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Effect of Using Some Sources of Phosphorus on Flowering, Fruiting and Productivity of Olive Trees

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Abstract: This investigation was carried out through 2014 and 2015 seasons on Picual and Kalamata olive cultivars. Trees were about 12 years old, planted at 6x4 meters apart in a sandy soil, under drip irrigation system at privet orchard located at Cairo –Alexandria desert road. The investigation aimed to study of independent effects of foliar application with Mono ammonium phosphate, Mono potassium phosphate and Urea phosphate at the rate of 1% on flowering, fruit set, yield, oil content and fruit characteristics of Picual and Kalamata olive trees. Results revealed positive effects for improving flowering, fruit set, yield, fruit characters, fruit oil content and reduced the number of dropped fruits. The most effective treatment by spraying Mono potassium phosphate(twice), first in the mid of January and repeated in the mid of May that help to compensate the depletion of mineral nutrient and enhancing tree yield and fruit characters of Picual and Kalamata cultivars.

Kew words: Olive (*Olea europaea*) · Kalamata · Picual · Foliar application · Mono ammonium phosphate · Mono potassium phosphate and Urea phosphate

INTRODUCTION

Olive (*Olea europaea* L.) is a traditionally important crop grown extensively in the Mediterranean basin. World olive production perform an important role in the economies of many countries such as Spain, Italy, Greece, Turkey and Tunisia [1] .The olive tree yield has two main products: oil and table olives, produced from several cultivars such as Picual and Klamata. In Egypt, olive cultivation production considered among the major commercial fruit varieties, its ranks the fourth after citrus, mango and grapes [2, 3]. Over the last three decades the Egyptian olive agro sub- sector has seen unprecedented development, the total acreage reached 243.183 feddans in 2017 produced 874.748 tons Olive according to statistical of the Ministry of Agriculture. Egypt produced more than 13 percent of the world's table olives that making Egypt is the world's top producer of table olives but is limited by under developed post-harvest practices. Egypt's considered competitor in international markets - exported 12 percent and 11 percent of the world's table olive exports, respectively [4]. Olive trees are majority cultivated in the new reclaimed areas, most of theses areas are sandy soil, the production of olive under these areas conditions is generally low as a result of loosing Substantial amounts of nutrients from trees due to fruit removal, annual pruning of leaves and wood and natural leaf drop [5, 6]. Removed nutrients must be replaced and where natural levels in the soil are insufficient, appropriate fertilization is necessary to supply the minerals for new growth and for the following year's yield. Foliar spray is a widespread application method that provides good nutritional results and increases olive yields [7, 8]. The balance between NPK fertilizers is useful in the annual growth cycle of olive trees. Phosphorus (P) is one of the 17 necessary elements that plant needed for its genetic growth and reproduction. Olive tree requires phosphorus to promote root growth, flower bud formation, many biochemical processes as cell division, development of meristematic tissue (new growth), photosynthesis linked carbon fixation from carbon dioxide, intermediary metabolism , breakdown the carbohydrates, the utilization of sugars and starch and transfer the energy within the plant and its role in nucleic acids and activity in biological energy change via adenosine triphosphates (ATP) [9-11]. Phosphorus is considered a key to all forms of life and one of the main yield limiting factors in many arid and semi-arid regions.

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The common types of Phosphor are: potassium or ammonium salts of phosphoric acid and urea phosphate. Mono ammonium phosphate one of types of phosphor is commonly used in fertigation field practices and foliar application in many crops [12]. In constant, Mono potassium phosphate is a soluble salt of potassium hydroxide and phosphoric acid. It is used in fertigation field and it is recommended as a foliar fertilization in olive orchards growing in the dry lands due to its lower application cost compared to injecting fertilizers into soils [13, 14]. Additionally, potassium plays an important role on growth and water –use- efficiency in olive and could be useful in ameliorating a biotic stresses effect in olive plants [15, 16]. In contrast, mono Potassium Phosphate is a most effective and readily available fertilizer and fast source of P and K when applied as a foliar application. Moreover, Urea phosphate is a chemical adduct between urea and phosphoric acid molecules. Foliar application of urea is an effective method of replacing nitrogen fertilization of the soil [17]. The use of UP has resulted in early flowering and enhancing fruit yield [18].

The objective of the present work aimed to the study of independent effects of foliar application with Mono ammonium phosphate, Mono potassium phosphate and Urea phosphate on flowering, fruit set, yield and fruit characteristics of Picual and Kalamata olive trees.

MATERIALS AND METHODS

The field experiment was conducted on twelve years old of Olive cultivars (Picual and Kalamata) grown in a private orchard at 90- Kilometer from Cairo (Cairo- Alexandria desert road) during two successive seasons 2014 and 2015. The trees nearly uniform and vigor growth and planted 6 x 4 meters apart in sandy soil under drip irrigation system and received the regular horticultural practices. Selected trees were visually free from any disease symptoms. Farm fertilization (organic and mineral fertilization) was applied in winter at the beginning of November and chemical fertilization program during the growing season according to the recommendation of Ministry of Agriculture and Land Reclamation [19]. The experiment was set a factorial experiment as it included two factors (cultivar and cultural treatments).

