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Effect of Foliar Spraying with Different Sources of Potassium on Growth, Leaf Mineral Composition, Yield and Fruit Quality of Picual Olive Trees.

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THIS study was conducted during the 2018/2019 and 2019/2020 seasons on 12- year- old Picual olive trees grown in a private orchard located 182 kilometers south of Cairo on the Western Desert Road in Minia Governorate, and aimed to investigate the effect of foliar sprays with different potassium sources on growth, leaf mineral composition, yield and fruit quality. Foliar application potassium sources such as; potassium sulfate, potassium nitrate, potassium citrate and monopotassium phosphate were applied at 1.5 % and 3 % . Spraying is carried out three times immediately after the final fruit set (May), after hardening of the pit (first week of August) and after harvesting (October). The results showed that using the studied foliar potassium sources significantly improved vegetative growth, leaf mineral composition, fruit set, yield and fruit quality of Picual olive trees in comparison with control trees. Spraying of potassium nitrate at 3 % achieved the best results in terms of vegetative growth (shoot length - number of new laterals / shoot - number of leaves - leaf area) followed by spraying with potassium citrate at 3% in both seasons. As for leaf mineral content, nitrogen and potassium percentages were increased as a result of foliar application with potassium nitrate at 3 %. Picual olive trees were sprayed with potassium nitrate and potassium citrate at 3 % had the highest values in the flowering characteristics. Yield and fruit quality were significantly affected and the highest values were achieved in Picual olive trees sprayed with potassium nitrate at 3% followed by potassium citrate at 3% in both seasons.

Keywords: Potassium sources, Olive, Picual, Yield, Quality, Foliar application.

Introduction

Olives (*Olea europaea* L.) belongs to the family (Oleaceae) and is an old tree that has been cultivated for decades in the Mediterranean region producing more than 90% of the world production. The total acreage of olive in Egypt reached about 245142 feds. during the 2019 season producing about 981451 tons with an average of 4.7 tons / feddan according to the Ministry of Agriculture and Land Reclamation 2019. Olives comprise many cultivars that are used for both pickling and oil extraction. Olive fruits are commercially valuable for their edible flesh and their oil content. Fruit size, pulp to stone ratio, flesh texture, oil content and chemical composition are important features for evaluating table olives. Olive oil is an important source for fatty acids, vitamins and antioxidants. Its quality is evaluated according to flavor, color and aroma in addition to its' chemical characteristics. Importance of olive oil is due to its beneficial effects on human health, dedicated primarily to the high content of monounsaturated fatty acids, such as oleic acid in addition to lower content of linoleic acid linoleic acid, improving the stability of oil oxidation (Simoes et al., 2002 and Morales-Sillero et al., 2007). Fruit components are formed during the growth and ripening and are influenced by cultivar, climate and horticultural practices as, fertilization (Thanaa Mahmoud et al., 2017).

Picual olive cultivar is one of the olive cvs. grown in Egypt and is used as oil and table olives, it has some production problems, especially in newly reclaimed soils, such as low productivity and poor fruit properties due to malnutrition in terms of doses and methods of application

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(Desouky et al., 2009 and Gowda et al., 2011). Mineral nutrition is one of the main tools for improving fruit yield and quality (Tagliavini and Marangoni, 2002). It is well known that spraying fruit trees with nutrients improved vegetative growth, flowering and correction of deficiency symptoms reflects on the quality of the fruits (Josan et al., 1995 and Dalal et al., 2017).

Potassium is an essential element in fruit trees because it is a mineral osmosis plays an important factor in osmotic and pressure regulator, so potassium plays an important role in cell enlargement, plant growth and finally the opening and closing of leaf stomata (Shabala, 2003). When irrigation water is scarce or in areas of low rainfall, foliar spraying of potassium is important to compensate for the lack of potassium absorption by roots from the soil (Elloumi et al., 2009).

Potassium activates enzymes for photosynthetic, protein synthesis, oxidative metabolism and electrical charge balancing of plant cell membranes (Shabala, 2003). It is well known that Potassium has a positive effect on flowering (Fabbri and Benelli, 2000) and promotes the formation of amino acids that stimulate the formation of Indole Acetic Acid oxidase (IAA) which stimulates the induction of flowering (Gonzalez-Garcia et al., 1972 and Mazuelos et al., 1983). Potassium has an important role in the yield and quality of olives in addition to, it's easy absorption and distribution through leaf tissues which improved growth (Arquero, et al., 2006). Using potassium nitrate as the foliar application has a positive effects on the growth , yield and fruit quality of olives (Gonzalez-Garcia et al., 1972 and Mazuelos et al., 1983). Olives are one of the fruit trees that require high amounts of potassium, their fruits are rich in potassium (Fernandez-Escobar, et al., 2004 and Hegazi et al.,2011) reported that foliar application of potassium nitrate on Picual olive trees, improved vegetative growth, nutritional status, yield, fruit quality and flesh oil content. Beneficial effects of potassium on growth, productivity and fruit quality are due to its vital role in stimulating cell division and elongation as well as biosynthesis and transport of organic compounds that promote tree growth and fruiting (Nijjar, 1985).

