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EFFECT OF POTASSIUM FERTILIZER ON FRUIT QUALITY AND MINERAL COMPOSITION OF FIG (*FICUS CARICA* L. CV. BROWN TURKY).

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Abstract

The impact of potassium fertilization on fruit quality and content of some nutrients of Brown Turky Fig grown in Dirab, Riyadh, King Saud University was studied during the 2015 and 2016 seasons. Results showed that applying K_2O at a rate of 400 g per tree followed by an application rate of 200 g per tree increased the fruit weight, fruit volume, and fruit dimensions. Highest total acidity in the first season was observed in fruits from the control trees (no potassium fertilizer added) followed by fruits from trees treated with K_2O at rate of 100 g per tree. Application of K_2O at a rate of 400 g per tree followed by a rate of 200 g per tree led to higher values of TSS and total sugars in the fruits of both the seasons. It was noted that the K_2O when applied at a rate of 400 g per tree increased reducing sugars and moisture content and when applied at a rate of 200 g per tree led to the highest non-reducing sugars in both the seasons. In addition, the results indicated that the N and K contents increased while P content decreased significantly with increasing rate of potassium fertilization in both the seasons. Treatments of K_2O at a rate of 100 g per tree led to the highest P content in both the seasons.

Key words: Fig, Fertilization, Fruit quality, Nutrient content.

Introduction

Fig (*Ficus carica*, L.) is one of the oldest fruit trees of the Mediterranean zone mentioned in the Quran. Its habitat extends from Turkey to northern India and it is spread throughout the Mediterranean countries. It is also cultivated in West Asia and in the Middle East. Fig is rich in vitamins (vitamin C), minerals (such as calcium, phosphorus), sugar, and fiber. Health benefits of eating fig include prevention of constipation, acne, pimples, and high blood pressure, and protection against cancer (Condit, 1947; Condit, 1955).

Fig trees grow in dry and semi-dry areas. The characteristics of fig fruits help to shopping, transport, and store. The fruits may be eaten fresh or dried (El-Rayes, 1995).

In traditional agriculture, chemical fertilizers such as nitrogen, potassium, and phosphorus are used. Potassium, in particular, plays an important role in maintaining the pH of the soil, regulation of osmosis, synthesis of protein, the movement of stomata, photosynthesis, and the extension of the cells (Läuchli & Pflüger, 1978).

According to Penteado (1986), only a little information is available on the nutritional needs of the fig trees which can help increase their production. In fact, large-scale research has been targeted toward nitrogen fertilization while studies carried out with potassium and other nutrients are very few.

Indeed, the estimation of nutrients within the leaves or fruits is very important and complex because it is associated with many physiological processes within the plant and fruits. Ahlawat & Yamdagni (1988) found that low levels of potassium result in poor vegetable growth, crop shortage, and low fruit quality, despite using nitrogen and phosphorus as fertilizers.

Potassium fertilization increases yield by increasing the number, weight, and size of fruits (Hillebrand, 1978; Kilani, 1979; Haeseler *et al.*, 1981; Boidron, 1986; El-Sese *et al.*, 1988; Dhillon, 1999; Klein *et al.*, 2000). In addition, potassium improves the quality of fruits, increasing total soluble solids and total sugars (Gopalswamy & Rao, 1972; Hillebrand, 1978; Morris *et al.*, 1987; Kilani, 1979; Ahlawat & Yamdagni, 1988).

Since farmers do not use a well-known and regulated system for potassium fertilization, its requirements for different varieties of figs cultivated in Riyadh are yet unknown.

The objective of this study was to illustrate the effect of potassium fertilizer on the production, fruit quality, and mineral composition of Fig (*Ficus carica* L. cv. Brown Turky) cultivated under conditions prevalent in Riyadh, Saudi Arabia.

Materials and Methods

The present investigation was carried out on Brown Turky Fig trees in two successive seasons, 2015 and 2016 at the Agricultural Research and Experiment Station, Dirab, King Saud University, Riyadh. The trees were 4 years old, grown on yellow sandy soil, spaced 4 x 4 meters. The experimental trees were free from disease and showed ideal growth, vigor, height, and production of fruits. The selected fig trees were subjected to all other regular agricultural practices followed on the farm. Water used for irrigation and the soil were analyzed according to the method of Chapman and Pratt (1961). The results are presented in Table 1. Potassium fertilizer in the form of potassium sulfate (48 % K_2O), was added to each experimental tree in the following concentrations: K_2O_0 (control), K_2O_1 (400), K_2O_2 (200) and K_2O_3 (100) g per fig tree. The potassium fertilizer was added in three equal doses in the middle of March, April, and May in both the seasons. Each treatment was added through as broad molding on the soil surface, 75 cm from the fig trunk.