Cultivars: Two olive cultivars "Picual and Kalamata" were subjected in this study.

Cultural Treatments: The tested cultivars were sprayed in both seasons with one of the following treatments:

- Control: Tested olive trees were sprayed with water as a control treatment.
- Mono Ammonium phosphate (MAP1) was sprayed at the rate of 1% once in the mid of January.
- Mono Ammonium phosphate (MAP2) was sprayed at the rate of 1% twice, first in the mid of January and repeated again in the mid of May.
- Mono Potassium phosphate (MKP1) was sprayed at the rate of 1% once in the mid of January.
- Mono Potassium phosphate (MKP2) was sprayed at the rate of 1% twice, first in the mid of January and repeated again in the mid of May.
- Urea- phosphate (UP1) was sprayed at the rate of 1% once in the mid of January.
- Urea- phosphate (UP2) was sprayed at the rate of 1% twice, first in the mid of January and repeated again in the mid of May.

Furthermore, Tween 20 was added at 0.1 % as a surfactant to all spray solutions including the control. Spraying process was carried out using a compression sprays (7 L. solution/tree).

The treatments were arranged in a completely randomized design with three replicates for each treatment and each replicate was represented by three trees. Moreover, the response of Picual and Kalamata trees to the tested treatments was evaluated through the following measurements:

Leaf Minerals Content: Samples were collected at the end of each growing season during second week of July, Whereas, two leaves from every shoot (4^{th} and 5th leaves) were picked as a composite from the middle portion at one year old shoot each replicate tree then mixed together as a composite and oven dried at 70ºC till constant weight, for determination the following nutrient elements (Percentage as dry weight):

Nitrogen: Using the modified micro-Kjeldahl method as lined by Pregl [20].

Phosphor: Was estimated as described by Chapman and Pratt [21].

Potassium: Was determined by using Flame photometer according to Brown and Lilleland [22].

Table 1: Characteristics of phosphorus fertilizers that used in spraying treatments

Name	MAP	MKP	U P
Formula	$NH_4H_2PO_4$	KH_2PO_4	$(NH2)_2CO•H_3PO_4$
PH (1%solution)	4.3-4.5	4.5	1.8
P_2o_5%	61	51.5	44
K_2o %	0	34	0
N-NH_2%	0	0	17.5
N-NH_4%	12	0	0
Comments	Safe to metal parts	Safe to metal parts	Avoid metal parts

MAP (Mono ammonium phosphate); MKP (Mono potassium phosphate); UP (Urea Phosphate).

Twenty shoots (one year old) were chosen and labeled for every replicate to determine the following.

Flowering Behavior

Flowering Density: Average number of inflorescence per shoot was recorded and calculated per meter.

Perfect Flowers (%): Thirty inflorescences at the balloon stage the percentage of perfect flowers to the total number of flowers were calculated.

$$\text{The perfect flowers \%} = \frac{\text{No. of perfect flowers}}{\text{Total No. of flowers}} \text{ x } 100$$

Fruiting and Yield: Fruit set (%) = The number of Fruit set on each replicate was recorded after 60 days from full bloom and fruit set percentage was calculated according to Rosa *et al.* [23] as follows:

$$\text{Fruit set (\%)} = \frac{\text{No. of developing fruitlets}}{\text{Total No. of flowers}} \text{ x } 100$$

Yield: The average yield for each individual tree was recorded at harvesting time for each cultivar from each treatment in both seasons as (kg/tree).

Fruits Physical and Chemical Characteristics: Fifty fruits per each treated trees were randomly picked in both seasons, from examined shoots for each replicate to study physical and chemical characteristics of fruit according to the following basis:

Fruit length (cm), fruit diameter (cm), fruit shape index (L|D), flesh weight, fruit weight (gm) and the stones were extracted from the selected fruits to determine the stone length (cm), stone diameter (cm) and stone weight (g), flesh/fruit ratio according to Fouad *et al.* [24]. Fruit oil percentage as a dry weight was determined according to A.O.A.C [25] method by extraction the oil from the dried fruits with soxelt fat extraction apparatus using petroleum ether 60-80°C of boiling point.

Economic Evaluation: Economic evaluation was calculated according to Heady and Dillon [26] as follows:

- Number of trees/Fadden= 175 trees - Amount of sprays/tree = 7 Litter
- Amount of sprays/Fadden in January = 7 × 175 = 1225 Litter
- Amount of sprays/Fadden in (January and May) = 2450 Litter
- Price of MAP (Kg) = 8 L.E, MKP (Kg) =13 L.E and U-P (Kg) = 8 L.E
- Cost of spraying treatments /Fadden = amount of spraying treatments (kg) /Fadden× price of spraying treatments/Fadden
- Fixed expenses (cost of the spraying unit and labor cost) =100 L.E for each spray.
- Total cost of spraying= cost of spraying treatments /Fadden + fixed expenses
- Total cost of spraying MAP1= 198 L.E and MAP2 = 396 L.E
- Total cost of spraying MKP1= 259.25 L.E and MKP2 = 518.5 L.E
- Total cost of spraying U-P1= 198 L.E and U-P2 = 396 L.E
- Total gross income =average yield of two seasons (kg)/ Fadden × price| kg
- Price/kg of Picual (4 L.E) and Price/kg of Kalamata (13 L.E)
- Average net return = total gross income- total cost of spraying.

