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Effect of Potassium Nitrate on Vegetative Growth, Nutritional Status, Yield and Fruit Quality of Olive cv. "Picual"

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Abstract: The present investigation was carried out during two successive seasons 2009 and 2010 in a private orchard located at Cairo-Alexandria, desert road, Egypt (about 50 Km from Cairo) to study the effective concentration and application time of potassium nitrate (KNO_3) on vegetative growth, nutritional status, yield and fruit quality of Picual olive trees under sandy soil conditions. The obtained results showed that, foliar application of potassium nitrate at 4 % after final fruit set or pit hardening improve the vegetative growth, nutritional status especially in the second season and the productivity in both seasons. While sprays potassium nitrate at 4 % after pit hardening gave the best values of fruit quality and flesh oil content of Picual olive fruit in both seasons of the study.

Key words: Olive · Potassium nitrate · Yield · Fruit quality · Nutritional status · Vegetative growth

INTRODUCTION

Olive (*Olea europaea* L.) is a long-lived evergreen tree, one of the most widely cultivated and economically important fruit crop for several countries, olive native to the Mediterranean basin that accounts for about 90 % of the world's olive cultivation and production. In Egypt, the cultivated area with olive increases gradually and reached 158,000 feddan (one feddan=4200 m^2) according to Ministry of Agriculture and Land Reclamation [1], but in new reclaimed lands as a result of bearing the olive trees to many soil and environmental conditions inappropriate for the cultivation of many fruit crops. Such newly reclaimed lands characterizes by low fertility, therefore, the foliar application is an attractive solution, especially in the critical times of various stages from tree growth. Picual olive cv. was introduced from Spain to Egypt and considered one of the best and main widely planted cultivars. In Egypt, it used for both oil and table olive. Alternate bearing affects many fruit tree species, including olive. The term "alternate or biennial" bearings are used by horticulturists to designate the production of a heavy fruit crop one year followed by a light crop the next year [2]. The phenomenon is a feature to a greater or lesser extent of all cultivated olive varieties [3] and can be occurred in an orchard or even of individual parts of a single tree.

Foliar application of nutrients is in general helpful to satisfy plant requirement and has a high efficiency [4]. K application to trees is an attractive method especially in arid zones where a lack of water under low rainfall conditions in summer drastically depresses absorption of soil nutrients [5].Potassium is known, not only to play an important role in olive yield and quality but also in water-use efficiency, it is easily absorbed and distributed through leaf tissues and plays an important role in growth of olive [6]. Potassium is particularly well adapted to this form of fertilization because soon after foliar spraying takes place, it is rapidly translocated from the leaves [7].

The main role of potassium is the activation of many enzyme systems involved in the structure of organic substances and in the building up of compounds such as starch or protein and also involved in cell enlargement and in triggering the growth of young meristematic tissues. Also, K promotes photosynthesis and transport the assimilates of the carbohydrates to the storage organs. Potassium is involved in many aspects of the plant physiology [8]. Foliar applications of potassium

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nitrate have a positive effect on the quality of table olives and improve the leaf potassium content [9]. Moreover, foliar application of potassium nitrate increases yield and fruit quality, it also, enhances nutritional status of olive leaves [10]. Thus, the aim of this study was to study the effect of foliar application with potassium nitrate on vegetative growth, leaves mineral contents, yield, fruit quality and bearing behavior of Picual olive under sandy soil conditions.

MATERIALS AND METHODS

This study was carried out during two successive seasons 2009 and 2010 in a private orchard located at Cairo-Alexandria, desert road, Egypt (about 50 Km from Cairo). The experiment was done in sandy soil which is poor in nutrients such as nitrogen, phosphorous and potassium, in addition to high pH, orchard soil analysis are given in Table 1 according to procedures which are outlined by Wild *et al.* [11].

The study was conducted on fifteen years old olive trees of Picual cv. planted at (5x8) m apart, uniform in shape. The experiment was set in a completely randomized block design with five treatments each contains three replicates and the replicate represented by one tree and the normal horticultural practices that used in the farm were applied, as well as spraying potassium nitrate at different concentrations and time of application in the two seasons as follow:

- Control (spraying the trees with underground water)
- Spraying (KNO_3) at 2 % immediately after final fruit set (mid May)
- Spraying (KNO_3) at 4 % immediately after final fruit set (mid May)
- Spraying (KNO_3) at 2 % after pit hardening (first week of August)
- Spraying (KNO_3) at 4 % after pit hardening (first week of August)

On early March of each season, twenty healthy one year old shoots well distributed around the canopy of each tree were randomly selected and labeled (5 shoots of each direction) for carrying out the following measurements:

Vegetative Parameters: At the end of each growing season during first week of September the following characteristics were measured.