Table 1. Results of analysis of soil sample and irrigation water as an average of two seasons.

Soil analysis at depth of 40 cm		Water analysis			
Character	**Value**	**Character**	**Value**	**Character**	**Value**
EC(dsm-1)	3.62-6.86	ECds/m	2.58	B PPm	1.38
pH	7.5-7.8	pH	6.99	Mn PPb	15.1
CaCO3 (%)	33.7	$Na^{+ meq/L}$	11.34	Cr PPb	90.6
Organic matter (%)	0.36	$K^{+ meq/L}$	0.39	Co PPb	4.9
		$Ca^{++ meq/L}$	9.51	Ni PPb	109
		$Mg^{++ meq/L}$	5.25	Cu PPb	291
		$HCO_3^{meq/L}$	3.72	Zn PPb	204
		$SO_4^{- meq/L}$	17.62	As PPb	1.64
		$CL^{- meq/L}$	11.26	Cd PPb	1.73
		$NO_3^{- PPm}$	9.04	Pd PPb	15.8

A randomized complete block design was employed for the four experimental treatments, each with three replications (one fig tree for each replication = 12 trees). The fruits were harvested during the second half of July of each season to determine their physico-chemical characteristics.

Fruit physical characteristics: Ten fruits were taken randomly from each tree to determine fruit size and fruit dimensions (in cm), fruit weight, flesh weight, and seed weight (in g). The results are presented as the means of five replicates.

Chemical properties

Total soluble solids: The percentage of TSS was determined by the hand refractometer (A.O.A.C., 1995).

Fruit acidity: Titratable acidity was calculated as citric acid, according to A.O.A.C. (1995).

Total soluble sugars and reducing soluble sugars: Percentage of total soluble sugars and reducing soluble sugars in the juice were analyzed by the Lane and Eynon method, as outlined in the A.O.A.C. (1995).

Non-reducing sugars: Non-reducing sugars were calculated based on the difference between total and reducing sugars.

Moisture content: Moisture content was determined according to A.O.A.C. (1995) method.

Leaf mineral analysis: The collected plant sample was subjected to plant analysis using wet digestion in H_2SO_4-H_2O_2 acid mixture as described by Parkinson & Allen (1975).

Total nitrogen was determined by semi-micro Kjeldahl method, as recommended by Bremner (1965). Phosphorus was colorimetrically determined using the molybdenum blow method according to Chapman & Pratt (1961). Potassium was determined using the flame photometer (Jackson, 1970).

Statistical analysis

The differences between the applied treatments were evaluated by the least significant difference (LSD) test (P = 0.05) using the software StatSoft (StatSoft Inc., 1995).

Results

Fruit characteristics

Physical characteristics

Fruit weight (g): The results obtained indicated that, there were differences between treatments in the two seasons. Addition of K_2O at a rate of 400 g per tree led to the highest fruit weight, followed by addition of K_2O at a rate of 200 g per tree compared to the control and other treatments.

Fruit volume (cm^3): The results obtained indicated that the fruit volume followed a trend similar to the fruit weight (Table 2).

Fruit dimensions: The fruit length and the fruit diameter were positively affected by the different treatments (Table 2). It was observed that maximum increase in fruit length and diameter was obtained upon supplementation with 400 g K_2O per tree followed by 200 g K_2O per tree in both the seasons. Less difference was observed between control fruit values and fruits of trees treated with K_2O at a rate of 100 g per tree.

Chemical characteristics

Fruit chemical constituents

Total acidity (%): The total percent acidity was positively affected by use of potassium fertilizer in the first season but not in the second season (Table 3). The fruits from control trees led to the highest total acidity followed by fruits from trees supplemented with 100 g K_2O per tree.

Table 2. Effect of potassium fertilizer on fruit physical properties.

Treatments	Fruit weight (g)	Fruit volume (cm)	Fruit length (cm)	Fruit diameter (cm)
		2014-2015 season		
K_2O added at a rate of 400 g per tree	38.2	39.4	4.8	5.5
K_2O added at a rate of 200 g per tree	29.4	29.3	4.5	4.7
K_2O added at a rate of 100 g per tree	28.7	29.0	4.1	4.5
No K2O added (control)	27.4	27.5	4.0	4.5
LSD at 0.05	**7.1**	**7.8**	**0.6**	**0.5**
		2015-2016 season		
K_2O added at a rate of 400 g per tree	48.7	46.3	5.1	4.4
K_2O added at a rate of 200 g per tree	38.9	38.7	4.6	3.9
K_2O added at a rate of 100 g per tree	37.0	37.3	4.5	3.8
No K_2O added (control)	32.9	33.7	4.4	3.7
LSD at 0.05	**6.5**	**9.5**	**0.6**	**0.3**

Table 3. Effect of potassium fertilizer on fruit chemical properties.

