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(Original Article)

Impact of Different Potassium Fertilization Sources on Growth, Yield and Fruit Quality of Sultani Fig Tree

Hassan A. Abd El-Galil[1]; Alaa A.B. Masoud[1]; Eman A.A. Abou-Zaid[1*]; Mohamed A.A. Abd El- khalek[2] and Nada S.A. Bahlol[2]

[1] Department of Pomology, Faculty of Agriculture, Assiut University, Egypt.
[2] Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.

*Corresponding author email: eman.hakeem@aun.edu.eg
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Abstract

The experiment was conducted on Sultani fig trees located on the farm of Shandawil Island Research Station, Sohag, Egypt, throughout the course of two subsequent growth seasons in 2020 and 2021. The goal of the study was to determine the applying various potassium sources to Sultani Fig trees' vegetative growth, yield components, and fruit quality. Data showed that when compared to untreated ones, the application of various potassium fertilization sources considerably enhanced leaf area, shoot length, and shoot thickness. Additionally, yield, ripeness, and fruit quality were all improved by all investigated potassium fertilization sources. The usage of potassium thiosulfate led to the maximum values of fruit weight, length, and diameter being noted. Between all examined treatments, there were no appreciable variations in fruit length or fruit diameter. The highest TSS and reducing sugar values, as well as the lowest titratable acidity values, were produced by vinasse and potassien. Additionally, no appreciable variations were discovered between them. One may deduce that in order to improve some vegetative development, high yield, and good fruit quality, different potassium fertilization sources were required twice a year. Therefore, from an economic perspective, vinasse and potassien are preferred. Due to reduced pollution and a lower overall cost of production.

Keywords: *Sultani Fig trees, Vinasse, Potassien, Fruit quality.*

Introduction

It is thought that fig trees, which are deciduous fruits that belong to the genus "Ficus" and family "Moracea," originated in the Arabian Peninsula and then spread to subtropical areas. Figs are a tree whose fruits have great nutritional content and are used for fresh consumption, drying, or the production of jam. They have a high concentration of iron, copper, calcium, sugar (52.9%), protein (3.6%), fat (1.3%), and vitamins A and C. Additionally, leaves, branches, and roots contain a white liquid with a medicinal quality (Goziekci, 2010). The top five nations in the world for producing fresh figs are Iran, Turkey, Egypt, Morocco, and Algeria. The production of fresh figs worldwide in 2019 was 1.315.588 tons (FAO, 2019). 70718 feddan in Egypt were used for fig cultivation, and this yielded roughly 211438 tons of fruit. (MALR, 2021).

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All of the indigenous fig types in Egypt belong to the same kind, and their fruits are among the most important ones for local consumption. Inadequate irrigation, improper or insufficient fertilization, pests that attack these trees and other problems may all contribute to the low growth and productivity of fig trees in arid areas (Taha *et al*, 1989 and Lavee *et al*., 1990).

All living things require the element potassium (K). Four physiological-biochemical responsibilities can be used to summarize the crucial roles that K plays in plants: (1) Enzyme activation (Walker *et al*., 1998); (2) translocation of assimilates and cellular membrane transport processes (Salisburg and Ross, 1992); (3) Anion neutralization is required to maintain membrane potential. (Leigh, 2001); and (4) One of the crucial methods for managing plant water interactions is osmotic potential regulation (Davies and Zhang, 1991). Potassium, the most common cation, aids in charge balancing and may be involved in sugar transfer. Increased TSS concentration and decreased overall fruit acidity were both a result of higher potassium supply. Increased polyphenolic fruit coloring content is facilitated by adequate potassium intake (Sommer, 1977 and Martin *et al*., 2004). In addition to influencing growth and development, potassium nutrient status is essential for plant disease resistance (Marschner, 1995 and Poor tree growth, low productivity, early leaf falls, delayed ripening, lower K content in the fruit, and decreased pH were all effects of insufficient K supply (Conradie and Saayman, 1989 and Schreiner *et al*., 2013).

