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Effect of Fertilization with Increasing Doses of Ammonium Nitrate on Growth, Yield, and Concentration of N, P, and K in Leaves of Olive Trees (Olea Europea L.) c.v. "Kalinioti"

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Effect of Fertilization with Increasing Doses of Ammonium Nitrate on Growth, Yield, and Concentration of N, P, and K in Leaves of Olive Trees (Olea Europea L.) c.v. "Kalinioti"

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Abstract: Nitrogen is the most commonly managed mineral nutrient in olive groves because it is essential for plant growth. The precise management of N fertilization in olive cultivation is still not fully clarified, but it is now essential for providing sustainable production. A nitrogen fertilizer experiment with olive trees (cv. Kalinioti) was carried out over a six-year period. Seven levels of nitrogen fertilizer given as ammonium nitrate (control, 1, 2, 3, 4, 5, and 6 kg/tree) were annually applied in order to determine the effect of nitrogen on vegetative growth, fruit set, fruit weight, yield, maturation index and leaf N,P, and K concentrations. The results indicate that, under these conditions, application of up to 4 kg NH_4NO_3/tree significantly increased yield to 62.5 kg/tree compared to the control. The positive effect was attributed to the initial and final fruit set increases (7.63 and 3.73%, respectively). However, the weight of 100 olives (337 g) at the same fertilizer rate was considerably lower compared to the control. Higher nitrogen rates decreased yield while increasing overall shoot growth. Nitrogen fertilization did not significantly influence the oil content of olive fruit. Fruit weight, maturation index and concentration of oil reached maximum levels in the beginning of December, indicating a suitable start to olive harvesting with reduced yield losses due to unfavorable weather conditions. With increasing fertilizer levels from 0 to 6 kg NH_4NO_3,/tree concentration of N in olive leaves also increased from 1.23% to 2.38%. Maximum yield was achieved at a level of 6 kg NH_4NO_3/tree, which corresponded to 2.01% N in leaves. The results suggest that application of 3 kg NH_4NO_3/tree can be recommended for table olive production due to the fact that fruit weight was not decreased, while fertilization with 4 kg NH_4NO_3/tree was suitable for oil olives.

Keywords: olive trees; nitrogen fertilization; yield; leaf concentration; fruit set

1. Introduction

Application of Nitrogen is the main aspect of olive orchard (*Olea europaea* L.) fertilization due to its significant influence on plant growth as a key nutritional component [1,2]. The importance of N fertilization in enhancing olive productivity has been reported by a number of researchers [3–6]. These studies have consistently reported a gradual increase in productivity, as a result of nitrogen applications.

There is some disagreement on the importance of applying nitrogen once a year, to increase olive production when it comes to fertilization management, since N is often given in too large of amounts [1,7,8]. According to Fernández-Escobar et al. [9], a major problem arises in olive orchards due to excessive nitrogen fertilization, leading to various adverse effects on both the trees and the soil. Furthermore, excessive use of fertilizer faces significant costs and results in the loss of nitrogen through leaching, which has detrimental effects on the ecosystem [10]. The optimal management of nitrogen fertilization in olive orchards, including fertilizer dose and timing of distribution, remains poorly understood [7,11,12]. However, it is of paramount significance to develop management

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strategies aimed at mitigating the environmental consequences of nitrogen losses and minimizing the adverse impacts of excessive nitrogen on tree health.

Many works on olive nutrition have pointed out that nitrogen fertilization a) promotes olive yield [4–6]; b) reduce the phenomenon of alternate bearing [6,13]; c) increases fruit set [14]; d) increases shoot length and the number of inflorescences and regulates the growth of female bodies of olive flowers [15–18]. Most of them have used between 0.5 and 1.3 kg N/ tree in their experiments, while the application of excessive amounts of nitrogen had adverse effects on yield, fruit weight, fruit set, oil content and oil quality [14,18–20]. Hartmann [15] pointed out that N fertilization consistently increases olive yield, but only when leaf N is below the sufficiency threshold. On the other hand, the limited supply of nitrogen resulted in a reduction in vegetative growth, flowering, fruit set, and ultimately fruit output. Furthermore, it has been observed that both excessive and insufficient amounts of nitrogen have a considerable negative impact on oil productivity, as demonstrated by previous studies [6,14]. It must be emphasized that early investigations have also shown that the application of nitrogen does not improve olive performance [9,21].