Treatments	Acidity %	TSS %	Reducing sugars %	Non-R. sugars %	Total sugars %	Moisture content %
			2014-2015 seasons			
K_2O added at a rate of 400 g per tree	0.128	23.2	18.3	3.7	22.0	81.7
K_2O added at a rate of 200 g per tree	0.128	22.9	15.2	6.2	21.4	76.5
K_2O added at a rate of 100 g per tree	0.141	22.8	16.9	3.7	20.6	74.1
No K_2O added (control)	0.205	20.8	15.5	3.7	20.1	64.3
LSD at 0.05	**0.05**	**2.2**	**Ns**	**ns**	**1.6**	**8.3**
			2015-2016 season			
K_2O added at a rate of 400 g per tree	0.230	25.2	18.8	4.2	23.0	
K_2O added at a rate of 200 g per tree	0.256	24.0	15.3	5.5	20.8	72.0
K_2O added at a rate of 100 g per tree	0.269	23.1	15.6	5.1	20.7	73.1
No K_2O added (control)	0.281	21.8	16.0	4.4	20.4	65.7
LSD at 0.05	**ns**	**1.12**	**1.6**	**1.8**	**1.3**	**9.4**

Total soluble solids (%): Treatment with potassium fertilizer showed a significant effect on total soluble solids percentage (TSS) (Table 3). Treatment with K_2O at a rate of 400 g per tree followed by a rate of 200 g per tree led to higher values of TSS than the control and treatment at 100 g per tree in the two seasons.

Sugar content (%)

Reducing sugars (%): Potassium fertilization increased the percentage of reducing sugars in the fruits in the second season. The highest increase in reducing sugars of the fruits was obtained by application of K_2O at a rate of 400 g per tree (Table 3). The reducing sugars were negatively affected by different potassium treatments in the first season.

Non-reducing sugars (%): Non-reducing sugars present in fruits were positively affected by potassium treatments in the second season (Table 3). It was observed that the addition of K_2O at a rate of 200 g per tree followed by a rate of 100 g per tree produced the highest values for non-reducing sugars. However, non-reducing sugar content was not significantly affected by any potassium treatment in the first season.

Total sugars (%): A rate of 400 g per tree of K_2O increased the total sugars compared to the control and other treatments in the first and second seasons (Table 2).

Moisture content (%): Addition of potassium fertilizer increased the moisture content of fruits in both the seasons. Moisture content was highest in fruits obtained from trees supplied with 400 g per tree K_2O compared to the control and other concentrations of K_2O (Table 3).

Effect of potassium fertilization treatments on the leaf mineral content: The results of the effect of potassium fertilization on leaf mineral content of fig in the two seasons are presented in Table 4.

Leaf nitrogen content (%): The results of both seasons showed that the nitrogen content increased with increasing level of fertilizer application in the two seasons. Treatments with K_2O at a rate of 400 g per tree led to the highest nitrogen concentration in leaf in both the seasons compared to the control and other K_2O treatments.

Leaf phosphorus content (%): Phosphorus concentration in leaf decreased as the level of potassium fertilization increased with highest values of phosphorus content associated with trees provided with K_2O at a rate of 100 g per tree followed by application at the rate of 200 g per tree, in both seasons.

Leaf potassium content (%): Potassium fertilization improved the concentration of potassium in leaves of the fig tree. An application rate of 400 g per tree followed by an application rate of 200 g per tree led to higher values of potassium percentage than the control and K_2O application rate of 100 g per tree, in the two seasons.

Table 4. Effect of potassium fertilization on leaf mineral content.

Treatments	N %	P %	K %
2015-2016 seasons			
K_2O added at a rate of 400 g per tree	1.50	0.22	0.86
K_2O added at a rate of 200 g per tree	1.25	0.25	0.74
K_2O added at a rate of 100 g per tree	1.15	0.27	0.65
No K_2O added (control)	1.11	0.17	0.61
LSD at 0.05	**0.06**	**0.19**	**0.026**
2015-2016 seasons			
K_2O added at a rate of 400 g per tree	1.58	0.25	0.98
K_2O added at a rate of 200 g per tree	1.34	0.27	0.77
K_2O added at a rate of 100 g per tree	1.19	0.30	0.70
No K_2O added (control)	1.15	0.22	0.64
LSD at 0.05	**0.09**	**0.03**	**0.02**

