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Effect of Increasing Fertilization Levels on Alternate Bearing of Olive Cv. "Picual"

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Abstract: The present study was carried out for three successive seasons 2008/2009, 2009/2010 and 2010/2011 on fifteen years old of olive trees cv. Picual to reduce the degree of alternate bearing through fertilization by NPK over than the rates recommended by the Ministry of Agriculture and Lands Reclamation. The obtained results showed that, fertilizing olive trees with 50% over NPK recommended doses in heavy crop year "on year" had a positive effect on improving the vegetative growth and increase yield in application year and the next year and reduce the degree of alternate bearing and improves fruit characteristics and oil content. alternate bearing fruit characteristics.

Key words: alternate bearing, fruit characteristics, NPK fertilization, oil content, Olive, vegetative growth, yield.

INTRODUCTION

Olive (*Olea europaea* L.) is a species of a small tree in the family Oleaceae, native to the coastal areas of the eastern Mediterranean Basin.

Alternate bearing is a widespread problem for growers of fruit trees, occurring in both evergreen and deciduous trees. The term “alternate or biennial” bearings are used by horticulturists to designate the production of a heavy fruit crop “on year” followed by a light fruit crop or trees may not bear a crop at the next “off year”.

In spite of alternate bearing is variety specific, but influenced by the growing environment (climate and soil) and horticultural practices which may increase or reduce the severity of alternate bearing or may lead the trees to enter the cycle of alternate bearing (Cimato and Fiorino, 1986).

The balance between NPK fertilizers is useful in the annual growth cycle of olive trees whereas, nitrogen increases leaf chlorophyll levels and photosynthesis, hence promoting shoot growth and flowering. Providing olive trees with additional doses of nitrogen before flowering and fruit set has proved beneficial. It also increases the ability of the olive tree to utilize other nutrients (Stan and David, 2007).

The olive tree requires phosphorus to promote root growth and flower bud formation. Phosphorus is needed for many biochemical processes as cell division, development of meristematic tissue (new growth), photosynthesis linked carbon fixation from carbon dioxide, intermediary metabolism and the utilization of sugars and starch (Stan and David, 2007).

Potassium has a number of important physiological and biochemical functions including: photosynthesis, respiratory processes, carbohydrate transport, synthesis of nitrogen compounds and carbohydrates, movement of water, and balancing nitrogen fertilizers (Stan and David, 2007).

Potassium fertigation of olive trees significantly increased yield and these increases were proportionate with potassium rates. El-Shazly and Abdel-Nasser (2001) and Hussein (2008). Also, it increased fruit quality parameters such as fruit weight, flesh weight, flesh percentage and fruit oil content. El-Shazly and Abdel-Nasser (2001), Ben-Mimoun *et al.,* (2004) and Elloumi *et al.,* (2009).

Substantial amounts of nutrients are lost from olive trees as a result of fruit removal, annual pruning of leaves and wood, and natural leaf drop. 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.

The main objective of this study was to try reduce the alternate bearing severity for Picual olive cv. by increasing the rates of NPK as soil fertilization.

MATERIALS AND METHODS

This study was carried out during three successive seasons, (2008/2009, 2009/2010 and 2010/2011) in a private orchard located at Cairo – Alexandria, desert road (about 50 Km from Cairo). The study was conducted on fifteen years old of olive trees cv. Picual planted at 3X5 m apart in a sandy soil, the orchard soil analysis is given in (Table 1) according to procedures which are outlined by (Wild *et al.,* 1985). The selected trees were uniform in shape, vigor, size and normal growth. All the chosen trees were going to an expected “on year” and received regular horticultural practices such as pruning, hoeing, pest and fungi control management that were carried out in the olive orchards. Irrigation was through drip system. Fertilization with farmyard manure,

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ammonium sulphate (20.6% N), calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) were added as recommended rates by Ministry of Agriculture and Land Reclamation. Fertilization by NPK rates higher than the recommended rates by the Ministry of Agriculture and Lands Reclamation as follows: (control) 100% NPK recommended rates [5 Kg ammonium sulfate (20.6 % N), 1.75 Kg of super phosphate (15.5 % P_2O_5) and 1.50 Kg of potassium sulfate (48 % K_2O)], 25% over NPK recommended rates and 50% over NPK recommended rates. All the rates were divided to three doses applied at January (before flowering) as NPK, June (after fruits set) as NK and August (after pit hardening) as NK then mixed with the soil surface layer (20 cm depth) surrounding the trunk at the external end of canopy shade.