The effects of different potassium sources on yield and fruit quality of fruit trees varied according to methods, frequency of application and rates in addition to fruit species and phenological stages (Awad et al., 2014, El-rahman & Mohamed, 2016 and Shen et al., 2016) However, there are no previous reports that compared effects of varies sources of potassium applied on different phenological stages to olives. Therefore, the current study was conducted to find out the effect of foliar applications of various potassium sources on the growth, yield and quality of fruits of Picual olive trees grown under the Western desert Minia Governorate conditions.

Materials and Methods

This study was conducted during two successive seasons 2018/2019 and 2019/2020 in a private orchard located 182 km. south of Cairo on the Western Desert Road in Minia Governorate, Egypt, trees used for the current investigation were on a 12 - years old olive trees cv. Picual. They were planted at 5 x 5 meters, in sandy soil and irrigated with a drip irrigation system (four dippers/tree). Well water of 2700 ppm was used for irrigation.

Experimental trees were selected at the beginning of the first season after harvesting in October 2018 to carried out the treatments during the two seasons. The selected trees were to be nearly uniform, in growth vigor, free from pathological and physiological disorders and all received the same farm management (irrigation, weed, pests and disease control usually applied in the orchard except for the foliar application of potassium sources). The experiment was set in a complete randomized block design with three replicates, one tree each. Four sources of potassium K were used as foliar application at two application rates of 1.5 and 3 % each. Spraying was carried out three times immediately after harvesting (October), after the final fruit set (May) and after hardening of the pit (first week of August).

Treatments (T)

T1: Control (spraying trees with water).
T2: Spraying trees with potassium sulphate K_2So_4 at 1.5 %.
T3: Spraying trees with potassium sulphate K_2So_4 at 3 %.
T4: Spraying trees with potassium nitrate KNo_3 at 1.5 % .
T5: Spraying trees with potassium nitrate KNo_3 at 3 %.
T6: Spraying trees with potassium citrate $K_3C_6H_5O_7$ at 1.5 %.
T7: Spraying trees with potassium citrate $K_3C_6H_5O_7$ at 3 %.

TABLE 1. Some physical and chemical properties of soil samples in the experimental orchard.

Character	value	Character	value
Particle size distribution %			
Clay	8.2	EC (mm/cm)	5.2
Silt	6.6	pH	7.9
Sand	85.2	organic matter%	0.66
Texture	sandy	CaCo3	11.4
Soluble cations mq/100g soil		Soluble anions mq/100g soil	
Ca^{2+}	0.43	Co3	--
Mg2+	0.19	Hco3	0.81
Na+	0.20	Cl	0.55
K+	0.10	So4	0.19
Available macronutrients %		Available micronutrients ppm	
N	0.46	Fe	1.02
P	0.13	Zn	1.10
K	0.39	Mn	1.59

T8: Spraying trees with monopotassium phosphate KH_2Po_4 at 1.5 %
T9: Spraying trees with monopotassium phosphate KH_2Po_4 at 3 %.

In early March of each study season, twenty shoots (one year old) were randomly selected and labelled, five shoots in each direction for the following measurement:

Vegetative growth

The following characteristics were measured at the end of each growing season during the first week of September:

- Shoots lengths (cm).
- Number of new shoots /twig
- Number of leaves /shoot
- Leaf area (cm2) according to the following equilibration = 0.53 (length× width) ١،٦٦+. (Ahmed and Morsy,1999)

Leaf mineral composition:

At the end of each growing season during the first week of September of each season, leaf samples were taken from the middle of the shoot (Piper, 1950), washed and dried at 70°C to constant weight. The finely ground sample as the known weight of the dry weight of leaves was digested for determination of the nitrogen, potassium and phosphorus in percentage using an acid mixture consisting of perchloric and sulfuric acids in the ratio of 4:1 (v/v) as follows:

Nitrogen was determined by the Microkjeldahl method (Pregl, 1945).

Phosphorous was estimated by the method of Murphy and Riely (1962).

Potassium was determined by flame- photometer according to Brown and Lilleland (1946).