All phases of protein synthesis depend on potassium, which is also a crucial mineral component for all plant growth processes (Arquero *et al*., 2006). By modifying the rate of photosynthesis and speeding up the rate at which leaves are transferred through the phloem to storage tissue, potassium controls a variety of enzyme activity in plants, improving fruit yield and quality (Saykhul *et al*., 2013). Southwick *et al*. (1996) revealed that potassium uptake from the soil, where soil-cation interactions may impede the process, may not be as reliable and effective as uptake through foliar spray. Foliar fertilization with nutrients is most efficient when the nutrients are indirectly delivered to developing leaves and reproductive tissues, as well as when they are absorbed (Mengel, 2002). On the other hand, altering fertilizer levels, particularly potassium, affects the concentrations of primary and secondary chemicals in plants (Liaqat *et al*., 2012). Different carbon/nitrogen ratios could result, which would alter how secondary metabolites (such phenolic) are produced by plants (Bryant *et al*., 1983).

Therefore, the goal was to assess how potassium dosages affected the quantity and quality of fig fruits grown in comparable settings.

Materials and Methods

The experiment was conducted on 15 subjects who were uniformly strong, healthy, in good physical shape, and free of insects and infections over the course of two subsequent seasons in 2020 and 2021. In the farm of the Shandawil island research station in Sohag, Egypt, sixteen-year-old Sultani Fig trees are being grown. They had grown 5 × 5 meters apart in clay soil with surface irrigation.

When the tree was left with its winter pruning, there were a total of 72 branches on the tree. The same agricultural management was used to all trees.

The experimental included the following five treatments:

- Control (sprayed with water only).
- Application potassium sulphate (50% K2O) 200 g/tree.
- Spraying of vinasse (2%) 5 L/tree.
- Spraying of potassien (32% K) 312.5 ml/tree.
- Spraying of potassium thiosulfate KTS (25%) 400 ml/tree.

All Potassium treatments were applied at the mid of May and July. All treatments were sprayed by using a backpack machine gun to the runoff. The experimental was arranged in a randomized complete block design (RCBD) with three replications, one tree/ replicate.

Measurements

The effects of various treatments on some vegetative development, yield, and fruit quality during the two research seasons were assessed using the following metrics.

Measurements of vegetative growth characters

Average leaf area (cm^2) was calculated after 20 mature leaves' diameters from the middle of the branch were measured.

Leaf area (cm^2): was measured using the following equation:

Leaf area (cm^2) = 0.30 (0.79 × d2) + 76.71, where d is the maximum diameter of leaf, then the average leaf area was registered.

Shoot length (cm).

Shoot thickness (mm) by using Vernier caliper.

Yield components

The yield of each tree was recorded in terms of weight (in kg).

Ripening fruit% was measured using the following equation total ripe fruits number /total fruits number.

Physical and chemical characteristics of the berries: Fruit weight (g), Fruit length (cm) and Fruit diameter (mm) by using Vernier caliper.

A portable refractometer was used to estimate the percentage of total soluble solids in the juice. In an electric blender, 50 grimes of flesh were combined with 100 ml of desilted water. The extract was then filtered, and the TSS% was calculated using a portable refractometer.

The volumetric method used to calculate the percentage of reducing sugars in the juice is given in A.O.A.C. (1985).

By titrating against 0.1 N NaOH and using phenolphthalein as an indicator, the percentage of total acidity was calculated (A.O.A.C., 1985).

Statistical analysis

Statistics were used to tabulate and analyzed the data. According to Snedecor and Cochran (1990) and Mead *et al*. (1993), the analysis of variance (ANOVA) was used. Utilizing the updated L.S.D. values at the 5% level of probability, treatment means were compared.

Results

Some vegetative growth

The Sultani Fig trees' leaf area, shoot length, and shoot thickness were affected by various potassium fertilization sources throughout the 2020 and 2021 growing seasons, according to data in table 1. The data clearly show that the outcomes followed a similar trend during the two research seasons.