- Number of new shoots per twig
- Number of leaves per shoot
- Leaf area (cm^2) according to Ahmed and Morsy [12] using the following equilibration: Leaf area = 0.53 (length x width) + 1.66.

Leaf Mineral Contents: At the end of each growing season during first week of September, leaf samples were collected, washed and dried at 70°C until constant weight and then grounded for determination the following nutrient elements (Percentage as dry weight):

- N-Using the modified micro - kjeldahl method as lined by Pregl [13].
- P-Was estimated as described by Chapman and Pratt [14].

Table 1: Some physical and chemical characteristics of the experimental soil used in the present study.

Character	Value	Character	Value
Particle Size Distribution (%)			
Clay	4.47	EC (mm/cm)	0.37
Silt	5.23	pH	8.50
Sand	90.30	Organic matter (%)	0.52
Texture	Sandy	$CaCO_3$(%)	15.40
Soluble Cations (meq/100 g soil)		Soluble anions (meq/100 g soil)	
Ca^{2+}	0.45	CO_3^-	--
Mg^{2+}	0.18	HCO_3^-	0.70
Na^+	0.17	Cl^-	0.50
K^+	0.05	SO_4^{-2}	0.18
Available macronutrients (%)		Available micronutrients (ppm)	
N	0.55	Fe	0.96
P	0.18	Zn	1.12
K	0.45	Mn	1.74

- K-Was determined using Flamephotometer according to Brown and Lilleland [15].

Yield: At maturity stage of two seasons (mid October), fruits of each tree were separately harvested, then weighed and yield as kg / tree was estimated.

Fruit Quality: Thirty fruit per each tree were randomly selected for carrying out the fruit quality measurements:

- Fruit dimensions: Fruit length "L" (cm), fruit diameter "D" (cm) and fruit shape "L/D" ratio).
- Fruit volume (cm^3).
- Average weight of (fruit, flesh and seed) in (g).
- The ratio of flesh and seed / fruit was calculated.
- Flesh dry weight (%): Flesh dry weight percentage of fruit in the previous fruit samples was estimated, samples were dried at 60 º C in electrical air oven until constant weight, the fruit dry weight percentage was calculated according to A.O.A.C. [16].
- Flesh oil content (%): was determined according to Woodman [17] by extraction the oil from the dried flesh fruit with Soxhelt for extraction apparatus using petroleum ether 60-80°C of boiling point.

Statistical Analysis: All obtained data during both 2009 and 2010 experimental seasons were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran [18] using MSTAT program. Least significant difference (LSD) was used to compare between means of treatments according to Duncan [19] at probability of 5 %.

RESULTS AND DISCUSSION

Vegetative Parameters: Data in Table 2 indicated the effect of spraying potassium nitrate on number of new shoots per twig, number of leaves per shoot and leaf area of Picual olive trees during the two seasons of study. Number of new shoots per twig was significantly affected by different treatments in the second season. Potassium nitrate sprays at 4 % after final fruit set gave the highest number of new shoots per twig in both seasons. No significant effect observed when potassium nitrate sprayed at 4 % after pit hardening and 2 % after final fruit set in the two seasons. Concerning number of leaves per shoot, results showed that no significant differences between treatments in the first season, while potassium nitrate sprays at 4 % after final fruit set and 4 % after pit hardening or 2 % after final fruit set significantly increases the number of leaves per shoot in the second season.

Regarding leaf area, results indicated that there are no significant differences in leaf area due to different treatments in both seasons. The improvement in vegetative growth may be attributed to the important role of potassium in nutrient and sugar translocation in plant and turgor pressure of plant cells. Also potassium active numerous enzyme systems involved in the formation of organic substances and in the buildup of compounds such as starch or protein. Potassium is involved in cell enlargement and in triggening the young tissues or be due to that potassium is involved in plant mersitematic growth [20]. The effect of K on increasing olive trees growth was confirmed by Hussein [21] and Abdel- Nasser and El-Shazly [22].

Leaf Mineral Contents: Data presented in Table 3 illustrated the effect of spraying potassium nitrate on leaves N, P and K contents of Picual olive during the two seasons of study. Nitrogen content in leaves was significantly affected by spraying potassium nitrate in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest leaf content of N, while control treatment gave the lowest leaf content of N in the two seasons. Regarding P content in leaves, results clear that no significant differences between treatments in the first season, while potassium nitrate sprays at 4 % or 2% after pit hardening and 4 % after final fruit set significantly increased the P content in leaves, while control treatment gave the lowest leaf content of P in the two seasons of study.