Flowering characteristics

Inflorescence length (cm): was estimated as the average of thirty inflorescences for each replicate.

Flowering Density (as the number of inflorescences per meter): the average number of inflorescences per shoot was recorded and calculated per meter.

Flowering density = No. of inflorescences X 100/shoot length (cm)

Total number of flowers /inflorescence: A sample of twenty inflorescences for each tree was used and the total number of flowers for each inflorescence was counted.

Percentage of perfect flowers / inflorescence: Twenty inflorescences from each tree were collected from the middle parts of shoots in the ballon stage. The number of perfect and total flowers on each inflorescence were recorded and % of perfect flowers was calculated (Mofeed, 2002).

The perfect flowers (%) = No. of perfect flowers/ No. of total flowersx100

Sex ratio

The ratio of perfect flowers to male flowers was calculated for every replicate (El-Sharony, 2007).

Fruit set and yield

Fruit set Percentage: the percentage of the initial fruit set was calculated after 21 days from full bloom and the final fruit set percentage was calculated after 60 days from full bloom (Mofeed, 2002).

Fruit set (%) =No. of fruits/No. of total flowers x100

Yield

Average yield per tree was calculated from each treatment as Kg/tree.

Fruit quality

Fifty fruits per tree were randomly harvested and used to determine the following physical characteristics: Fruit Dimensions (Fruit Length(cm), Fruit Diameter (cm) and Fruit Shape (L/D) - Fruit weight (g) – flesh weight and seed weight (g) – flesh / fruit weight ratio – fruit moisture content % according to A.O.A.C 1995.

Flesh/fruit weight (%) =Flesh weight (g)/Fruit weight X 100

Fruit oil content (%) as a dry weight was determined according to A.O.A.C. (1995) method by extracting the oil from the dried fruits with Soxhlet apparatus using petroleum ether at 60-80^{0} C of boiling point.

Statistical Analysis

The obtained data were subjected to analysis of variance (ANOVA) using the MSTAT program according to (Snedecor and Cochran 1982). Differences between treatments were compared according to Duncan 1955 at a probability of 5%.

Results and Discussion

Vegetative growth measurements

Data in Table (2) show the effect of foliar applications of some potassium salts namely; potassium sulphate, potassium nitrate, potassium citrate and mono potassium phosphate on some growth parameters such as, shoot length, number of new laterals /shoot, number of leaves per shoot and leaf area of Picual olive trees in the 2018/2019 and 2019/2020 seasons. Compared with control, treated trees attained higher values of tested parameters. Highest values were recorded by foliar application of KNo_3 at 3 % in both seasons. Hence, the highest values of shoot length (30.97 and 35.12 cm), number of new laterals / shoot (8.87 and 10.30), number of leaves/shoot (34.23 and 36.30) and leaf area (5.50 and 5.70 cm^2) were obtained by trees that were sprayed potassium nitrate (KNo_3) at 3 % in both seasons, respectively. Trees sprayed with potassium citrate and mono- potassium phosphate followed in this respect. The lowest values were recorded by the control trees. This increase in the resulting growth parameters can enhance the ability of the leaf photosynthetic capacity, as mentioned by Bongi and Palliotti (1994), which results in more assimilates for fruit growth. The promotion of vegetative growth of Picual olive trees can be

TABLE 2. Effect of foliar application with various potassium sources on some vegetative growth parameters of Picual olive trees in 2018/2019 and 2019/2020 seasons.

Treatments	(Shoot length (cm		Number of new laterals / shoot		Number of leaves / shoot		Leaf area (cm^2)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Control	25.30 E	26.79 G	4.47 E	4.93 D	18.53 F	20.87 F	4.10 E	4.23 E
K- sulphate at 1.5 %	26.13 E	27.81 F	6.23 CD	6.83 BC	22.2CDE	23.60 DE	4.63 CD	5.00 BCD
K- sulphate at 3%	27.25 D	30.41 E	6.83 BC	7.87 ABC	23.7CDE	33.00 B	5.23 AB	5.17 ABC
K- nitrate at 1.5 %	28.19 CD	33.90 C	7.60 B	8.20 AB	21.87 DE	28.17 C	4.67 CD	5.33 ABC
K- nitrate at 3%	30.97 A	35.12 A	8.87 A	8.77 A	34.23 A	36.30 A	5.50 A	5.70 A
K- citrate at 1.5 %	27.34 D	30.00 E	6.97 BC	7.83 ABC	24.33 CD	28.30 C	4.30 DE	4.70 D
K- citrate at 3 %	29.77 B	34.81 AB	7.37 B	8.33 AB	28.60 B	33.57 B	5.47 A	5.30 ABC
Mono K- phosphate at 1.5%	28.11 CD	33.15 D	5.60 D	6.40 CD	20.60 EF	22.33 EF	4.60 CD	4.97 CD
Mono K- phosphate at 3%	29.00 BC	34.11 BC	6.50 C	7.24 ABC	25.23 C	25.53 D	4.90 BC	5.53 AB