Statistical Analysis: The obtained data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran [27] using MSTAT-C program. Least significant range (LSR) was used to compare between means of treatments according to Duncan [28] at probability of 5%.

RESULTS AND DISCUSSION

Leaf Mineral Content: Regarding to leaf nutrient content of N, P and K of Picual and Kalamata cultivars in Table (2), it could be noticed that , a positive effect of different forms of phosphorus MAP, MKP and UP on nutrition

Table 2: Effect of spraying MAP, MPK and U-P on nitrogen, phosphorus and potassium content (% dry matter) of "Picual and Kalamata" olive leaves during 2014 and 2015 seasons

	Nitrogen content (% dry matter)			Phosphorus content (% dry matter)			Potassium content (% dry matter)		
Treatmentss	Picual F1	Kalamata	Mean	Picual F1	Kalamata	Mean	Picual F1	Kalamata	Mean
				2014 season					
Control	1.35i	1.44h	1.40G	0.153j	0.347f	0.250F	0.810f	0.800f	0.805E
MAP 1	1.47g	1.53e	1.50D	0.191gh	0.503b	0.347B	0.837ef	0.950cd	0.893CD
MAP 2	1.50f	1.56d	1.53C	0.196g	0.573a	0.385A	0.870e	0.990c	0.930C
MPK 1	1.36i	1.58c	1.47E	0.188g-i	0.457d	0.322C	0.930d	1.100b	1.015B
MPK 2	1.43h	1.46g	1.45F	0.190g-i	0.480c	0.335BC	0.993c	1.200a	1.097A
UP 1	1.52ef	1.69b	1.60B	0.165ij	0.403e	0.284E	0.800f	0.930d	0.865D
UP 2	1.55d	1.74a	1.65A	0.170h-j	0.437d	0.303D	0.820ef	0.947cd	0.883D
Mean	1.45B	1.56A	---	0.179B	0.457A	----	0.866B	0.988A	----
				2015 season					
Control	1.30k	1.38l	1.31G	0.151j	0.337f	0.244F	0.817g	0.757i	0.787F
MAP 1	1.44h	1.52e	1.48D	0.192g	0.533b	0.363B	0.827g	0.930d	0.878D
MAP 2	1.47g	1.53e	1.50C	0.194g	0.597a	0.395A	0.870f	0.973c	0.922C
MPK 1	1.35j	1.57c	1.46E	0.187gh	0.483c	0.335C	0.900e	1.087b	0.993B
MPK 2	1.43hi	1.42i	1.43F	0.189gh	0.487c	0.338C	0.960c	1.147a	1.053A
UP 1	1.50f	1.60b	1.55B	0.167ij	0.390e	0.278E	0.800h	0.930d	0.865E
UP 2	1.55d	1.68a	1.61A	0.172hi	0.410d	0.291D	0.823g	0.937d	0.880D
Mean	1.44B	1.52A	----	0.179B	0.462A	----	0.857B	0.966A	----
MAP (Mono ammonium phosphate)				MKP (Mono potassium phosphate)			UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

statius during two studied seasons. Nitrogen content was significantly affected by foliar treatments. Moreover, trees that sprayed with U-P2 in mid of January and May achieved the highest values of leaf nitrogen content (1.65 &1.61%) comparing with other treatments, while control treatment indicated the lowest value (1.40 & 1.31%) in the first and second seasons, respectively. Regarding to Phosphor content, results showed that MAP2 gave the highest content (0.385 and 0.395%) compared with other treatments, while control had the lowest values (0.250 and0.244%) in both seasons respectively. By contrast, spraying MPK2 had a positive effect on increasing potassium level (1.097 &1.053%) compared to other treatments. On the other hand, control treatment had the lowest effect of enhancing the potassium content in leaves (0.805 & 0.787%) in both seasons respectively. Furthermore, Kalamata leaves had superior in N, P and K content compared to Picual leaves during 2014 and 2015 seasons. Moreover, spraying treatment with UP2 had superior in N content, MAP2 in P content and MKP2 in K content as the effect of interaction between cultivars and spraying treatments.