Concerning K content in leaves, results showed that Spraying potassium nitrate led to significant increase in leaf content of K in both seasons. Potassium nitrate sprays at 2 % or 4 % after pit hardening and 4 % after final fruit set gave the highest leaf content of K in the first season, while in the second season, potassium nitrate sprays at 4 % after pit hardening gave the highest leaf content of K. In contrast, control treatment gave the lowest leaf content of K in both seasons.

Yield (kg/tree): Yield was significantly affected by potassium nitrate spray treatments in both seasons. The highest yield was observed in the both seasons when trees were sprayed by 4 % after final fruit set, while control treatment gave the lowest average of yield in both seasons (Table 4).

It is obvious from above mentioned results that, foliar application of potassium nitrate at 4 % after final fruit set or after pit hardening improves the productivity of olive trees. These results were the integration of foliar

Table 2: Effect of spraying potassium nitrate on number of shoots per twig, number of leaves per shoot and leaf area of Picual olive trees.

	No. new Shoots		No. leaves / shoot		Leaf area(cm^2)	
Treatments	2009	2010	2009	2010	2009	2010
Control	5.33 a	8.67 c	23.67 a	28.00 c	3.63 a	3.22 a
KNO_3 (2 %) Spray after final fruit set	6.33 a	10.67 ab	23.67 a	32.67 ab	3.26 a	3.44 a
KNO_3 (4 %) Spray after final fruit set	8.00 a	12.00 a	24.67 a	35.33 a	3.64 a	4.31 a
KNO_3 (2 %) Spray after pit hardening	5.67 a	9.33 bc	19.67 a	29.67 bc	3.20 a	3.48 a
KNO_3 (4 %) Spray after pit hardening	7.67 a	11.33 a	24.67 a	35.00 a	3.51 a	3.98 a

Mean in each column with similar letters are not significantly different at 5 % level.

Table 3: Effect of spraying potassium nitrate on N, P and K contents of Picual olive leaves.

	N (%)		P (%)		K (%)	
Treatments	2009	2010	2009	2010	2009	2010
Control	0.73 c	0.78 e	0.43 a	0.54 c	0.54 c	0.84 d
KNO_3 (2 %) Spray after final fruit set	0.83 bc	0.85 d	0.44 a	0.58 b	0.58 b	0.87 cd
KNO_3 (4 %) Spray after final fruit set	0.87 bc	0.93 c	0.44 a	0.59 ab	0.59 ab	0.91 c
KNO_3 (2 %) Spray after pit hardening	0.96 b	1.01 b	0.46 a	0.60 a	0.60 a	0.98 b
KNO_3 (4 %) Spray after pit hardening	1.24 a	1.33 a	0.50 a	0.60 a	0.60 a	1.13 a

Mean in each column with similar letters are not significantly different at 5 % level.

The optimum ranges of NPK in olive leaves were 1.5 - 2.00 % (N), 0.10 -0.30 % (P) and 0.80 (K) according to Stan and David [23].

Table 4: Effect of spraying potassium nitrate on yield of Picual olive trees.

	Yield (kg/tree)		± Control		± Control (%)	
Treatments	2009	2010	2009	2010	2009	2010
Control	22.33 b	16.00 b	--	--	--	--
KNO_3 (2 %) Spray after final fruit set	24.00 ab	18.67 ab	+ 1.67	+ 2.67	7.48	16.69
KNO_3 (4 %) Spray after final fruit set	25.67 a	21.67 a	+ 3.34	+ 5.67	14.96	35.44
KNO_3 (2 %) Spray after pit hardening	23.00 ab	16.67 b	+ 0.67	+ 0.67	3.00	4.19
KNO_3 (4 %) Spray after pit hardening	23.00 ab	17.00 ab	+ 0.67	+ 1.00	3.00	6.25

Mean in each column with similar letters are not significantly different at 5 % level.

Table 5: Effect of spraying potassium nitrate on fruit dimensions (Fruit length "L", fruit diameter "D" and fruit shape "L/D") of Picual olive.