Values within each column followed by different letters are significant at $p < 0.05$ according to Duncan's multiple range tests.

attributed to the physiological role of potassium in carbohydrate formation which is translocation and accumulation within the plant organs and the turgor pressure of plant cells. (Meyer and Anderson, 1970). Potassium also contributes to the growth of meristematic cells, cell enlargement and the stimulation of the young tissue (Mengel and Kirkby, 1987). In addition to the synergistic affect between K and indole acetic acid (IAA) and the enhancement of K on the effect of gibberellic acid and cytokinins on plant growth Cocucci, and Rosa, 1980.The effect of K in increasing the growth of the olive tree was confirmed by Hussein (2008), Hegazi et al. (2011), Gowda et al. (2011) and Thanaa Mahmoud et al. (2017).

Leaf mineral composition

The results presented in Table (3) demonstrate the effect of K – forms on leaf N, P and K contents of Picual olive trees during the two seasons of study. Leaf nitrogen content was significantly affected with foliar application of various potassium sources in both studied seasons. Trees that were sprayed with potassium nitrate at 3 % had significantly the highest N content in leaves (1.157 and 1.260 %) in both seasons. Regarding leaf potassium content, results show significant effects for potassium foliar applications on leaf potassium content. The highest percentage of potassium in leaves was in trees sprayed with potassium nitrate at 3 % (0.760 and 0.753) in 2018/2019 and 2019/2020 seasons, respectively. Leaf phosphorus content wasn't significant in both seasons by conducted treatments. The lowest values of leaf N and K contents were recorded by control trees in both seasons. These results are following with the results by Dikmelik et al. (1999) and Hegazi et al. (2011) on olives Also, Calvert (1969) and El-Darier (1991), suggested that spraying KNO_3 or K_2SO_4 is more effective in increasing potassium content of leaves in Balady Mandarin. In addition to Sarrwy et al. (2012) reported the highest K leaf content in Balady mandarin trees sprayed with KNO_3.

Flowering characteristics

Table (4) shows the effect of the studied treatments on the flowering characteristics of Picual olive trees in the 2018/2019 and 2019/2020 seasons. Significant variations were observed among all evaluated treatments. As a general trend, trees sprayed with any of the potassium treatments had a more pronounced effect than control with respect to the studied flowering parameters.

Regarding the length of inflorescences, data in Table (4) reveal that trees treated with foliar potassium nitrate at 3 % showed the longest of inflorescences (2.81 and 2.88 cm) followed by the potassium citrate treatment(2.76 and 2.83 cm) in both studied seasons, respectively with insignificant differences. Control trees showed the lowest values in this respect. Concerning

TABLE 3 . Effect of foliar application with various potassium sources on leaf mineral composition (nitrogen, phosphorus and potassium) of Picual olive trees in 2018/2019 and 2019/2020 seasons.

Treatments	N %		%P		% K	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Control	0.613 E	0.737 C	0.30 A	0.34A	0.603 DE	0.637 D
K- sulphate at 1.5 %	0.887 D	0.803 BC	0.32 A	0.35A	0.667 BC	0.660 CD
K- sulphate at 3%	1.027 B	1.137ABC	0.34 A	0.37 A	0.70 ABC	0.72ABC
K- nitrate at 1.5 %	1.067 AB	1.183 AB	0.31A	0.34A	0.653 CD	0.68BCD
K- nitrate at 3%	1.157 A	1.260 A	0.31 A	0.37 A	0.760 A	0.753A
K- citrate at 1.5 %	0.833 D	1.10ABC	0.32A	0.34 A	0.570 E	0.69ABC
K- citrate at 3 %	1.010 BC	1.254 A	0.33A	0.38A	0.660 CD	0.727 AB
Mono K- phosphate at1.5%	0.897 D	0.98ABC	0.31A	0.36A	0.653 CD	0.637 D
Mono K- phosphate at3%	0.923 CD	1.14ABC	0.36A	0.39A	0.727 AB	0.717ABC

Values within each column followed by different letters are significant at $p < 0.05$ according to Duncan's multiple range tests.

the flowering density, the highest values were attained by trees treated with mono- potassium phosphate at 3 % (57.45 and 59.54) followed by trees applied with potassium nitrate at 3 % (54.05 and 57.63) with significant differences. Control trees had the lowest values (44.15 and 45.73) in 2018/2019 and 2019/2020 seasons, respectively.

