes	18.98 ef	20.14 a	19.52 cd	19.34 de	19.94 ab	19.58 A
Means (B)	17.78 E	18.72 A	18.25 C	18.02 D	18.52 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 , Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Table 9. Effect of cultivars, potassium sources and their interactions on total sugars (%) in tuber at harvesting time of potato plants during 2021 and 2022 summer seasons

Cultivars (A)	Potassium sources as foliar spray (B)					
	Unsprayed	KSli	KCit	KF	KTS	Means (A)
			2021 season			
Spunta	1.469 a	1.241 de	1.347 bc	1.407 ab	1.229 ef	1.338 A
Santana	1.367 bc	1.193 efg	1.203 ef	1.316 cd	1.203 ef	1.256 B
Cara	1.313 cd	1.115 ghi	1.221 ef	1.226 ef	1.179 efg	1.210 C
Lady Rosetta	1.247 de	1.058 i	1.083 hi	1.149 fgh	1.050 i	1.117 D
Hermes	1.205 ef	1.041 i	1.092 hi	1.118 ghi	1.073 hi	1.105 D
Means (B)	1.320 A	1.129 D	1.189 C	1.243 B	1.146 D	
			2022 season			
Spunta	1.341 a	1.151 g	1.272 b	1.304 ab	1.133 gh	1.240 A
Santana	1.266 bc	1.092 hi	1.166 efg	1.217 cd	1.212 def	1.190 B
Cara	1.217 cde	1.014 jkl	1.140 gh	1.164 fg	1.092 hi	1.125 C
Lady Rosetta	1.142 gh	0.978 l	1.047 ij	1.005 jkl	1.008 jkl	1.036 D
Hermes	1.115 gh	0.969 l	1.011 jkl	1.034 jk	0.995 kl	1.024 D
Means (B)	1.216 A	1.040 D	1.127 B	1.144 B	1.088 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

Values within each column that do not share a common letter are significantly different by Duncan's test at $P \leq 0.05$

Effect of the interaction

Data in Tables 6 , 7, 8, 9 shows that fertilizing Hermes cultivar with KSil as foliar spray increased DM (23.73 %), starch (19.88%) and total carbohydrates (20.20 %) in tubers as average of the two seasons compared to the other treatments. Unsprayed Spunta cultivar with any potassium sources increased total sugars in tubers (1.405 %) as average of the two seasons. These results are in harmony with previous findings by (15) indicated that spraying spunta cultivar with potassium silicate recorded the best tuber quality Dry matter % , total carbohydrates % , Vitamin C and total sugars %) than spraying Lady Rosetta cultivar with potassium silicate . Finally , it could be concluded that, under sandy conditions and using pivot irrigation system, spraying Cara cultivar with KCit increased shoot dry weight / plant , number of tubers/ plant and total yield /ha., whereas spraying Spunta cultivar with KCit, followed by Cara cultivar with KCit increased average tuber weight in both seasons. Spraying Hermes cultivar with KSil as foliar spray increased DM, starch and total carbohydrates in tubers compared to the other treatments. Spraying Spunta cultivar with water only increased total sugars in tubers. In addition, the fertilization of Cara cultivar with KCit as a foliar application recorded a relative increase in the total yield of tubers amounting to about 72.50% as an average of the two seasons compared to the same cultivar that was fertilized with water only.

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