Table 1. Effect of different potassium sources spraying on leaf area, shoot length and shoot thickness of Sultani Fig trees during 2020 and 2021 seasons.

Treatment	Leaf area (cm^2)			Shoot length (cm)			Shoot thickness (mm)		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
T1	160.17	154.33	157.25	177.83	178.56	178.19	1.55	1.64	1.59
T2	173.97	170.66	172.32	190.33	194.67	192.50	1.68	1.78	1.73
T3	175.71	176.33	176.02	215.33	210.67	213.00	1.81	1.92	1.87
T4	176.00	171.66	173.83	203.00	217.00	210.00	1.95	1.84	1.89
T5	166.35	163.66	165.02	209.67	212.33	211.00	1.79	1.86	1.83
L.S.D 0.5%	**6.39**	**8.55**		**11.63**	**12.89**		**0.9**	**0.11**	

T1: Control, T2: Potassium sulphate, T3: Vinasse at 2%, T4: Potassien and T5: Potassium thiosulphate.

Concerning the effect of different potassium fertilization sources, the results showed that all studied treatments gave significantly increase of leaf area compared with untreated ones. No significantly increase were obtained due to different potassium fertilization sources. The maximum values of leaf area were recorded due to vinasse application followed by potassien application. Whereas the untreated ones gave the least values. The recorded leaf area was (157.25, 172.32, 176.02, 173.83 and 165.01 cm2 as an average of the two studied seasons, respectively) due to untreated (T1), potassium sulphate (T2), vinasse at 2% (T3), potassien (T4) and potassium thiosulphate (T5), respectively. Moreover, the corresponding obtained shoot length was (178.19,192.5, 5.21, 210 and 211 cm as an average of the two studied seasons, respectively). All studied treatments gave significantly increase of the shoot length compared with untreated ones. Also, no significant differences between vinasse, potassien and potassium thiosulphate application. The recorded shoot thickness was (1.59, 1.73, 1.87, 1.89 and 1.83 mm as an average of the two studied seasons, respectively) due to untreated (T1), potassium sulphate (T2), vinasse at 2% (T3), potassien (T4) and potassium thiosulphate (T5), respectively. The maximum value of shoot thickness was recorded due to use potassien followed by vinasse. Whereas untreated ones gave the least values. Then the increment percentage of leaf area was attained (9.58, 11.94, 10.54 and 4.94%) due to use potassium sulphate (T2), vinasse at 2% (T3), potassien (T4) and potassium thiosulphate (T5) compared to untreated (T1) as an average of the two studied seasons, respectively. It could be concluded that any studied potassium application applying beneficial improvement growth of Sultani Fig trees.

Yield components

The Sultani Fig tree's yield per tree and fruit ripeness percentage were affected by potassium fertilization throughout the 2020 and 2021 growing seasons, according to data reported in Tables (2). The data clearly show that the outcomes followed a similar trend during the two research seasons. According to the findings of potassium fertilization, yield per tree and fruit ripeness percentage were both considerably impacted. Therefore, using differenced potassium sources were significantly increase the yield/tree and ripping fruit% compared to untreated ones. Moreover, using potassium sulphate gave the heaviest yield weight compared to use other treatments but no significant differences between different potassium sources. Potassien application gave the maximum value of ripping fruit%. Also, no significant differences between all different potassium recourses. The recorded yield/tree was (78.82, 93.24, 89.28, 89.28 and 92.52 kg as an average of the two studied seasons, respectively) due to untreated (T1), potassium sulphate (T2), vinasse at 2% (T3), potassien (T4) and potassium thiosulphate (T5), respectively. Moreover, the corresponding obtained ripping fruit% was (70.49, 76.54, 75.47, 76.66 and 76.22% as an average of the two studied seasons, respectively). Then, the increment percentage of yield/tree was attained (18.29, 13.27, 13.27 and 17.38%) due to T2, T3, T4 and T5 compared to T1 during the two studied seasons, respectively.