As for the total number of flowers / inflorescences, Table (4) show also that in general K- sources application significantly increased the number of total flowers/inflorescences in both seasons compared with control trees. Whereas the highest number of total flowers / inflorescences of 13.58 and 14.87 were recorded with foliar application of mono potassium phosphate at 3 % in 2018/2019 and 2019/2020 seasons, respectively.

Concerning the perfect flowers percentage, data in Table (4) reveal that the perfect flowers % was significantly increased with all K- forms foliar application in comparison with the untreated trees which showed the lowest values in both seasons. The trees treated with the potassium nitrate at 3 % gave the highest perfect flower percentages (55.46 and 60.41) followed by potassium citrate at 3 % (53.68 and 58.85) with insignificant differences. while the least value was detected in the control trees (45.98 and 46.77) in both seasons, respectively.

The effect of foliar spray treatments on the percentage of the sex expression ratio is illustrated in Table (4). It is observed that the trees treated with potassium nitrate at 3 % had the highest sex ratio of 2.93 and 3.94 % in the 2018/2019 and 2019/2020 seasons, respectively followed by trees treated with potassium citrate and monopotassium phosphate at 3% while the untreated trees gave the lowest values. The stimulation effect of the potassium nutrients caused an improvement in flowering parameters and photosynthesis which certainly reflected positively on both vegetative growth and flowering characteristics, and this effect may be attributed to the role of potassium which is important for carbon dioxide uptake and general photosynthetic capacity of olive trees (Erel et al., 2014 and Erel et al., 2015). Under higher K availability, higher levels of starch were found in growing olive trees (Erel et al., 2014).

Fruit set and yield

Table (5) shows the effect of the K- sources foliar application treatments on fruit set and yield of Picual olive trees in the 2018/2019 and 2019/2020 seasons. Significant responses were among the studied treatments as compared with the control trees. Concerning initial and final percentage, presented data indicated that trees treated with potassium nitrate attained the highest percentages amounting to (11.98 and 12.61 &

TABLE 4. Effect of foliar application with various potassium sources on some flowering parameters of Picual olive trees in 2018/2019 and 2019/2020 seasons.

Treatments	Inflorescence Length (cm)		Flowering density		Total Number of flowers/ .infl		Perfect flowers(%)		Sex Ratio	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Control	2.43 E	2.52 E	44.15F	45.73 G	10.51 D	11.05 F	45.98 D	46.77 D	0.71 E	0.82E
K- sulphate at 1.5 %	2.53 DE	2.63D	46.71 E	48.58 E	12.2BC	12.71 D	47.9CD	55.65 C	2.34D	2.91C
K- sulphate at 3%	2.70 BC	2.72C	51.48 C	55.30 C	13.0AB	14.4AB	52.42 B	57.85 B	2.49BC	3.15B
K- nitrate at 1.5 %	2.67 BC	2.73C	48.53 D	52.54 D	12.6BC	13.26 C	48.96 C	57.48 B	2.58BC	2.87C
K- nitrate at 3%	2.81A	2.88A	54.05 B	57.63 B	13.1AB	14.03 B	55.46 A	60.41 A	2.93A	3.94A
K- citrate at 1.5 %	2.56D	2.63D	46.56 E	46.8FG	10.62 D	11.89 E	47.2CD	54.54 C	2.38CD	2.55D
K- citrate at 3 %	2.76AB	2.83 B	55.38 B	56.09 C	12.76AB	13.90 B	53.68AB	58.85AB	2.66B	3.79A
Mono K- phosphate at 1.5%	2.60 D	2.68 D	45.70 F	47.27 F	11.94 C	12.4DE	49.07 C	55.64 C	1.71B	2.47D
Mono K- phosphate at 3 %	2.66BC	2.80 B	57.45 A	59.54 A	13.58 A	14.87 A	52.61 B	58.33 B	2.59BC	3.21B

Values within each column followed by different letters are significant at $p < 0.05$ according to Duncan's multiple range tests.