The experiment was set in a completely randomized block, each treatment contains three replicates, each replicate represented by one tree.

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

Character	Value	Character	Value
Particle Size Distribution (%)			
Clay	10.47	EC (mm/cm)	0.37
Silt	5.23	pH	8.10
Sand	84.30	Organic matter (%)	0.52
Texture	Sandy	$CaCO_3$ (%)	15.40
Soluble Cations (meq/100 g soil)		Soluble anions (meq/100g 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	0.85	Fe	0.96
P	0.38	Zn	1.12
K	0.55	Mn	1.74

Measurements and Analysis:

1. Vegetative Growth:

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

a. Number of new shoots (current season growth).

b. Number of leaves per shoot.

c. Leaf area (cm^2) according to (Ahmed and Morsy, 1999) using the following equilibration: Leaf area = 0.53 (length x width) + 1.66.

2. Leaf Mineral Content:

For studying the effect of fertilization treatments on leaves mineral contents, leaves samples were collected at the end of each growing season during first week of September, Whereas, two leaves from every shoot (4^{th} and 5^{th} leaves) were picked then mixed together as a composite and oven dried at 70ºC till constant weight, for determination the following nutrient elements (Percentage as dry weight):

N: Using the modified micro-Kjeldahl method as lined by Pregl (1945).

P: Was estimated as described by Chapman and Pratt (1961).

K: Was determined using Flamephotometer according to Brown and Lilleland (1946).

3. Yield:

Olives were harvested at mid October every season when about 75% of the olives reached purple color, fruits of each tree were separately harvested, then weighed and yield as Kg/tree was estimated. The average two seasons of yield was calculated to avoiding the influence of alternate bearing on yield.

4. Fruit Characteristics:

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

a. Fruit length L (cm), fruit diameter D (cm) then fruit shape (L/D) ratio was calculated.

b. Average weights of fruit, flesh and seed in (g).

c. The weight ratio of flesh or seed to fruit were calculated.

d. Flesh dry weight (%): samples were dried at 60ºC in electrical air oven until constant weight then dry weight percentage was calculated according to A.O.A.C. (1995).

e. Flesh oil content (%): was determined according to Woodman (1941) by extraction the oil from the dried flesh with Soxhelt using petroleum ether 60-80°C of boiling point.

Statistical Analysis:

All obtained data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1982) using MSTAT-C program. Least significant range (LSR) was used to compare between means of treatments according to Duncan (1955) at probability of 5%.

RESULTS AND DISCUSSION

1. Effect of Fertilization with NPK on Vegetative Growth Characteristics:

A. Number of New Shoots:

Results presented in Table (2) indicate that, numbers of new shoots were significantly affected by different fertilization treatments in 2010 and 2011 seasons only**.** Use of 50% over NPK recommended doses gave the highest number of new shoots, while the lowest numbers of new shoots were observed with control in 2010 and 2011 seasons of the study.

(B) Number of Leaves/Shoot:

Results in Table (2) show that numbers of leaves/shoot were significantly affected by different fertilization treatments in the three seasons of the study**.** Number of leaves/shoot were significantly increased in the three seasons when trees were fertilized with 50% over NPK recommended doses, while the lowest number of leaves/shoot were observed with control.

(C) Leaf Area (Cm²):

As shown in Table (2) leaf area was significantly affected by different fertilization treatments in the three seasons of the study. In addition, leaf area was significantly increased in the three seasons when trees were fertilized with 50% over NPK recommended doses, while the lowest leaf area was observed with control.