Nitrogen fertilization is usually applied to the soil at 0.5–1.5 kg per olive tree at the end of winter, using urea, ammonium sulfate, or ammonium nitrate, mainly depending on soil properties [22,23]. A lack of nitrogen is a common nutritional deficiency in olives. Symptoms of nitrogen deficiency in olive trees have been recorded by many workers [15,17]. Concentration of N can be correctly detected through a leaf analysis, which is the best diagnosis method to determine the nutrient status and plan fertilizer recommendations [24]. Despite the economic importance of olive tree cultivation in the Mediterranean region, there is not enough information regarding olive nutrient requirements, mainly nitrogen [17,25]. Ferreira et al. [26] argue that previous studies on nitrogen fertilization in olive groves, while important, lack conclusive guidance for fertilizer recommendation systems. Consequently, this topic holds scientific interest and carries substantial practical significance within the field of olive grove fertilization.

A good knowledge of olive nutrition is fundamental in order for fertilization to promote olive fruit and oil production and decrease the phenomenon of alternate bearing. This phenomenon may influence the nutrient content of the trees and their annual nutrient consumption [27]. The lack of data regarding nitrogen fertilization of the olive variety Kalinioti cultivated in South Albania, in conjunction with the fact that olive fertilization is usually based on visual practices, has resulted in the thoughtless and excessive use of nitrogenous fertilizers that many times adversely affect productivity, fruit quality, olive oil production, and groundwater quality [28–30]. The aim of this work was to study the effect of nitrogen fertilization on the vegetative growth, yield, fruit set, fruit weight, and fruit oil concentration of the olive cultivar Kalinioti and to determine its nitrogen requirements.

2. Results

A significant and positive impact of N-fertilizer doses on shoot length was recorded (Table 1). Tree crown volume showed the same tendency with the amount of N applied (Table 2). At the highest level, N trees showed excessive vegetative growth with many water shoots.

Table 1. The effect of increasing doses of ammonium nitrogen fertilizer on shoot length of olive (c.v. Kalinioti) trees.

Treatments	Shoot length (cm)
Control	9.2*a* (1)
1 kg NH_4NO_3/tree	11.4*b*
2 kg NH_4NO_3/tree	12.8*bc*
4 kg NH_4NO_3/tree	19.3*e*
5 kg NH_4NO_3/tree	24.7*f*

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6 kg NH_4NO_3/tree	30.2*h*

(1) Means in the same column followed by different letters denote significant differences according to Duncan's multiple range test (P=0.05).

Table 2 shows that N fertilization positively affected olive yield compared to control. The increase was significant with the application of 4 kg NH_4NO_3/tree, where yield reached 62.5 kg/tree compared to 37.1 kg/tree of the control. Further increases in N rates significantly reduced yield but increased the number of water shoots.

Table 2. The effect of increasing doses of ammonium nitrogen fertilizer on fruit yield and canopy volume of olive (c.v. Kalinioti) trees. .

Treatments	Yield (kg/tree)	Canopy volume (m^3)	Yield (kg/m^3)
Control	37.09*a* (1)	18.2*a*	2.03*a*
1 kg NH_4NO_3/tree	39.2*a*	19.4*a*	2.02*a*
2 kg NH_4NO_3/tree	45*ab*	19.8*ab*	2.27*a*
3 kg NH_4NO_3/tree	54*c*	21.5*b*	2.51*ab*
4 kg NH_4NO_3/tree	62.5*d*	21.0*ab*	2.97*b*
5 kg NH_4NO_3/tree	49.0*b*	24.7*c*	1.98*a*
6 kg NH_4NO_3/tree	46.4*ab*	25.8*cd*	1.79*a*

(1) Means in the same column followed by different letters denote significant differences according to Duncan's multiple range test (P=0.05).

As regards fruit set, a significant increase in the initial fruit set was recorded due to the application of 3 and 4 kg NH_4NO_3/tree compared to the control (Table 3). Application of 4 kg fertilizer/tree gave the highest initial and final fruit sets (7.63 % and 3.03 % respectively) among treatments. A further increase of N fertilizer (5 kg NH_4NO_3/tree and 6 kg NH_4NO_3/tree, or approximately 1.74 and 2.1 kg N/tree, respectively) reduced fruit set.