2.82 and 2.88 %) for initial & final fruit set in 2018/2019 and 2019/2020 seasons, respectively. Meanwhile, the untreated trees had the lowest values in both seasons. As for fruit weight its values ranged from (6.11 to 7.88) in the first season and from (5.87 to 7.47) in the second one. The highest values were attained by potassium nitrate KNO3 at 3% followed by potassium nitrate at 1.5% with insignificant differences between them. Regarding yield (kg / tree) both potassium nitrate at 3% and potassium citrate at 3% resulted in significantly the highest yield was amounting to (18.11 and 29.92) and (17.72 and 29.47) respectively while the lowest yield was (14.08 and 23.91) for control trees in 2018/2019 & 2019/2020 seasons, respectively. The improvement in yield of Picual olive trees was associated with the increase in fruit weight as a result of applying potassium sources. The positive effect of the K- sources treatments on fruit set and yield was reported in the findings of Hegazi et al., 2011and Amnon, et al., 2018/2019. Shen, et al., (2016) reported that a significant increase in pear yield was achieved by foliar application with the application of KNO3. In addition to the positive effect of potassium citrate is either due to the role of potassium in photosynthesis and osmosis regulation, allowing the import of the assimilates from the source into the fruits, which in turn leads to an increase in fruit weight, or due the role of citric acid in pathways of respiration and energy production important (ATP synthesis) for all vital reactions inside the cell (Taiz, and Zeiger, 2002) . Our results may gain support from those obtained by Arquero et al. (2006), Sarrwy et al. (2010), Hussein (2008), Abdel-Nasser and EL-Shazly (2001), Amnon et al. (2018/2019) on olive trees. Moreover, (Vijay et al., 2017) found that foliar application of potassium nitrate and potassium sulphate significantly enhanced the yield of 'Jaffa' sweet oranges and potassium nitrate improved fruit yield of plum trees (Jawandha et al., 2017). On 'Canino' apricot trees, the yield was increased significantly with the application of potassium citrate (Haggag et al., 2016) and application of potassium nitrate and potassium citrate (Okba et al., 2021).

Fruit quality

Fruit Dimensions (Fruit Length, Fruit Diameter and Fruit Shape)

Data presented in Table (6) show the effect of spraying with various potassium sources on fruit length, fruit diameter and fruit shape ratio of Picual olive trees in 2018/2019 and 2019/2020 seasons. Significant variations were observed among the tested treatments as compared with control trees. It was observed that fruit length and diameter were significantly affected by different treatments in both seasons. K- supply as potassium nitrate at 3% resulted in significantly the highest values following by potassium citrate at 3%, but differences were statistically in the case of fruit diameter. Meanwhile control showed the lowest values in this respect. As for fruit shape ratio results showed significant differences obtained between treatments. Highest ratio was attributed to potassium nitrate treatment at 3%

TABLE 5. Effect of foliar application with various potassium sources on fruit set, fruit weight and yield of Picual olive trees in 2018/2019 and 2019/2020 seasons.

Treatments	(%) Initial fruit set		(% Final fruit set		Fruit weight (gm)		Yield (kg / tree)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Control	8.85 G	9.51 F	1.66 G	1.87 H	6.11 E	5.87 E	14.08 E	23.91 E
K- sulphate at 1.5 %	10.29 D	10.83 DE	2.26 DE	2.44 F	7.09 CD	6.71 D	14.82 DE	24.25DE
K- sulphate at 3%	10.38 D	11.63 BCD	2.58 BC	2.67 C	AB 7.78	7.26 BC	16.65 B	26.07 C
K- nitrate at 1.5 %	10.76 C	11.15 CDE	2.35 D	2.52 E	7.5ABC	7.16 AB	16.30 B	27.19 BC
K- nitrate at 3%	11.98 A	12.61 A	2.82 A	2.88 A	7.88 A	7.47 A	18.11 A	29.92 A
K- citrate at 1.5 %	9.60 F	10.23 EF	2.18 E	2.39 F	7.42BCD	7.12 BC	14.65 DE	25.74CD
K- citrate at 3 %	11.59 B	12.23 AB	2.66 B	2.78 B	7.68 AB	7.34 AB	17.72 A	29.47 A
Mono K- phosphate at 1.5 %	9.92 E	10.58 E	1.96 F	2.23 G	7.06 D	6.84 CD	15.10CD	27.22 BC
Mono K- phosphate at 3 %	10.71 C	11.98 BC	2.52 C	2.58 D	7.64 AB	7.15 BC	16.00BC	28.54AB

Values within each column followed by different letters are significant at $p < 0.05$ according to Duncan's multiple range tests.

whereas, lowest ratio was due to control. The present findings are in line with those attained by Inglese et al. (2002), Elloumi et al. (2009), Hegazi et al. (2011) and Thanaa Mahmoud et al. (2017). The maximum size of apricot fruits were produced from trees treated with potassium nitrate, followed by potassium citrate (Okba et al., 2021).