Flowering Behavior

Flowering Density: Results presented in Table (3) showed that, flowering density as a number of inflorescences per meter was significantly affected by different phosphor treatments. Foliar spraying with MAP1 that sprayed at mid of January recorded the highest flowering density (52.88 & 46.89). On the other hand, control treatment records the lowest value (36.50 & 26.74) in both seasons respectively. Concerning the interaction between cultivars and spraying treatments, each of UP1 and UP2 treatments on Kalamata cv., in the first seasons and MAP1 treatment on Picual cv., in the second season gave the highest flowering density. Moreover, the evident results from perfect flowers percent of the two studied cultivars were affected by different treatments in both seasons. The highest value was determined with the foliar tested application with MKP1 (89.66 & 85.70%). Whereas, the lowest value (64.54 & 63.47%) was obtained from control trees in both seasons respectively. Concerning effect of the interaction, treatment with MKP2 in the both season sharing with MKP1 in the first season indicated the highest values. Additionally, Picual cv. was superior to Kalamata cv. in each of flowering density and perfect flowers % in the two growing seasons.

Fruiting and Yield: Results in Table (4) demonstrate the effect of spraying (MAP, MPK and U-P) on fruit set, fruit drop percentage and yield during 2014 and 2015 seasons. It is obvious that Picual cv. surpassed Kalamata cv. in fruit set % in both seasons. Moreover, spraying MKP2 gave the highest significant values of

Table 3: Effect of spraying MAP, MPK and U-P on flowering density and perfect flowers % of "Picual and Kalamata" olive trees during 2014 and 2015 seasons

	Flowering density			Perfect flowers %		
Treatments	Picual	Kalamata	Mean	Picual	Kalamata	Mean
			2014 season			
Control	41.42 i	31.58 j	36.50 F	64.59g	64.50g	64.54E
MAP 1	54.78 b	50.99 d	52.88 A	80.65d	84.11c	82.38C
MAP 2	52.92 c	51.46 d	52.19 B	84.15c	80.57d	82.36C
MPK 1	48.41 f	43.80 h	46.11 E	89.66a	89.66a	89.66A
MPK 2	51.28 d	49.14 e	50.21 D	89.35a	85.40b	87.37B
UP 1	48.14 f	56.15 a	52.14 B	76.04f	78.53e	77.28D
UP 2	45.35 g	56.62 a	50.99 C	78.53e	75.37f	76.95D
Mean	48.90 A	48.53 B	----	80.42A	79.73B	----
			2015 season			
Control	23.38k	30.09 j	26.74 G	65.04j	61.90k	63.47F
MAP 1	48.46 a	45.32 c	46.89 A	80.20ef	82.38c	81.29C
MAP 2	46.98 b	43.86 e	45.42 B	81.37d	79.78f	80.57D
MPK 1	38.97i	39.46 i	39.13 F	85.68b	85.72b	85.70A
MPK 2	42.41f	40.18 h	41.30 E	88.76a	81.10de	84.93B
UP 1	41.06 g	45.03 cd	43.05 C	76.41g	75.45h	75.93E
UP 2	40.25 h	44.62 d	42.44 D	79.79f	73.35i	76.57E
Mean	41.41 A	40.03 B	----	79.61A	77.10B	----
MAP (Mono ammonium phosphate)		MKP (Mono potassium phosphate)		UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

Table 4: Effect of spraying MAP, MPK and U-P on fruit set (%), fruit drop (%) and yield (kg) of "Picual and Kalamata" olive trees during 2014 and 2015 seasons

	Fruit set (%)			Fruit drop (%)			Yield (kg/tree)		
Treatments	Picual	Kalamata	Mean	Picual	Kalamata	Mean	Picual	Kalamata	Mean
				2014 season					
Control	27.16 i	25.06 j	26.11F	28.32 a	21.40 d	24.86 A	27.35i	22.00j	24.67 F
MAP 1	40.29 d	31.66 h	35.98D	25.55 b	19.81 f	22.68 B	40.99d	28.85h	34.92D
MAP 2	42.63 c	33.45 g	38.04C	23.38 c	15.97 k	19.67 C	44.41c	30.71g	37.56C
MPK 1	51.75 b	34.40 g	43.08B	18.32 h	16.67 j	17.49 E	47.22b	33.80f	40.51B
MPK 2	55.52 a	35.68 e	45.60A	16.66 j	13.85 l	15.26 F	50.73a	34.31f	42.52A
UP 1	37.20 e	31.31 h	34.25E	20.87 e	18.40 h	19.64 C	38.33e	28.52hi	33.43E
UP 2	40.03 d	32.04 h	36.04D	19.20 g	17.05 i	18.13 D	40.10d	29.59gh	34.84D
Mean	42.08 A	31.94 B	----	21.76 A	17.59 B	----	41.30 A	29.68 B	----
				2015 season					
Control	21.26 j	20.31 j	20.78 F	22.60 a	18.89 c	20.75 A	11.26 j	17.38 g	14.32 F
MAP 1	33.60 e	27.48 g	30.54 D	20.86 b	16.47 e	18.66 B	15.67 h	23.02 de	19.35 D
MAP 2	37.94 c	27.48 g	32.71 C	17.04 d	12.84 i	14.94 E	17.87 g	24.63 c	21.25 C
MPK 1	43.09 b	27.35 g	35.22 B	14.07 h	14.08 h	14.08 F	21.10 f	26.74 b	23.92 B
MPK 2	50.72 a	31.56 f	41.14 A	13.07 i	11.51 j	12.29 G	23.61 cd	29.16 a	26.39A
UP 1	30.82 f	24.76 i	27.79 E	16.63 e	15.93fg	16.28 C	14.05 i	22.23ef	18.14E
UP 2	35.37 d	26.12 h	30.75 D	16.04 f	15.56 g	15.80 D	15.24 hi	23.80cd	19.52D
Mean	36.11 A	26.44 B	----	17.19 A	15.04 B	----	16.97 B	23.85 A	----
MAP (Mono ammonium phosphate)				MKP (Mono potassium phosphate)			UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