Furthermore, a delay of 8–10 days on fruit coloration was evident (Table 4). Fresh weight of 100 olives, oil content, and maturation index increased with time, reaching maximum levels at 5–10 December. Even though maximum yield was achieved with the addition of 4 kg NH_4NO_3/tree, the weight of 100 olives was significantly lower compared to the other treatments. The application of nitrogenous fertilizer had no effect on oil content, but higher fertilizer applications (5 and 6 kg NH_4NO_3/tree) in December substantially reduced the maturation index.

Table 3. The effect of increasing doses of ammonium nitrogen fertilizer on initial (June) and final (November) fruit set of olive (c.v. Kalinioti) trees. .

Treatments	Initial fruit set (June) (%)	Final fruit set (November) (%)
Control	3.07*a* (1)	0.7*a*
1 Kg NH_4NO_3/tree	3.55*a*	1.13*a*
2 Kg NH_4NO_3/tree	5.32*ab*	1.79*ab*
3 Kg NH_4N0_3/tree	6.09*b*	2.53*c*
4 Kg NH_4N0_3/tree	7.63*bc*	3.03*cd*
5 Kg NH_4N0_3/tree	5.91*ab*	1.71*ab*
6 Kg NH_4N0_3/tree	5.19*ab*	1.65*ab*

(1) Means in the same column followed by different letters denote significant differences according to Duncan's multiple range test (P=0.05).

Table 4. The effect of time collection, on weight of 100 olives (W, g./tree), oil content (OC, %) and maturation index (M.I., %) of olive (c.v. Kalinioti) trees.

	1-5 November			20-25 November			5-10 December			20-25 December		
	W_{100}	OC	M.I.	W_{100}	OC	M.I.	W_{100}	OC	M.I.	W_{100}	OC	M.I.
Treatments	g	%	%	g	%	%	g	%	%	g	%	%
Control	336*a*(1)	21.8*a*	2.13*a*	360*a*	24.2 *a*	3.05*a*	389*a*	27.1	3.66*a*	384*a*	26.2	3.37*a*
1 kg NH_4NO_3/tree	*325ab*	21.3*a*	2.10*a*	353*a*	23.8	3.15*a*	375*a*	26.8	3.75*a*	375*a*	26.5	3.44*a*
2 kg NH_4NO_3/tree	321a b	21.2*a*	2.18*a*	342*ab*	24.5 *a*	3.21*a*	370*ab*	27.2	3.82*a*	369*a*	26.7	3.48*a*
3 kg NH_4NO_3/tree	318*ab*	21.0*a*	2.12*a*	329*b*	23.7 *a*	3.28*a*	365*ab*	27.5	3.78*a*	361*ab*	26.0	3.51*a*
4 kg NH_4NO_3/tree	381*c*	20.9*a*	2.10*a*	309*c*	23.5 *a*	3.15*a*	337*c*	26.3	3.66*a*	331*c*	25.8	3.55*ab*
5 kg NH_4NO_3/tree	315*d*	20.8*a*	1.95*a b*	345*ab*	24.1 *a*	2.75*a b*	374*ab*	26.8	3.16*a*	370*ab*	25.9	3.00*a*
6 kg NH_4NO_3/tree	312*d*	21.1*a*	1.87*b*	340*ab*	23.7 *a*	2.71*a b*	378*a*	27.0*n s*	3.11*a*	373*a*	26.1*n s*	3.01*a*

(1) Means (values of 6 years) in the same column followed by different letters denote significant differences according to Duncan's multiple range test (P=0.05). ns: no significant differences.

With increasing N doses, leaf N concentration increased, reaching 2.38% at the level of 6 kg NO_3NH_4/tree (Table 5). Maximum yield (62.5 kg/tree at the dose of 4 kg/tree) corresponded to 2.01 % N in leaves. Control trees and trees receiving 1 kg NO_3NH_4 showed leaf N concentrations (1.23-1.34%, d.w.) below the optimum levels (1.5-2.3%) [31,32]. High fertilizer levels (5-6 kg NH_4NO_3/tree) reduced P and K concentrations in leaves compared to control; however, the decrease was significant only for K. Leaf P and K concentrations were within the optimal range (0.09-0.3% for P and 0.70-1.0% for K) [17,32], with the exception of the concentration of K in the leaves of trees receiving N dosages (5-6 kg NH_4NO_3/tree), where values were above deficient levels (0.4%, dry weight).