	Fruit length (cm)		Fruit diameter (cm)		Fruit shape ratio	
Treatments	2009	2010	2009	2010	2009	2010
Control	2.58 c	2.67 c	2.27 b	2.30 d	1.14 b	1.16 c
KNO_3 (2 %) Spray after final fruit set	2.78 bc	2.80 b	2.30 ab	2.33cd	1.21 ab	1.20b c
KNO_3 (4 %) Spray after final fruit set	2.77 bc	2.85 b	2.32 ab	2.38 bc	1.19 ab	1.20b c
KNO_3 (2 %) Spray after pit hardening	2.97 ab	3.01 a	2.35 ab	2.41 ab	1.26 a	1.25a b
KNO_3 (4 %) Spray after pit hardening	3.03 a	3.09 a	2.42 a	2.46 a	1.25 a	1.26 a

Mean in each column with similar letters are not significantly different at 5 % level.

Table 6: Effect of spraying potassium nitrate on weights of fruit, flesh and seed of Picual olive fruit.

	Fruit weight(g)		Flesh weight(g)		Seed weight(g)	
Treatments	2009	2010	2009	2010	2009	2010
Control	8.68 c	9.40 c	7.46 c	8.14 d	1.22 a	1.26 a
KNO_3 (2 %) Spray after final fruit set	9.64 bc	10.33 b	8.41 bc	9.05 c	1.23 a	1.28 a
KNO_3 (4 %) Spray after final fruit set	9.95 ab	10.38 b	8.79 ab	9.12 bc	1.16 a	1.26 a
KNO_3 (2 %) Spray after pit hardening	10.63 ab	10.75 b	9.41 ab	9.49 b	1.22 a	1.26 a
KNO_3 (4 %) Spray after pit hardening	11.01 a	12.08 a	9.78 a	10.76 a	1.23 a	1.32 a

Mean in each column with similar letters are not significantly different at 5 % level.

Table 7: Effect of spraying potassium nitrate on dry weight and flesh oil content of Picual olive fruits.

	Flesh dry weight (%)		Flesh oil content (%)	
Treatments	2009	2010	2009	2010
Control	29.33 c	33.65 c	38.52 d	43.60 e
KNO_3 (2 %) Spray after final fruit set	30.44 bc	34.51 c	39.15 cd	44.99 d
KNO_3 (4 %) Spray after final fruit set	30.98 b	37.37 b	40.82 bc	46.46 c
KNO_3 (2 %) Spray after pit hardening	31.77 b	38.67 ab	41.51 b	52.67 b
KNO_3 (4 %) Spray after pit hardening	34.55 a	40.84 a	43.58 a	55.93 a

Mean in each column with similar letters are not significantly different at 5 % level.

nutrition had a positive effect on the characteristics of drupes and reduced fruit drop, therefore increasing the productivity [4] or might be attributed to the role of K in stimulate tree growth due to increase the nutrients uptake, thereby improve the fruit set and enhanced many metabolic processes such as carbohydrate transport [8]. These results may gain support from those obtained by Arquero *et al.* [6], Sarrwy *et al.* [10], Hussein [21], Abdel-Nasser and EL-Shazly [22].

Concerning the effect of spraying potassium nitrate on bearing behavior of Picual olive trees it could be noticed that, bearing behavior resembled by yield determination was improved as comparing with control in the two seasons of study. Potassium nitrate at 4 % after final fruit set caused a marked increase of yield in comparison with control. Such results could be attributed to the enhancement of nutritional status of the trees and increases the vegetative growth which refluxing positively on the productivity and bearing of the trees.

Fruit Dimensions (Fruit Length "L", Fruit Diameter "D" and Fruit Shape "L/D"): Data presented in Table 5 showed the effect of spraying potassium nitrate on fruit length, fruit diameter and fruit shape ratio. It was observed that fruit length was significantly affected by different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest fruit length in both seasons, meanwhile control treatment gave the lowest values of fruit length. Fruit diameter was significantly affected by different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest fruit diameter in both seasons, while the lowest fruit diameter was observed with control in both seasons. Concerning fruit shape ratio, potassium nitrate sprays at 2 or 4 % after pit hardening increased fruit shape significantly in the two seasons. On contrast, control treatment recorded the lowest fruit shape in both seasons.

Fruit Volume: Fig. 1 illustrated that, fruit volume was significantly affected by different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest value to fruit volume in both seasons, while the lowest fruit volume was recorded by control treatment in both seasons.

Weights of Fruit, Flesh and Seeds: Data in Table 6 showed that, fruit weight was significantly increased as affected by different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest fruit weight in both seasons, while the lowest fruit weight was observed by control treatment in both seasons. Data also in Table 6 showed that potassium nitrate sprays significantly increases flesh weight of Picual olive fruits. Potassium nitrate sprays at 4 % after pit hardening gave the highest flesh weight in both seasons. While control treatment gave the lowest flesh weight in both seasons. Concerning seed weight, it was observed that there were no significant differences between different treatments in both seasons of the study.