It could be concluded that all studied potassium fertilization sources were beneficial improvement of yield and ripening fruit.

Table 2. Effect of different potassium sources spraying on yield/tree and ripping fruit% of Sultani Fig trees during 2020 and 2021 seasons.

Treatment	Yield/tree (kg)			Ripening fruit%		
	2020	2021	Mean	2020	2021	Mean
T1	77.00	80.64	78.82	70.16	70.82	70.49
T2	90.00	96.48	93.24	76.73	76.35	76.54
T3	87.84	90.72	89.28	74.82	76.11	75.47
T4	86.4	92.16	89.28	76.11	77.20	76.66
T5	93.60	91.44	92.52	75.57	76.86	76.22
L.S.D 0.5%	**6.16**	**5.89**	**-**	**4.16**	**3.39**	**-**

T1: Control, T2: Potassium sulphate, T3: Vinasse at 2%, T4: Potassien and T5: Potassium thiosulphate.

Some fruit quality attributes

Tables (3 and 4) offer information on some physicochemical characteristics of Sultani Fig trees as affected by various potassium fertilization throughout the 2020 and 2021 seasons. The data clearly show that the outcomes followed a similar trend during the two research seasons.

Table 3. Effect of different potassium sources spraying on fruit weight, fruit length and fruit diameter of Sultani Fig trees during 2020 and 2021 seasons

Treatment	Fruit weight (g)			Fruit length (cm)			Fruit diameter (mm)		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
T1	36.00	37.13	36.57	3.43	3.48	3.46	3.39	3.52	3.46
T2	40.40	42.16	41.28	3.70	3.76	3.73	3.71	3.72	3.72
T3	38.38	38.90	38.64	3.56	3.59	3.58	3.57	3.65	3.61
T4	38.50	40.46	39.48	3.62	3.62	3.62	3.56	3.64	3.60
T5	42.75	41.11	41.93	3.69	3.64	3.67	3.74	3.69	3.72
L.S.D 0.5%	1.75	1.55		0.11	0.11		0.14	0.12	

T1: Control, T2: Potassium sulphate, T3: Vinasse at 2%, T4: Potassien and T5: Potassium thiosulphate.

Table 4. Effect of different potassium sources spraying on total soluble solids (TSS)%, reducing sugar% and titratable acidity% of Sultani Fig trees during 2020 and 2021 seasons.

Treatment	TSS%			Reducing sugar%			Titratable acidity%		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
T1	15.10	15.50	15.30	9.23	9.45	9.34	0.146	0.135	0.141
T2	16.20	16.30	16.25	9.89	9.98	9.94	0.125	0.121	0.123
T3	18.10	18.10	18.10	11.03	11.08	11.06	0.118	0.114	0.116
T4	18.20	18.10	18.15	11.00	11.10	11.05	0.120	0.118	0.119
T5	15.80	16.20	16.00	9.65	9.86	9.76	0.130	0.126	0.128
L.S.D 0.5%	0.48	0.55		0.38	0.34		0.013	0.010	

T1: Control, T2: Potassium sulphate, T3: Vinasse at 2%, T4: Potassien and T5: Potassium thiosulphate.

The results showed that some physical characteristics, such as fruit weight, fruit length, and fruit diameter, as well as chemical characteristics, such as total soluble solids, reducing sugars, and titratable acidity, were significantly influenced by all potassium sources.