Table 5. The effect of increasing doses of ammonium nitrogen fertilizer on N, P, K concentration of leaves of olive (c.v. Kalinioti) trees.

Treatments	**N (%, d.w.)**	**P (%, d.w.)**	**K (%, d.w.)**
Control	1.23a (1)	0.123ab	0.78b
1 kg NH_4NO_3/tree	1.34a	0.125ab	0.75b
2 kg NH_4NO_3/tree	1.55b	0.128b	0.77b
3 kg NH_4NO_3/tree	1.89c	0.131b	0.73b
4 kg NH_4NO_3/tree	2.01d	0.129b	0.69ab
5 kg NH_4NO_3/tree	2.29e	0.120a	0.61a
6 kg NH_4NO_3/tree	2.38ef	0.115a	0.57a

(1) Means in the same column followed by different letters denote. significant differences according to Duncan's multiple range test (P=0.05).

3. Discussion

The significant and positive impact of N-fertilizer doses on shoot length and tree crown volume indicated that nitrogenous fertilization promoted vegetative growth. In fact, the highest level of leaf N (2.38%) found in treatments with 6 kg NH_4NO_3/ tree showed excessive vegetative growth. Similar findings were reported by Hartman [33] and Gavalas [17], where shoot growth was increased by high N doses (1.5-2 kg/tree). Haberman et al also [6] also found that the highest N level was the most effective in promoting vegetative growth but did not induce an increase in yield, whereas low nitrogen fertilization has negative effects on both vegetative growth and the production of olive fruit and oil content. These effects were attributed to a decrease in the intensity of flowering and a reduction in the rate of perfect flowers and fruit set.

The high yields achieved at 3 and 4 kg fertilizer/ tree were necessary for a satisfactory production, which is probably attributed to different soil climate conditions, different varieties, e.t.c. Similar findings were reported by Esteban et al. [34] where maximum yields corresponded to 1.2 kg N/tree (about 3.4 kg NH_4NO_3/ tree). In addition, many workers found an increase in olive yield of up to 50% when nitrogen was given at a level of 1.2 kg/tree compared to untreated trees [13,16,17]. Olive trees in southern Spain's arid regions were fertilized annually with varying quantities of nitrogen. Fernández-Escobar and Marín [22] and Fernández-Escobar et al. [35] concluded that after three and six years of experimentation, respectively, increasing the amount of N applied from 0 to 1 kg of N per olive tree (about 2.86 kg NH_4NO_3/ tree) did not result in an increase in yield, fruit size, oil content, or vegetative growth. Fernández-Escobar and Marín [22] suggested that there is no need for annual application of nitrogen fertilizer in olive orchards, in order to achieve satisfactory productivity and growth, as long as the leaf nitrogen levels remain over the sufficiency threshold. Further increases in N rates (>4 kg fertilizer/ tree) reduced yield and increased the number of water shoots, which have high requirements for nutrients and water [15,17]. Ângelo Rodrigues et al [36] recommend adjustments to the rates of N every year to prevent reductions in tree crop performance and improve nutrient-use efficiency.

High application rates of nitrogen (3-4 kg NH_4NO_3/tree) significantly reduced fruit set compared to control. Similar results were found by other workers [16,17,34]. In a container experiment, Erel et al. [18] investigated the effects of nitrogen, phosphorus, and potassium concentrations in the irrigation solution on olive tree flowering and fruit set (*Olea europaea* L. cv. Barnea). They observed that the highest N concentration in the irrigation solution (14.1mM) decreased fruit set, but to a lesser extent than flowering. According to the findings of Fernández-Escobar et al. [37], the maturation of the fruit was observed to be delayed in trees exhibiting elevated nitrogen levels. This delay was attributed to the increased concentration of anthocyanin. Similarly, N deficiency has an adverse impact on fruitset [38], probably due to inadequate total quantities of nutrients available to the flowers when they developed into fruit [18].

The results of olive yield and the observations taken during the experimental period show that the NH_4NO_3 doses of 3-4 kg/tree reduced alternate bearing. Moreover, under low N availability, trees appeared to be more susceptible to alternate bearing [6]. Nitrogen fertilization before and after fruit set (June) seems to correct this phenomenon [39]. Therefore, the ratio yield from 6:1 at control was reduced to 4.5:1 and 4:1 at 3 and 4 kg NH_4NO_3/ tree respectively. González et al [13] showed that sufficiency of nitrogen during and after fruit set in the year of olive production strengthens shoot growth, which, when there is a large amount of final fruit set, is usually exceptionally low and consequently the next year's yield as well.