The flesh weight, seed weight, flesh / fruit percentage

Data in Table (7) show that conducted treatments significantly increased the considered parameters. The highest flesh weight and seed weight (6.56 & 6.19 and 1.32 &1.28) were achieved with spraying trees K- supply as potassium nitrate KNO3 at 3 % followed descending order by potassium citrate at 3 % (6.38 & 6.03 and 1.30 &1.31) and the differences between them weren't significant in 2018/2019 & 2019/2020 seasons, respectively. Control showed the least values in this respect in both seasons.

Regarding flesh/ fruit weight percent, foliar application with potassium nitrate KNO3 at 3% was superior in this respect and resulted in the highest flesh/ fruit of 83.25 and 82.85 % as compared with control trees which showed the lowest values (80.03 and 79.40 %) in the first and second seasons, respectively. These results are in harmony with those obtained by Hegazi et al. (2011), Thanaa Mahmoud et al. (2017). Foliar application of KNO, during the second and third stages of olive growth improved fresh weight and flesh to pit ratio (Inglese et al., 2002). These results were achieved as a result of foliar fertilization with potassium which improved yield and quality as well as fruit weight and flesh to pit ratio of olives (Ben-Mimoum et al., 2004).

Fruit moisture and oil content

Fruit moisture and oil content percentage in dry weight of Picual olive trees treated with K- forms under study were significantly affected and the differences among treatments were significant in both seasons. Data presented in Table (7) reveal that control treatment attained the highest fruit moisture content (69.43 and 70.12 %) whereas the lowest fruit moisture was in fruits of treatment that applied with potassium nitrate at 3 % (56.89 and 55.11 %) in both seasons, respectively.

Concerning the oil percentage in fruit dry weight of Picual olive cv., it ranged from (29.89 to 37.41%) in the first season and from (31.00 to 41.88 %) in the second season. Data in table (7) show that K- sources foliar application significantly affected fruit oil content and the highest content was in that trees treated with potassium citrate at 3 % (37.41 and 41.88 %) and potassium sulphate at 3 % (35.26 and 41.19 %) followed by that treatment applied with potassium nitrate at 3 % (34.49 and 39.75 %) while control treatment gave the lowest fruit oil content (29.89 and 31.00 %) 2018/2019 and 2019/2020 seasons, respectively. These observations agree with the findings of Hegazi et al. (2011), Sarrwy et al. (2010) concluded that foliar spraying with 3 % potassium nitrate increases yield and fruit quality as well as fruit oil content of olive trees.

TABLE 6. Effect of foliar application with various potassium sources on fruit dimensions, fruit length(cm), fruit diameter (cm) and fruit shape

Treatments	(Fruit shape index (L/D		Fruit diameter (cm)		Fruit length (cm)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Control	2.49 F	2.52 F	2.18 F	2.16	1.14E	1.17E
K- sulphate at 1.5 %	2.64 E	2.67 E	2.23 F	2.25 E	1.18 C	1.19 E
K- sulphate at 3 %	2.86 BC	2.90 BC	2.36 C	2.41 AB	1.21 AB	1.22 DE
K- nitrate at 1.5 %	2.72D	2.89 BC	2.41AB	2.34 CD	1.20 B	1.24 BC
K- nitrate at 3 %	2.96 A	3.05 A	2.43 A	2.45 A	1.22 A	1.25 AB
K- citrate at 1.5 %	2.62 E	2.73 D	2.27DE	2.28 DE	1.15 DE	1.20 A
K- citrate at 3 %	2.90 B	2.93 B	2.42 A	2.40ABC	1.17 CD	1.21 CD
Mono K- phosphate at 1.5 %	2.67 DE	2.74 D	2.31CD	2.30 DE	1.16 CD	1.19 CD
Mono K- phosphate at 3%	2.83 C	2.85 C	2.32CD	2.37 BC	1.17 CD	1.20 DE

index (L/D) of Picual olive trees in 2018/2019 and 2019/2020 seasons.

Values within each column followed by different letters are significant at $p < 0.05$ according to Duncan's multiple range tests.

TABLE 7. Effect of foliar application with potassium sources on fruit quality of Picual olive trees in 2018/2019 and 2019/2020 seasons