fruit set % (45.60 &41.14%) compared with other treatments, while control treatment gave the lowest value (26.11 & 20.78%) during 2014 and 2015 seasons. As the effect of interaction between cultivars and sprayed treatments, Picual trees that sprayed with MPK2 had superior values to Kalamata cv. concerning fruit drop percentage in Picual and Kalamata cvs., the control gave the highest value (24.86 & 20.75%), while MKP2 achieved the lowest fruit drop percent (15.26 and 12.29%) in both seasons. Furthermore, Picual cv. illustrated the highest

drop percentage as compared with Kalamata cv. Moreover, control treatment of Picual cultivar gave as the highest significant value as the effect of interaction between cultivars and treatments. As shown the production during 2014 and 2015 that presented in Table (4). Data observed that, Picual cv. surpassed Kalamata cv. during 2014 season. While, Kalamata cv. was superior in 2015 season. Moreover, the treatments with MKP which sprayed twice enhanced yield (42.52 & 26.39 kg) and performed the highest significant difference compared to the control (24.67 & 14.32 kg). Meantime, the other treatments showed the intermediate values in yield. Moreover, Picual cv. that sprayed with MKP2 was superior as the result of interact between cultivars and treatments.

Fruit Characteristics: In regard to fruit length in Table (5) data revealed that, there was no clear indication of the effect of treatments in the fruit length. Moreover, Kalamata cv. was superior compared to Picual cv. during the two growing seasons. As for the interaction effects between cultivars and treatments, there were an intermediate significantly value was observed. Moreover, spraying (UP1) was the most effective treatments on fruit diameter during the first season, while each of (MAP1 and MKP2) was superior in the second season. As the effect of cultivar, Picual cv. was surpassed compared to Kalamata cv. in both seasons. Additionally, the interaction between cultivars and treatments took the same direction of treatment. Regarding to fruit shape index, control treatment gave the highest values in two studied seasons. Moreover, Kalamata cv. was superior comparing to Picual cv., additionally, the control of Kalamata cv. was superior as the effect of interaction in both seasons.

In regard to flesh weight and fruit weight of Picual and Kalamata cvs., that presented in Tables (6). It is obvious that, Picual cv. gave the highest significant values compared to Kalamata cv. in both 2014 and 2015 seasons. As the effect of treatments, (MKP1), (MKP2) and (MAP2) performed the highest significant values as compared to other treatments, meantime, control treatments gave the lowest value in both seasons. As the effect of interaction in flesh weight, MKP1 in Picual cv., was superior in both seasons. While, the interaction effect on fruit weight of Picual cv., was affected by aforementioned treatments. Concerning flesh/fruit weight of Picual and Kalamata cvs., the results obtained that Kalamata cv. was superior during 2014 season, while, no difference was observed between cultivars in 2015 season. Moreover, an intermediate value was observed as the effect of interaction; similarly, statically analysis did not show any differences between treatments in both seasons.

Concerning seed characteristics that presented in Table (7), data showed that, the trees that sprayed with (MKP1and MKP2) was superior in seed length as compared to the control and other treatments in both seasons. Meantime, Kalamata cv. was surpassed to Picual cv and there were a convergence between cultivars and treatment as the effect of interaction. In regard to seed diameter and seed weight, it could be noticed that, spraying with (MKP2) was superior in the first season, whereas, slightly difference between treatments was observed in the second season comparing to control which achieved the lowest values. Meantime, Picual cv. was superior to Kalamata cv. in both seasons. Concerning the interaction between treatments and cultivars, an intermediate significant value was observed in Picual cv. in seed diameter and seed weight during 2014 and 2015 seasons.

As shown the results in Table (8), it could be noticed that, flesh/pit weight, Kalamata cv. was surpassed on Picual cv. Meanwhile, control treatment gave the highest values as the effect of treatments and the same effect in the interaction between cultivars and treatments in two studied seasons. Additionally, the oil content (dry weight) of Picual and Kalamata cvs., was affected by all spraying treatments during 2014 and 2015 seasons, Picual cv. gave the highest significant values of oil content in both seasons. As the effect of treatments, each of (MKP1 and MKP2) indicates the highest oil content comparing with other treatments and control. Concerning to the interaction between cultivars and treatments, there wasn't definite trend of Picual and Kalamata cvs towards spraying treatments in both seasons.