The significant increase with time in fresh weight of 100 olives, oil content, and maturation index (Table 4) reached maximum levels at 5–10 December, indicating a suitable period for harvest when considering the local soil climatic conditions. In this way, we can avoid yield losses derived from early or late harvests. Even though maximum yield was achieved with the addition of 4 kg NH_4NO_3/tree, the weight of 100 olives was significantly lower compared to the rest of the fertilization rates, which is not desirable for table olives. Many authors have also reported that high N fertilization reduces olive weight [15,17,40]. In particular, Silva et al. [40] reported that Nitrogen application decreased the fruit's weight and size due to photosynthate partitioning. In addition, elevated nitrogen applications (4-6 kg NH_4NO_3/tree) had a negative impact on maturation index relative to the control by extending the coloration period and fruit maturation [14,18,41]. Silva et al. [40] reported that Nitrogen application reduced the fruit maturation index, particularly when applied at high rates (120 N kg ha^{-1})

Moreover, our results showed that nitrogen fertilization did not affect oil content. Similar findings were also reported by Fernández-Escobar et al. [35] where increasing the amount of nitrogen applied from 0 to 1 kg of N per olive tree did not result in an increase in oil content. Moreover, Fernández-Escobar and Marin [22] found that the oil content of trees with leaf nitrogen concentrations below the deficient threshold of 1.4% was lower, indicating that lipogenesis was also delayed. In contrast, other authors have shown that nitrogen fertilization has positive effects on oil content [41]. Erel et al. [42] highlighted the significance of balanced N nutrition in oil-olive cultivation for optimizing oil content production.

The nitrogen status of olive trees is often assessed by analyzing the concentration of nitrogen in the leaves during the month of July. A leaf nitrogen content below 1.2-1.4% is generally regarded as a deficiency level [21,35,43,44]. Control trees and trees receiving 1 kg NH_4NO_3 showed leaf N concentrations (1.23 % dw and 1.34 % dw, respectively) below the optimum levels. On the other hand, maximum yield corresponded to 2.01% N in leaves. Almeida et al [45] found that maximum olive yield corresponded to 2.1 % N concentration in leaves. Vasilaki Stamou and Prasoulidou Bovi [46] did not find a significant increase in yield when N leaf levels ranged between 1.54 and 1.66 % compared to untreated trees, but significant yield increases were evident at 2.05% N. On the other hand, Gonzalez et al. [13] reported reduced yields when the concentration of N in leaves exceeded the level of 2.3%. Similarly, in our study, leaf N concentrations of 2.29–2.38% in trees treated with 5–6 kg of NH_4NO_3 were associated with reduced yields. According to Ferreira et al. [26], the response of olive plants to nitrogen is dependent on agroecological growing conditions, specifically those determining yield potential and nutrient removal.

In addition, after six years of experiments, even control trees showed leaf P and K concentrations in leaves within the optimum range according to Gavalas [17] (0.09-0.11% for P and 0.70-0.90% for K), which is probably due to the fact that basic soil analysis showed an excessive concentration of P (120 mg kg^{-1}) and an adequate level of available K (0.45 meq/100g).

4. Materials and Methods

For the experiment, 25-year-old irrigated olive trees cv. "Kalinioti" grafted on wild olive rootstock (O.e.v. Oleaster) were selected. The soil of the experimental field was clay loamy, with slightly alkaline pH 7.8, rich in total $CaCO_3$ (10.3%), poor in organic matter (1,2 %), medium in total N (1.47 mg/g), relatively high in available K (0.45 meq/100g) and very rich in available phosphorus (120 mg kg-1), indicating that phosphorus is more likely to be lost by runoff, since levels of P-Olsen exceeded 60 mg kg-1 [47]. A complete randomized design was implemented with seven levels of nitrogenous fertilizer NH_4NO_3, 0 (control) to 6 kg/tree, which corresponded to approximately 0, 0.3, 0.7, 1.0, 1.3, 1.7, and 2 kg N /tree respectively. Each treatment consisted of three plots and each plot had five well-developed olive trees. The selection of trees was based on criteria of uniformity for vigor and fruit load. Fertilizer was applied on a per-tree basis. Half of the fertilizer was given at the beginning of the annual cycle, in the first 10 days of March, and the rest was given at the end of the fruit set [48], which approximately corresponded to the end of May and the beginning of June. Trees were drip-irrigated with hundred liters of water per week.