Discussion

The aim of this study was to investigate the effects of potassium fertilization on the fruit quality of the fig cultivated in Riyadh. The results of this study illustrate that the improvement in physical properties of fruits was significantly affected by treatment with potassium fertilization in both the seasons. Adding K_2O at a rate of 400 g per tree led to the highest fruit quality followed by application rate of 200 g per tree. The results are in agreement with those reported by Al-Juburi *et al.,* (1996), El-Hammady *et al.,* (1994), Kassem 2012, Kassem *et al.,* (1997), Abdalla *et al.,* (1987), and El-Hammady *et al.,* (1987), who reported that potassium fertilization increased the weight, volume, and dimensions of the fruit. Ganeshamurthy *et al.,* (2011) found that high concentrations of K are needed to achieve highest total fruit production of grapes and bananas of good keeping quality and those suitable for marketing. Potassium (K) plays an active role in the swelling and expansion of cells and has a close relationship with water. More than one study showed a beneficial effect of K supplementation on the volume of fruits and the thickness of the crust in citrus (Mattos *et al.,* 2005). In addition, potassium plays an important role in maintaining the pH of soil, osmotic regulation, synthesis of protein, the movement of stomata, the process of photosynthesis, and the extension of cells (Läuchli and Pflüger, 1978).

In addition, the fruit quality (total acidity, total soluble solids, non-reducing sugars, reducing sugars, total sugars, and content of fruits of moisture) was positively affected by treatments used in this study. It was evident that the greatest improvement in fruit quality parameters was achieved upon addition of K_2O at rate of 400 g per tree compared to the control and other K_2O concentrations used in this trial. These findings are supported by those of Hussein & Hussein (1972), Abdalla *et al.,* (1987), El-Hammady *et al.,* (1987&1994), and Kassem *et al.,* (1997). Ganeshamurthy *et al.,* (2011) found that the use of potassium as a fertilizer lead to increased juice and vitamin C content in bananas and grapes. It also helped match the shape of fruits and achieve early maturity and imparted resistance to bruises, scratches, or physical collapse during transport and storage of bananas and grapes. Pacheco *et al.,* (2008), recorded that the acidity and soluble solid content of the kiwifruit were not affected by potassium supplementation although the thickness of the flesh was less.

El-Makhtoun *et al.,* (1997), Bamiftah. (2000), Harhash (2000), Soliman & Shaban (2006), Harhash & Abdel-Nasser (2008), Harhash & Abdel-Nasser (2010), Osman (2010), Hend (2011), Al-Obeed *et al.,* (2013), and Ibrahim *et al.,* (2013), found that potassium fertilization improved the quality of fruits and yield in the cultivars studied.

Al-Moshileh & Al-Rayes (2004) noted that using potassium fertilizer at high levels increased the yield of seedless grape vines. The percentage of soluble solids in the juice increased with increasing levels of K while the acidity of the fruit juice decreased compared to the control.

Leaf nutrient content was positively affected with K treatments in the two seasons. Treatments with K_2O at a rate of 400 g per tree followed by K_2O at a rate of 200 g per tree increased N and K percentage in leaves to a greater extent than that achieved by treatment with 100 g per tree K_2O and the control.

These results are in line with those reported by Al-Moshileh and Al-Rayes indicating that there is a close relationship between the NPK content of the leaves and the doses of K fertilizer used.

When the rate of potassium is increased in summer months, leaf content of N, P, and K increases. This may be attributed to the high temperatures causing increased evaporation, leading to increased concentration of the elements in the leaves. Nitrogen concentrations in the leaves also increased with increased potassium doses, possibly due to photosynthesis activity in the summer and senescence at the end of the season. Similar findings were reported by Hunter *et al.,* (1994) and Patel & Chadha (2002).

Treatment with K_2O at a rate of 100 g per tree followed by K_2O treatment at a rate of 200 g per tree led to higher values of phosphorus percentage than the control and K_2O treatment at 400 g per tree. These results are in line with those reported by Soliman & Osman (2003) in date palm who found that the phosphorus concentration in leaves decreased as the level of N and K fertilization increased.

In conclusion, potassium fertilization treatment in the form of K_2O applied at a rate of 400 g per tree was the most effective fertilization treatments for fig under cultivation in Riyadh. It brought about the greatest improvement in the physical and chemical quality of fruits by increasing the weight, size, and dimensions of the fruit, as well as the total sugars, reducing and non-reducing sugars, total soluble solids, and leaf mineral content, compared to the control and the other concentrations of K_2O used.

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