Economic Study: The economic consideration comparative study of olive Picual and Kalamata cultivars in 2014 & 2015 seasons that presented in Table (9) observed that, all sprayed treatments led to increase the fruit yield as compared with control. Moreover, sprayed trees with MKP2 led to get the highest fruit yield (6504.75 &5554.5 kg|fed) in Picual and Kalamata cultivars respectively, that achieved highest gross income. (26019 and 72208.5 EPG/Fed) which had the highest net return (25500.5 & 71690.0 EPG|Fed). On the other hand, control treatment gave the lowest net return (13517.0 &44794.75 EPG|Fed) in both Picual and Kalamata cvs. respectively. So we can conclude that, spraying MKP2 is preferable for getting higher profit as comparing with other treatments.

Table 5: Effect of spraying MAP, MPK and U-P on fruit diameter (cm), fruit length (cm) and fruit shape index of "Picual and Kalamata" olive trees during 2014 and 2015 seasons

	Fruit length " L" (cm)			Fruit diameter " D" (cm)			Fruit shape index L|D		
Treatments	Picual	Kalamata	Mean	Picual	Kalamata	Mean	Picual	Kalamata	Mean
				2014 season					
Control	2.55e	2.86a	2.71B	1.85e	1.72f	1.79E	1.38d	1.66a	1.52A
MAP 1	2.66d	2.85a	2.76AB	2.60b	1.82e	2.21B	1.02f	1.57bc	1.25DE
MAP 2	2.69cd	2.86a	2.78A	2.62b	1.78ef	2.20B	0.91g	1.61b	1.26D
MPK 1	2.75bc	2.79ab	2.77A	2.15c	1.80e	1.98C	1.28e	1.55bc	1.40C
MPK 2	2.73b-d	2.76bc	2.75AB	2.00d	1.78ef	1.89D	1.37 d	1.55bc	1.46B
UP 1	2.65d	2.81ab	2.73AB	2.76a	1.82e	2.29A	0.84h	1.54bc	1.19E
UP 2	2.77ab	2.79ab	2.78A	2.05d	1.82e	1.94CD	1.35d	1.53c	1.43BC
Mean	2.69B	2.82A	----	2.29A	1.79B	----	1.19B	1.57A	----
				2015 season					
Control	2.56f	2.92a	2.74B	1.80ef	1.74f	1.77E	1.42d	1.68a	1.55A
MAP 1	2.65e	2.91a	2.78AB	2.61a	1.89d	2.25A	0.94 f	1.54c	1.24D
MAP 2	2.65e	2.92a	2.79AB	2.56a	1.82d-f	2.19 B	0.94 f	1.60b	1.27C
MPK 1	2.75d	2.83bc	2.79AB	2.09b	1.83de	1.96 C	1.29 e	1.55c	1.42B
MPK 2	2.74d	2.86ab	2.80A	2.59 a	1.89d	2.24AB	0.99 f	1.51c	1.25D
UP 1	2.62ef	2.85ab	2.74B	1.98c	1.81d-f	1.90D	1.31e	1.57c	1.44B
UP 2	2.78cd	2.84bc	2.81A	2.03bc	1.86de	1.95CD	1.35d	1.53c	1.45B
Mean	2.68B	2.88A	----	2.24A	1.83B	----	1.21B	1.57A	----
MAP (Mono ammonium phosphate)				MKP (Mono potassium phosphate)			UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

Table 6: Effect of spraying MAP, MPK and U-P on flesh weight, fruit weight and flesh/fruit weight percentages of "Picual and Kalamata" olive trees during 2014 and 2015 seasons