These results are in accordance with those obtained by Amit *et al.*, (1999), Abdel-Nasser and El-Shazly (2001), Ben-Mimoun *et al.*, (2004) and Hussein (2008). They mentioned that different fertilizers quantities showed positive effects on vegetative parameters of olive trees.

Table 2: Effect of NPK as soil fertilization on some vegetative growth characteristics of olive cv. Picual from 2009 to 2011 seasons.

	No. New shoots			No. Leaves/shoot			Leaf area (cm²)		
Treatment	2009	2010	2011	2009	2010	2011	2009	2010	2011
Control (NPK at 100 %)	8.67 a	11.50 b	8.83 b	19.00 c	26.00 c	20.33 c	4.41 b	5.11 c	4.45 b
25 % over NPK recommended dose	9.00 a	13.33 a	9.45 ab	23.00 b	28.33 b	24.67 b	4.56 ab	5.70 b	4.79 a
50 % over NPK recommended dose	9.00 a	14.00 a	10.83 a	25.00 a	31.67 a	25.67 a	4.68 a	5.85 a	4.84 a

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation

2. Effect of Fertilization with NPK on Leaves Mineral Contents:

Table (3) illustrates the effect of NPK as soil fertilization on NPK contents of olive leaves cv. Picual during 2009 and 2010 seasons. NPK content in leaves were significantly affected by different fertilization treatments in the three seasons of the study**.** Moreover, fertilizing olive trees with 50% over NPK recommended doses gave the highest NPK content in leaves, while the control gave the lowest NPK content in leaves.

Brown *et al.*, (1995) reported that in an “on year”, the macronutrient demand by leaves plus fruit is more extended throughout the season. Also, Richard *et al.*, (1998) showed that heavy fruiting significantly reduced NPK at the end of the year. Heavy cropping, however, significantly reduced both functional storage and tree nutrient contents in “on year”.

The improvement of nutritional status may be attributed to the differential accumulation of NPK in the leaves of olive trees which increases the efficiency either in absorption or utilization of nutrient.

These observations are in accordance with those obtained by Abdel-Nasser and El-Shazly (2001), Ben-Mimoun *et al.,* (2004), Hussein (2008) and Elloumi *et al.,* (2009). They revealed that increasing NPK fertilization level significantly increased leaf content of NPK.

Table 3: Effect of NPK as soil fertilization on NPK contents of olive leaves cv. Picual during 2009 and 2010 seasons.

	N (%)		P (%)		K (%)	
Treatment	2009	2010	2009	2010	2009	2010
Control (NPK at 100 %)	0.79 b	0.77 c	0.35 c	0.40 c	0.74 b	0.79 c
25 % over NPK recommended dose	0.87 b	0.99 b	0.49 b	0.68 b	0.85 b	0.90 b
50 % over NPK recommended dose	1.21 a	1.51 a	0.67 a	0.86 a	1.05 a	1.34 a

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation.
- 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 (2007).

3. Effect of Fertilization with NPK on Yield and Alternate Bearing Behavior:

Table (4) shows that, yield was significantly affected by different fertilization treatments in the three seasons of the study**.** In the three seasons, fertilizing olive trees with 50% over NPK recommended doses significantly increased the yield while the control gave the lowest yield.

As it is well known that alternate bearing is a characteristic feature of olive, the effect of fertilization treatments on the total yield of three seasons 2009, 2010 & 2011 was subjected to analysis of variance. The obtained results revealed that 50% over NPK recommended doses gave the highest total yield, however the lowest total yield was observed with control.

Concerning the alternate bearing index, results showed that control trees gave the highest alternate bearing index while fertilizing olive trees with 25 or 50 % over NPK recommended doses reduce the alternate bearing index.

These results are in agreement with Abdel-Nasser, and El-Shazly (2001), Ben-Mimoun *et al.,* (2004), Hussein (2008) and Elloumi *et al.,* (2009). They reported that increasing mineral fertilization significantly increased the yield of olive trees. On the other hand, Restrepo *et al.,* (2008) concluded that there were no significant differences on yield as results of K fertilization.