Therefore, it can be stated that using potassium fertilization sources enhanced the fruit quality by increasing fruit weight, length, diameter, TSS, reducing sugar, and decreasing titratable acidity when compared to untreated ones. due to the use of potassium thiosulphate, the highest values of fruit weight, length, and diameter were noted. Between all examined treatments, there were no appreciable variations in fruit length or fruit diameter. Additionally, there were no discernible variations between the potassium sulphate and potassium thiosulphate contents of the fruit. The recorded fruit weight was (36.57, 41.28, 38.64, 39.48 and 41.93 g as an average of the two studied seasons, respectively) due to T1, T2, T3, T4 and T5, respectively. Then, the increment percentage of fruit weight was attained (12.88, 5.66, 7.96 and 14.66%) due to T2, T3, T4 and T5 compared to T1 as an average of the two studied seasons, respectively. As well as the recorded fruit length was (3.46, 3.73, 3.58, 3.62 and 3.67 cm) and fruit diameter was (3.46, 3.72, 3.61, 3.6 and 3.72 mm) due to T1, T2, T3, T4 and T5 as an average of the two studied seasons, respectively.

In addition, vinasse and potassien gave the highest values of TSS and reducing sugar and least value of titratable acidity. Also, no significant differences found between them. the recorded TSS was (15.3, 16.25, 18.1, 18.15 and 16%) and reducing sugar was (9.34, 9.94, 11.06, 11.05 and 9.76%) due to T1, T2, T3, T4 and T5 as an average of the two studied seasons, respectively. Then, the increment percentage of TSS attained (6.21, 18.30, 18.63 and 4.58%) and reducing sugar (6.42, 18.42, 18.31 and 4.49%) due to T2, T3, T4 and T5 compared to (T1) as an average of the two studied seasons, respectively.

On contrary, the values of titratable acidity were (0.141, 0.123, 0.116, 0.119 and 0.128%) due to T1, T2, T3, T4 and T5 as an average of the two studied seasons, respectively. Hence, the decrement percentage of titratable acidity was (12.77, 17.73, 15.60 and 9.22%) due to T2, T3, T4 and T5 compared to (T1) as an average of the two studied seasons, respectively.

Hence, it may be concluded that using vinasse and potassien as an organic or bio fertilizers instead of Mineral-K to get good growth, high yield with good fruit quality and reducing environmental pollution and cost.

Discussion

The synthesis and functioning of proteins, lipids, carbohydrates, and chlorophyll as well as the preservation of the equilibrium between salts and water in plant cells all depend on potassium (Marschner, 1995). Due to a scarcity of natural K resources, crop K demands become a significant expense. It has been thought about to investigate additional potassium sources. In addition to conventional and organic forms, there is rising interest in and need for slow-releasing, organic, and bio sources of K. Chemical fruit characteristics were significantly improved by employing slow-release organic or bio fertilizers, or even a combination mixture, as opposed to Mineral-K fertilization alone. Natural fertilization uses between 25 to 46% fewer mineral fertilizers than synthetic fertilizers, which lessens soil and environmental contamination.

A vital role for potassium sulphate is in the uptake and transfer of nutrients from roots to vegetative development (Cushnahan *et al*., 1995). Additionally, potassium is crucial for photosynthesis and osmoregulatory processes (Nelson, 1978), and it is necessary for physiological functions such the activation of enzymes, controlling osmotic pressure, and moving stomata (Gollback *et al*., 2003). Furthermore, it assists in the translocation of sugars and stimulates the enzymes necessary for sugar production (Archer.,1988). Additionally, potassium demonstrated a critical role in regulating the production and mobilization of carbohydrates in plant tissues, which had an impact on fruit weight and yield. The results reported on the impact of potassium spraying on several fig tree cultivars are consistent with those of Sotiropoulos *et al*., (2020) and Moura *et al*., (2023).