	Flesh weight (gm)			Fruit weight (gm)			Flesh / Fruit weight %		
Treatments	Picual	Kalamata	Mean	Picual	Kalamata	Mean	Picual	Kalamata	Mean
				2014 season					
Control	5.44f	5.23g	5.34E	6.52e	5.90f	6.21C	0.831d	0.886a	0.859A
MAP 1	5.72e	5.11h	5.40D	6.86d	5.74fg	6.335B	0.842d	0.866a-c	0.852A
MAP 2	5.97b	5.12h	5.56A	7.10a	5.85fg	6.48A	0.844cd	0.840d	0.858A
MPK 1	6.02a	5.09h	5.57A	7.09ab	5.91f	6.50A	0.840d	0.866a-c	0.857A
MPK 2	5.94bc	5.09h	5.50B	7.03b	5.88f	6.45A	0.831d	0.875ab	0.853A
UP 1	5.89c	5.09h	5.50B	6.90cd	5.87f	6.39B	0.851b-d	0.867a-c	0.861A
UP 2	5.82d	5.07h	5.44C	6.95c	5.80g	6.38B	0.834d	0.873ab	0.853A
Mean	5.83A	5.11B	----	6.92A	5.86B	----	0.839B	0.872A	----
				2015 season					
Control	5.22de	5.28d	5.25C	6.30e	5.94fg	6.12D	0.844f	0.890b	0.858A
MAP 1	5.63c	5.14ef	5.39B	6.76d	5.86hi	6.31C	0.882de	0.864c	0.854A
MAP 2	5.68c	5.14f	5.48A	6.80 cd	5.94 fg	6.37 B	0.885d	0.865c	0.846A
MPK 1	5.89a	5.11f	5.50A	7.01a	5.91gh	6.46A	0.875e	0.865c	0.852A
MPK 2	5.77b	5.18ef	5.49A	6.87b	5.99f	6.43A	0.899a	0.876de	0.864A
UP 1	5.81b	5.17ef	5.39B	6.83bc	5.92gh	6.38B	0.896ab	0.873e	0.861A
UP 2	5.68c	5.04g	5.36B	6.81b-d	5.83i	6.32C	0.886d	0.863c	0.848A
Mean	5.67A	5.15B	----	6.77A	5.91B	----	0.881A	0.871A	----
MAP (Mono ammonium phosphate)				MKP (Mono potassium phosphate)			UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

Table 7: Effect of spraying MAP, MPK and U-P on seed length (cm), seed diameter (cm) and seed weight (gm) of "Picual and Kalamata" olive trees during 2014 and 2015 seasons

	Seed length (cm)			Seed diameter (cm)			Seed weight (gm)		
Treatments	Picual	Kalamata	Mean	Picual	Kalamata	Mean	Picual	Kalamata	Mean
				2014 season					
Control	1.74g	1.96a	1.85C	0.890c	0.717f	0.803D	1.080c	0.673h	0.877D
MAP 1	1.82ef	1.92a-c	1.87BC	0.947a	0.777e	0.862C	1.087c	0.787e	0.937B
MAP 2	1.87c-e	1.85de	1.86BC	0.913bc	0.840d	0.877BC	1.110b	0.760f	0.935B
MPK 1	1.90b-d	1.94ab	1.92A	0.920a-c	0.833d	0.877BC	1.137a	0.790e	0.935B
MPK 2	1.84d-f	1.95ab	1.90AB	0.910bc	0.897bc	0.903A	1.120ab	0.733g	0.955A
UP 1	1.84d-f	1.90b-d	1.87BC	0.927ab	0.833d	0.880BC	1.010d	0.767f	0.888C
UP 2	1.79f	1.87c-e	1.83C	0.920a-c	0.853d	0.887AB	1.137a	0.737g	0.937B
Mean	1.83B	1.91A	----	0.918A	0.821B	----	1.097A	0.750 B	----
				2015 season					
Control	1.73j	2.06a	1.89B	0.893cd	0.763f	0.828C	1.087b	0.653g	0.870 D
MAP 1	1.84g	1.95d	1.90B	0.937a	0.757f	0.847B	1.30a	0.723f	0.927 B
MAP 2	1.83g	1.93e	1.88C	0.907bc	0.837e	0.872A	1.123a	0.793d	0.958 A
MPK 1	1.87f	1.97c	1.92A	0.923ab	0.820e	0.872A	1.120a	0.807d	0.963 A
MPK 2	1.84g	2.01b	1.93A	0.880d	0.877d	0.878A	1.100b	0.810d	0.955 A
UP 1	1.80h	1.97c	1.89BC	0.917b	0.820e	0.868A	1.027c	0.750e	0.888 C
UP 2	1.78i	1.93e	1.85D	0.907bc	0.830e	0.868A	1.130a	0.797d	0.963 A
Mean	1.81B	1.97A	----	0.909A	0.815B	----	1.102 A	0.762 B	----
MAP (Mono ammonium phosphate)				MKP (Mono potassium phosphate)			UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

Table 8: Effect of spraying MAP, MPK and U-P on flesh/pit weight and oil content of "Picual and Kalamata" olive trees during 2014 and 2015 seasons

	Flesh / pit ratio			Oil content % (dry weight)		
Treatments	Picual	Kalamata	Mean	Picual	Kalamata	Mean
			2014 season			
Control	5.04g	7.76a	6.40A	40.49g	38.33h	39.41D
MAP 1	5. 46f	6.46d	5.96C	43.92de	41.94f	42.93C
MAP 2	5.42f	6.70b-d	6.06BC	44.16c-e	43.41e	43.78B
MPK 1	5.32fg	6.47d	5.90C	44.93a-c	44.56a-d	44.75A
MPK 2	5.03g	7.00b	6.02C	45.40a	45.19ab	45.29A
UP 1	5.83e	6.65cd	6.24AB	43.46e	42.53f	43.00C
UP 2	5.12g	6.88bc	6.00 C	44.33b-e	43.55e	43.94B
Mean	5.32B	6.85A	----	43.81A	42.79B	----
			2015 season			
Control	4.80g	8.08a	6.44 A	41.39e	39.39f	40.39E
MAP 1	5.24e	6.39c	5.82 DE	40.97e	42.93d	41.95D
MAP 2	5.24e	6.44c	5.84 D	45.13ab	43.79cd	44.46B
MPK 1	5.10ef	6.37c	5.73 DE	45.50a	44. 90ab	45.20A
MPK 2	4.83fg	7.11b	5.97 C	45.97a	45.73a	45.85A
UP 1	5.65d	6.89b	6.27 B	44.34bc	42.70d	43.52C
UP 2	5.03ef	6.32c	5.67 E	45.09ab	43.72cd	44.41B
Mean	5.13 B	6.80 A	----	44.06A	43.31B	----
MAP (Mono ammonium phosphate)		MKP (Mono potassium phosphate)		UP (Urea Phosphate)		