Table 4: Effect of NPK as soil fertilization on yield and alternate bearing index of olive cv. Picual from 2009 to 2011 seasons.

	Yield (Kg/tree)			Average two seasons of yield		Alternate bearing index (ABI)
Treatment	2009	2010	2011	2009&2010	2010&2011	
Control (NPK at 100 %)	22.33 c	17.67 c	43.00 c	20.00 c	30.34 c	0.267
25 % over NPK recommended dose	24.00 b	23.00 b	47.33 b	23.50 b	35.17 b	0.184
50 % over NPK recommended dose	25.67 a	25.33 a	54.00 a	25.50 a	39.67 a	0.184

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation.

4. Effect of Fertilization with NPK on Fruit Characteristics:

A. Fruit Length:

Results presented in Table (5) show that fruit length was significantly affected by different fertilization treatments in the three seasons. The highest fruit length was observed with trees treated by 50% over NPK recommended doses in the three seasons and 25% over NPK recommended doses in 2011 season while the lowest fruit length was observed with the control in the three seasons of the study.

B. Fruit Diameter:

As shown in Table (5) fruit diameter was significantly affected by different fertilization treatments in the three seasons. In addition, the highest fruit diameter was observed with trees treated by 50% over NPK recommended doses in the three seasons and 25% over NPK recommended doses in 2011 season while the lowest fruit diameter was observed with the control in the three seasons of the study.

C. Fruit Shape Index (L/D):

Results presented in Table (5) indicate that, fruit shape index was significantly affected by different fertilization treatments in 2009 and 2010 seasons only. In the three seasons, the highest fruit shape index was obtained by the control. On the other hand, fertilizing olive trees with 50% over NPK recommended doses gave the lowest fruit shape index.

Table 5: Effect of NPK as soil fertilization on fruit dimensions and fruit shape index of olive cv. Picual from 2009 to 2011 seasons.

Treatment	Fruit length "L" (cm)			Fruit diameter "D" (cm)			Fruit shape index (L/D)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
Control (NPK at 100 %)	2.62 b	2.83 b	2.40 b	2.15 c	2.23 c	1.87 b	1.22 a	1.27 a	1.28 a
25 % over NPK recommended dose	2.70 ab	2.92 b	2.53 a	2.35 b	2.47 b	2.00 a	1.15 ab	1.18 b	1.27 a
50 % over NPK recommended dose	2.75 a	3.07 a	2.60 a	2.48 a	2.65 a	2.08 a	1.11 b	1.16 b	1.25 a

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation

D. Fruit Weight:

Fruit weight was significantly affected by different fertilization treatments in 2009 and 2010 seasons only (Table 6). The highest fruit weight was observed with 25 or 50% over NPK recommended doses in the three seasons. However, the control gave the lowest fruit weight in 2009 and 2010 seasons of the study with no significant differences between all treatments in 2011 season.

E. Flesh Weight:

Table (6) shows that, flesh weight was significantly affected by different fertilization treatments in the three seasons. Use of 50% over NPK recommended doses significantly increased flesh weight in the three seasons and this was on a par with 25% over NPK recommended doses in 2010 season while the control gave the lowest flesh weight.

F. Seed Weight:

As shown in Table (6), seed weight was not affected significantly by different fertilization treatments in the three seasons of the study.

Table 6: Effect of NPK as soil fertilization on weights of fruit, flesh and seed of olive cv. Picual from 2009 to 2011 seasons.