Treatments	Flesh weight(gm)		Flesh/fruits %		Seed weight (gm)		Fruit moisture content %		Oil content %	
	2018/2019	2018/2019	2018/2019	2018/2019	2018/2019	2018/2019	2018/2019	2018/2019	2018/2019	2018/2019
Control	4.89 F	4.66 E	80.03E	79.40E	1.22 C	1.21 D	69.43A	70.12A	29.89E	31.00 F
K- sulphate at 1.5 %	5.82 E	5.49 D	82.09 D	81.82D	1.27ABC	1.22 CD	61.02B	61.84B	32.69CD	38.50CD
K- sulphate at 3 %	6.45AB	6.02 AB	82.91 B	82.92 A	1.33 A	1.24BCD	61.39B	63.18B	35.26 B	41.19AB
K- nitrate at 1.5 %	6.18CD	5.88 BC	82.40 C	82.12 C	1.32 AB	1.28 ABC	60.01 BC	57.82 DE	35.19 B	39.15 C
K- nitrate at 3 %	6.56 A	6.19 A	83.25 A	82.85 A	1.32 AB	1.28 ABC	56.89 C	55.11 E	34.49 BC	39.75 BC
K- citrate at 1.5 %	6.12 D	5.82 C	82.50 C	81.74D	1.30 ABC	1.30 AB	60.87 B	58.92 CD	29.90 E	36.88 DE
K- citrate at 3 %	6.38AB	6.03AB	83.07AB	82.15C	1.30 ABC	1.31 A	56.99 C	58.28 DE	37.41 A	41.88 A
Mono K- phosphate at 1.5 %	5.83 E	5.59 D	82.5 C	81.73D	1.23 BC	1.25ABCD	66.94 A	64.09 B	31.11 DE	35.84 E
Mono K- phosphate at 3%	6.34BC	5.88BC	82.98B	82.24C	1.30 ABC	1.27ABCD	68.77 A	67.37A	34.57 BC	38.66 CD

Values within each column followed by different letters are significant at $p < 0.05$ according to Duncan's multiple range tests.

Conclusion

Under similar conditions, it may be recommended that spraying potassium nitrate or potassium citrate at 3% three times immediately after harvesting (October), after the final fruit set (May), after hardening of the pit (first week of August) improving growth, leaf mineral composition, yield, fruit quality and fruit oil content of Picual olive trees.

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Conflicts of interest

The authors declares that there are no conflicts of interest related to the publication of this study.

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تأثير الرش الورقي بمصادر مختلفة من البوتاسيوم على النمو والمحتوي المعدني للاوراق والمحصول وجودة الثمار لأشجار الزيتون صنف البيكوال.

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أجريت هذه الدراسة خلال موسمين متتاليين ٢٠١٩/٢٠١٨ و ٢٠٢٠/٢٠١٩ على أشجار زيتون صنف البيكوال وعمرها ١٢ سنة مزروعة في بستان خاص يقع على بعد ١٨٢ كيلومتر جنوب القاهرة على الطريق الصحراوي الغربي بمحافظة المنيا ، وهدفت الدراسة إلى معرفة تأثير الرش الورقي بمصادر البوتاسيوم المختلفة علي النمو الخضري والمحتوي المعدني للأوراق والمحصول وجودة الثمار. وكانت مصادر البوتاسيوم المستخدمة في الرش الورقي هي: كبريتات البوتاسيوم ، نترات البوتاسيوم ، سترات البوتاسيوم ، فوسفات البوتاسيوم الأحادي وتم استخدامها رشا علي الاشجار بمعدل ١,٥٪ و ٣٪. وكان الرش ثلاث مرات بعد انتهاء عقد الثمار مباشرة (مايو) و بعد تصلب النواة (الأسبوع الأول من أغسطس) وبعد الحصاد (أكتوبر). وقد أظهرت النتائج أن استخدام الرش الورقي بمصادر البوتاسيوم تحت الدراسة أدى إلى تحسن معنوي في النمو الخضري ، والمحتوي المعدني للأوراق ، وعقد الثمار ، والمحصول وجودة ثمار أشجار الزيتون البيكوال مقارنة بالاشجار الغير معاملة. وقد حقق رش نترات البوتاسيوم بنسبة ٣٪ أفضل النتائج من حيث النمو الخضري (طول الافرع - عدد الفروع الحديثة / فرع - عدد الأوراق/ فرع - مساحة الورقة) ثم تلي ذلك الرش بسترات البوتاسيوم بنسبة ٣٪ في كلا الموسمين. أما بالنسبة للمحتوى المعدني للأوراق فقد زاد محتوي الاوراق من النيتروجين والبوتاسيوم نتيجة الرش بنترات البوتاسيوم بنسبة ٣٪. كما اعطي رش أشجار الزيتون البوتاسيوم. كما أدي الرش بنترات البوتاسيوم وسترات البوتاسيوم بمعدل ٣ ٪ أعلى القيم في خصائص التزهير. كما تأثر محصول اشجار الزيتون وكذلك جودة الثمار معنويا وسجلت أعلى القيم في الأشجار التي تم رشها بنترات البوتاسيوم بنسبة ٣٪ تليها سترات البوتاسيوم بمعدل ٣ ٪ خلال موسمين التجربة.