These findings underlined how crucial potassium fertilization is for growing full-bodied, robust trees. In addition to being used to reduce environmental problems and save money on potassium fertilization costs, vinasse contains high-density syrup residue from the sugar industry. Vinasse, a byproduct of the sugar cane distillery, has been applied to soil as an amendment since it is a significant source of organic matter and plant nutrients. Vinasse has a lot of organic matter, a lot of potassium, a lot of calcium, and a little bit of nitrogen and phosphorus. Vinasse application is a frequent procedure in locations where sugar cane is grown, and it can completely replace K and partially P in crop fertilization (Gomez and Rodriguez, 2000). Due to their favorable effects on improving soil fertility, microflora activity, N fixation, and the availability of all nutrients, bio fertilizers have been shown to have significant positive effects on the growth and fruiting of fruit trees. (Kannaiyar, 2002). Because potassien is essential for many physiological processes, using potassien as a potassium source enhanced growth, yield, and fruit quality. They highlighted the early effects of potassium fertilization on growth nutritional status and fruiting Omar (2000), Arafat et al. (2000), Shoaieb (2002), Tano *et al*. (2005), Abdel-Salam, Maha *et al*. (2009), El-Kady (2011), Sotiropoulos *et al*., (2020) and Moura *et al*., (2023). They concluded that using different forms of potassium fertilization had a positive effect on growth and leaf mineral content, as well as yield and fruit quality.

Conclusion

The current study has shown that potassium treatments can improve fruit quality, yield, and vegetative development. It may be inferred from this, that a foliar application of potassium thiosulfate, vinasse, and potassien at 400 ml per tree, 5 L per tree, and 312.5 ml per tree, respectively, was made in the middle of May and July. Due to their high potential, nutritive value, environmental friendliness, and low cost as a natural resource, they might be suggested.

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تأثير مصـــادر التســـميد البوتاســـى المختلفة على النمو والمحصــول وجودة ثمار أشـــجار التين السلطاني

حسن عبد القوي عبد الجليل[1]، علاء عبد الجابر بدوي مسعود[1]، إيمان عبد الحكيم عبد الله أبو زيد[1]*، محمد عبد الشكور علي عبد الخالق[2]، ندى صابر أحمد بهلول[2]

[1] قسم الفاكهة، كلية الزراعة، جامعة أسيوط، مصر.
[2] معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر.

الملخص

تم اجراء هذه التجربة خلال موسمي 2020، 2021 على أشجار التين السلطاني التي تبلغ من العمر16 ســـنة المنزرعة بالمزرعة البحثية لمحطة البحوث الزراعية – شـــندويل – ســـوهاج – مصر. بهدف دراسة تأثير التسميد ببعض الأسمدة البوتاسية مختلفة المصادر على النمو الخضري والمحصـــول والاثمار حيث تمت الاضـــافة للتربة والرش بالمركبات بصـــورة فرديه وبالتركيزات التالية (سـلفات بوتاسـيوم 200 جم/شـجرة، فيناس 5 لتر/شـجرة، بوتاسـين 312.5 ملى/شـجرة، بوتاسـيوم ثيوسـلفات 400 ملى/شـجرة) تمت إضـافتها على دفعتين في منتصـف شـهر مايو ويوليو وكان تصميم التجربة قطاعات كاملة العشوائية.

وقد أظهرت النتائج

أظهرت جميع معاملات التسـميد البوتاسـي زيادة جوهرية في مسـاحة الورقة وطول الأفرع وسمك الأفرع مقارنة بالأشجار التي لم تسمد بالتسميد البوتاسى (المقارنة).

أوضـحت جميع معاملات التسميد البوتاسى تحسنا معنويا في مكونات المحصول والصفات الطبيعية والكيميائية للثمار.

ســـبب الرش بالفيناس والبوتاســـين زيادة معنوية في محتوى عصـــير الثمار من TSS والسكريات المختزلة ونقص معنوي في الحموضة الكلية للعصير.

لم تكن هناك فروق جوهرية بين معاملات التسميد المختلفة في معظم الصفات المدروسة.

من نتائج الدراسة يمكن التوصية بأهمية التسميد بالأسمدة البوتاسية على دفعتين في منتصف شهر مايو ويوليو لتحسين النمو الخضري وإنتاج محصول عالي ذو خصـائص جودة عالية. نظراً لعدم وجود فرق معنوي بين معاملات التسـميد المختلفة يفضـل اسـتخدام الفيناس أوالبوتاسـين لتقليل التلوث البيئي وتكلفة الانتاج.