Flesh/Fruit Ratio: Flesh/fruit ratio was significantly increased by different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest ratio of flesh/fruit in both seasons with no significant differences comparing with 2 % after pit hardening and 4 % after final fruit set in both seasons, while the lowest flesh/fruit ratio was calculated with control treatment in both seasons (Fig. 2).

Seed/Fruit Ratio: Seed/fruit ratio was significantly decreased by different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the lowest seed/fruit ratio in both seasons, while control treatment gave the highest seed/fruit ratio in both seasons (Fig. 3).

Flesh Dry Weight: Data presented in Table 7 indicated that, flesh dry weight was significantly affected by

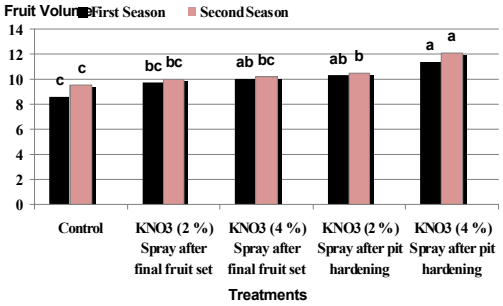

Fig. 1: Effect of spraying potassium nitrate on volume of Picual olive fruits

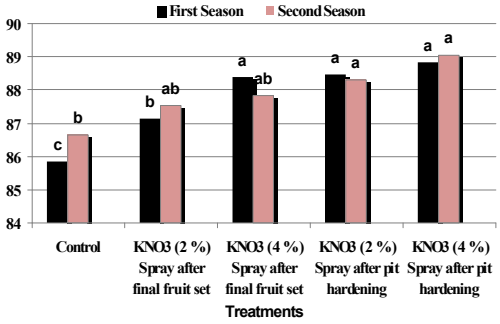

Fig. 2: Effect of spraying potassium nitrate on flesh/fruit ratio of Picual olive fruits

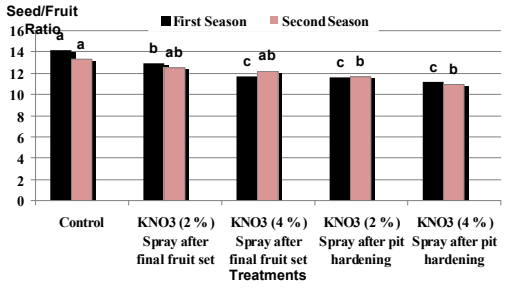

Fig. 3: Effect of spraying potassium nitrate on seed/fruit ratio of Picual olive fruits

different potassium nitrate spray treatments in both seasons. Potassium nitrate sprays at 4 % after pit hardening gave the highest flesh dry weight in both seasons, while control treatments gave the lowest flesh dry weight in both seasons of the study.

Flesh Oil Content: Concerning flesh oil content, it is obvious from Table 7 that, flesh oil content was significantly increased as affected by potassium nitrate spray treatments in both seasons. The highest flesh oil content was observed in the two seasons when trees were sprayed by potassium nitrate at 4 % after pit hardening, while control treatment gave the lowest flesh oil content in both seasons.

It is clear from above results that, foliar application of potassium nitrate at 4 % after pit hardening or after final fruit set improved fruit quality of Picual olive. The beneficial effects of potassium on growth, yield and fruit quality may be attributed to their vital role in stimulating cell division and elongation as well as the biosynthesis and trans-located of organic foods in favour of enhancing growth and fruiting of trees [24]. These results are in agreement with those obtained by Inglese *et al.* [4] who found that foliar application of KNO_3, during the second and the third phase of olive growth improved the fresh weight and the flesh to pit ratio. Ben-Mimoum *et al.* [25] reported that potassium fertilization improved yield and quality as well as fruit weight and flesh to pit ratio of olive. Sarrwy *et al*. [10] concluded that foliar spray with potassium nitrate at 3 % increase fruiting and fruit quality as well as fruit oil contents.

CONCLUSION

From the previously results it could be concluded that, the application of potassium nitrate seems to be beneficial for olive orchard and sprayed twice during the growth season at 4 %, the first after final fruit set to enhance nutritional status of trees and improve the vegetative growth, reduce the fruit drops and increase the productivity and the second after pit hardening, to increase fruit quality and the oil content.

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