Treatment	Fruit weight (gm)			Flesh weight (gm)			Seed weight (gm)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
Control (NPK at 100 %)	7.10 b	9.54 b	8.02 a	5.87 c	7.61 b	6.55 b	1.23 a	1.93 a	1.47 a
25 % over NPK recommended dose	8.63 a	9.86 a	8.05 a	6.73 b	8.59 a	6.80 ab	1.90 a	1.27 a	1.25 a
50 % over NPK recommended dose	8.82 a	9.80 a	8.25 a	7.59 a	8.67 a	7.20 a	1.23 a	1.13 a	1.05 a

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation

G. Flesh/Fruit Weight Percentage:

As shown in Table (7), flesh/fruit weight percentage was significantly affected by different fertilization treatments in the three seasons of the study. Flesh/fruit percentage during the three seasons was significantly greater when the trees treated by 50% over NPK recommended doses, also those were on a par with 25% over NPK recommended doses in 2010 season while the control gave the lowest flesh/fruit weight percentage in 2010 and 2011 seasons.

H. Seed/Fruit Weight Percentage:

Results in Table (7) indicate that, seed/fruit weight percentage was significantly affected by different fertilization treatments in the three seasons of the study. In the three seasons, 50% over NPK recommended doses significantly decreased seed/fruit weight percentage while the highest seed/fruit weight percentage was observed with 25% over NPK recommended doses in 2009 season and with the control in 2010 and 2011 seasons.

Table 7: Effect of NPK as soil fertilization on flesh and seed weight percentages of olive cv. Picual during 2009 and 2011 seasons.

Treatment	Flesh/fruit weight (%)			Seed/fruit weight (%)		
	2009	2010	2011	2009	2010	2011
Control (NPK at 100 %)	82.68 b	79.77 b	81.67 c	17.32 b	20.23 a	18.33 a
25 % over NPK recommended dose	77.98 c	87.11 a	84.47 b	22.05 a	12.88 b	15.53 b
50 % over NPK recommended dose	86.05 a	88.47 a	87.27 a	13.95 c	11.53 b	12.73 c

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation

I. Flesh Dry Weight (%):

Results presented in Table (8) indicate that, fruit dry weight percentage was significantly affected by different fertilization treatments in 2009 and 2011 seasons. In addition, flesh dry weight percentage was changeable during the three seasons, where the highest flesh dry weight was observed with control in 2009 and 2010 seasons while 25 or 50% over NPK recommended doses gave the highest flesh dry weight in 2011 season. On contrast, the lowest flesh dry weight was observed with 25 % over NPK recommended doses in 2009 season and control in 2011 season.

J. Flesh Oil Content (%):

As shown in Table (8), flesh oil content (%) was significantly affected by different fertilization treatments in the three seasons of the study. In the three seasons, fertilizing olive trees with 50% over NPK recommended doses gave the highest flesh oil content followed by 25% over NPK recommended doses and control gave the lowest flesh oil content.

These results are in agreement with El-Shazly and Abdel-Nasser (2001), Ben-Mimoun *et al.*, (2004), Hussein (2008), and Elloumi *et al.*, (2009). They showed that fruit quality parameters of olives such as fruit weight, flesh weight, flesh percentage and fruit oil content were significantly increased as a result of increasing mineral fertilization rates.

Table 8: Effect of NPK as soil fertilization on flesh dry weight and oil content percentages of olive cv. Picual during 2009 and 2011 seasons.

	Flesh dry weight (%)			Flesh oil content (%)		
Treatment	2009	2010	2011	2009	2010	2011
Control (NPK at 100 %)	26.74 a	29.08 a	25.29 b	27.67 c	32.02 c	29.45 b
25 % over NPK recommended dose	25.00 b	28.14 a	27.25 a	29.49 b	35.80 b	31.14 ab
50 % over NPK recommended dose	24.33 b	29.00 a	27.55 a	32.49 a	39.73 a	33.47 a

- Means followed by a letter in common in the same column are not significantly different at 0.05 level of probability
- NPK at 100 %: Recommended doses according to Ministry of Agriculture and Land Reclamation.

Conclusion:

Through the previous results one can say that the increase of fertilization rates by 50% over NPK recommended doses in “on year” helps to compensate for depletion of minerals nutrient and improves the vegetative growth, yield and fruit quality of the olive trees of the same “on” and next “off” year.

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