4.1. Measurements

1. *Vegetative growth*: From March to November, the length of 20 tagged shoots located at the four points of the horizon was measured monthly in two trees from each replicate.

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2. *Fruit set*: Fruit set was expressed as the percentage of the initial number of flowers. Four branches were taken from the middle of the crown of one tree/ plot/treatment and from the four points of the horizon. In total, 2000 buds were approximately used in each plot. Measurements were taken each month from May to November.
3. *Olive yield*: Harvest took place in the second half of December.
4. *Fruit weight*: The fresh weight of 100 fruits was measured from each tree in the experimental plots. Samples were taken every 15 days during November and December.
5. *Maturation index*: Samples of 100 olives per tree were selected every 15 days during November and December and were categorized into 8 colour classes in order to determine the maturation index according to the following equation [49].

$$M.I. = (\alpha\chi\ 0 + b\chi 1 + c\chi 2 + d\chi 3 + e\chi 4 + f\chi 5 + g\chi 6 + h\chi 7)\ /100$$

where a-h, are the numbers of olives and 1-7 are the numbers of colour classes.

6. *Canopy volume*: For the determination of the canopy volume the following equation was used according to Roose et al [50]:

$V=4/6 \times \pi \times H \times R2$ where V= volume (m^3) , $\pi=3.14$, H= tree height (m) and R= radius of canopy

7. *Fruit chemical analysis*: Oil content was determined on a sample of about 100 fruits per tree by extracting dry material with petroleum ether at 40–60 °C using a Soxhlet apparatus. Olives were dried at 70 °C in a ventilated oven until a constant weight was measured in two successive weighing measurements. Then olives were ground in a mortar and the paste was weighed and analyzed by the Soxhlet apparatus [51]
8. *Leaf analysis*: Samples of 40 fully-expanded, mature leaves (5-8 months old) per tree were collected at the end of August from the middle portion of non-bearing, current-season shoots, according to the method described by Koukoulakis and Papadopoulos, [52]. Once in the laboratory, samples were washed using 1% Triton X-100, and rinsed three times with water and deionized water. Moisture was eliminated using filter paper and then the samples were dried in paper envelopes at 70 ^{0}C until they reached a constant weight. Dried samples were ground in a stainless "Fritch" pulverisette mill to pass through the 1-mm round whole sieve. Ground samples were stored at room temperature in acid-washed glass jars. Leaf samples were analyzed for total N, P, K. Total N was determined by the Kjeldahl method, using a semiautomatic analyzer Buchi, B324. Prior to the measurement of the other nutrients, leaf subsamples were subjected to dry ashing at 520◦C for 6 hours, then diluted with hydrochloric acid (HCl) in a 1:1 ratio v/v [53]. Phosphorus was determined calorimetrically in the same solution by the vanado-molybdo-phosphoric method [54] using an UV–vis spectrophotometer. Total K, through atomic absorption spectrophotometry (PerkinElmer AAnalyst 100 atomic absorption spectrometer).

4.2. Statistical analysis

The effect of nitrogenous fertilizer on plant attributes was evaluated using one-way analysis of variance (ANOVA) with SPSS version 21. The experimental design used was Completely Randomized Design (CRD). Before performing analysis of variance (ANOVA), Shapiro-Wilk ($p \leq 0.05$) and Bartlett ($p \leq 0.05$) tests were applied to test normality and homogeneity of variances, respectively. Duncan's multiple-range test was used to test differences among means ($P < 0.05$).

In conclusion, considering the current experimental conditions, the application of 4 kg NH_4NO_3/ tree gave the highest yield while significantly reducing the weight of 100 olives and therefore this dose is recommended for olive oil production. Similar yields were also achieved by the lower dose of fertilizer, 3 kg NH_4NO_3/tree, without reducing olive weight indicating the appropriate fertilizer dose for table olives. Further additions of fertilizer caused reduced growth and a delay in fruit maturation. The best period for harvesting olives c.v. Kalinioti seems to be the beginning of December (5-10) when olive weight, oil content and maturation index are at their maximum levels.

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