Means within each column or raw followed by the same letter (s) are not significantly different at 5% level.

Table 9: Economic evaluation of" Picual" and "Kalamata" olive trees that prayed with different types of phosphorus

Treatments	Average yield of Picual (kg/Fed)	Average yield of Kalamata (kg/Fed)	Gross income of Picual/treatment (EPG/Fed)	Gross income of Kalamata /treatment (EPG/Fed)	Total cost of spraying treatments EPG/Fed)	Average net return of Picual (EPG/Fed)	Average net return of Kalamata (EPG/Fed)
Control	3379.25	3445.75	13517	44794.75	---------	13517	44794.75
MAP1	4957.75	4538.63	19831	59002.19	198	19633	58804.19
MAP2	5449.5	4842.25	21798	62949.25	396	21402	62553.25
MKP1	5978	5297.25	23912	68864.25	259.25	23652.75	68605
MKP2	6504.75	5554.5	26019	72208.5	518.5	25500.5	71690
U-P1	4583.25	4441.5	18333	57739.5	198	18135	57541.5
U-P2	4842.25	4671.63	19369	60731.19	396	18973	60335.19

MAP (Mono ammonium phosphate) MKP (Mono potassium phosphate) UP (Urea Phosphate)

Several studies regarding the important roles played by Phosphor nutrition on flowering and fruit set and productivity, but the mechanisms in which P nutrition contributes to olive productively are not yet understood [29, 18].

The abovementioned results cleared that, all phosphor treatments (MAP, MKP and U-P) have a positive effect for improving leaves nutrient content, the flowering, fruit set, yield, fruit characteristics and fruit oil content of Picual and Kalamata cvs. comparing to control. Regarding to leaves mineral content, the increase in the level of N, P and K in the leaves of two studied cultivars were agree with Diego *et al*. [30] who reported that, spraying phosphorus in different forms and concentrations raised N, P and K levels in leaves. Meantime, Ran *et al.* [17] demonstrated that increased leaf content of nitrogen and phosphorus on olive trees correlated with increased the level of urea fertilization .Moreover, Utkhede and Smith [31] reported that treated apple trees with MAP led to increase leaves N and P content. Additionally, Sarrwy *et al*. [16] and Diego *et al*. [30] found that that potassium content in the leaves of olive significantly increased as a result of MKP spraying at 1% and 2%. As regard to the flowering behavior, Barone *et al.*[12] mentioned that, an increases of hermaphrodite flowers due to high level of N that led to improve fruit set. Similarly, former investigations was obtained by Ran *et al.* [17] who showed that high flowering level of olive trees were found by MAP application due to high N and P concentration. Moreover, an increase of fruiting, yield and fruit quality and oil content as a foliar spray with MKP are in conformity with those of Hegazy *et al.* [32]; Taha [33] and Emad and Kamal [34]. Furthermore, the increment in yield as a result of spraying MKP may be due to improve the nutritional status of trees and increase availability of assimilates which may leading to stimulate the flower induction and increased both inflorescences formation, fruit set and productivity [16, 3]. In addition, the enhancement of fruit characteristics as a foliar spray with MKP due to different roles of P and K in enhancing the formation and translocation of carbohydrates from the shoot to the storage organ (fruit) that led to improve fruit quality [35, 36]. Similarly, a positive effect of spraying P are in accordance with Ramezani and Shekandeh [37] and Mahmoud *et al.* [3] summarized that foliar application of M KP during the second and third phase of olive growth improved the fresh weight and flesh to pit ratio. Concerning to the increase of oil content, it could be attributed to result of potassium which may control on the biosynthesis of oil by enzymes during the main metabolic pathway of the critical stages of development of olive which led to the accumulation of the oil in fruits [38, 39].

Generally, the overall better performance by foliar spray of mono-potassium phosphate (MKP2) at 1% concentration in the mid of (January and May). This considered as a fast source of P and K elements that preferable for helping to compensate the depletion of mineral nutrient and enhances tree fruiting, yield and fruit quality during "on" and next "off" year. Thus, we can recommend olive growers to apply this treatment that showed a good performance in increasing olive yield subsequently increase their income.

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