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Effects of Chemical Fruit Thinning on Oil Yield and Quality in 'Gemlik' Olive (*Olea europaea* L.)

Kimyasal Meyve Seyreltmesinin 'Gemlik' Zeytininde (*Olea europaea* L.) Yağ Verimi ve Kalitesine Etkileri

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Key Words:

Olive, oil, thinning, NAA, quality

ABSTRACT

Gemlik olive variety started to be grown in many areas of Turkey in recent years. 'Gemlik' is mainly a black table variety, but it is processed to oil in many areas. So chemical fruit thinning may be useful to control alternate bearing and standardization of the fruit and consequently the possible oil quality. In this work, predicting the effects of chemical fruit thinning by potassium salt of naphtaleneacetic acid (NAA-K) on oil yield and quality in 'Gemlik', which is one of the prominent olive variety of Turkey was aimed. Results showed that NAA applications decreased the oil acidity levels in the first year (off year). In the second year (on year), NAA sprayings at 100 and 120 ppm increased the oil acidity up to 1,75 % while 150 ppm decreased the acidity value to 0,36 %. 180 ppm NAA significantly augmented the oil content of olive fruits particularly in "on year" and gave rise to 22 and 48 % increments in oil rates successively on fresh and dry matter basis compared to control.

Anahtar Sözcükler:

Zeytin, yağ, seyreltme, NAA, kalite

ÖZET

Son yıllarda Türkiye'nin birçok bölgesinde 'Gemlik' zeytin çeşidi yetiştirilmeye başlanmıştır. Esasta siyah sofralık olan 'Gemlik', birçok yerde yağa da işlenmektedir. Bu nedenle periyodisite kontrolünün yanı sıra, meyve ve olası yağ kalitesinin standardizasyonunda kimyasal meyve seyreltmesi yararlı olabilir. Bu çalışmada, Türkiye'nin önemli zeytin çeşitlerinden 'Gemlik'te, naftalen asetik asitin potasyum tuzuyla (NAA-K) yapılan kimyasal meyve seyreltmesinin, yağ verim ve kalitesine etkilerinin saptanması amaçlanmıştır. Sonuçta, NAA uygulamaları birinci yılda (boş yılı) yağ asitliği değerini azaltmıştır. İkinci yılda (dolu yılı) ise, 100 ve 120 ppm'lik NAA uygulamaları yağ asitliğini %1,75'e kadar yükseltirken, 150 ppm asitlik değerini %0,36'ya düşürmüştür. NAA'nın 180 ppm'lik uygulaması özellikle "dolu" yılında meyvelerin yağ içeriklerini önemli düzeyde yükseltmiş, yaş ve kuru ağırlık yağ oranlarında, kontrole göre sırasıyla % 22 ve % 48 artış sağlamıştır.

INTRODUCTION

The cultivation of olives probably goes back to 6,000 years ago in the Middle East and moved to the west across the Mediterranean (Barranco, 2010). Turkey has an important place among the world olive growing countries, with its suitable ecological conditions. Olive has been grown on acreage of 826,000 ha which is the 3.9 % of the total agricultural lands of Turkey. About 8 % of total olive lands are irrigated. Turkey also ranked fourth in total world olive production with 1.6 million mt and sixth in olive oil with 190.400 mt respectively (FAOSTAT, 2017; IOOC, 2017). Production figures will significantly increase with new growing strategies and the increasing exports of olive oil was expected. Due to the increasing agricultural subsidies, the number of olive trees and the acreage of olive lands showed considerable increase in the last decade. Recent years, 'Gemlik' variety has been used in most of the new plantings, because of its high adaptation capability, early bearing, fruitfulness and the ease of propagation. The 80 % of entire olive tree population of Marmara region (north-west of Anatolia) consists of this cultivar, but it has been widely grown in most olive lands of Turkey in currency. Its tendency to alternate bearing has been known as intermediate. The most distinctive feature of 'Gemlik' olive is its deep black fruit color in maturity. Besides its availability for pickling, it has also a high content of oil up to 29 %. Its fleshy fruit has a thin skin together with a small pip. 'Gemlik' tree is generally medium sized, has an even round crown and medium vigor (Anonymous, 2000).

Olive is an evergreen plant and its flowers mostly occure on one year old shoots. Like some fruit species, olive has a very high tendency of "Alternate" or "Biennial" fruit production (Lavee, 2007; Dag et al., 2009). Thus, olive produces a large crop one year followed by a small or negligible crop in the following year (Monselise and Goldschmidt, 1982). This causes severe economic problems can affect the entire olive sector (Lavee, 2007; Dag et al., 2009). The selection of proper cultivar together with using the cultural practices (irrigation, fertilization, pruning, spraying) should be met to control alternate bearing (Therios, 2009). The excessive crop load has to be diminished to mitigate the alternate bearing (Krueger et al., 2005). In fact, that only 1.2 % of entire flower population needs to be involved to ensure a sufficient commercial crop in olive (Jackson et al., 2011). Crop load can be controled by chemical thinning, pruning or hand thinning (Krueger et al., 2005). Chemical fruit thinning is the most useful practice to control the fruit yield and consequently alleviate the alternate bearing in olive tree (Krueger et al., 2005; Lavee, 2007; Dag et al., 2009; Jackson et al., 2011). Chemical thinning also increases the fruit size, oil yield and composition in table and oil cultivars and moreover, positively affects the flower bud differentiation and return bloom (Barone et al., 1994; Lavee, 2007; Dag et al., 2009; Therios, 2009; Haouari et al., 2013). Chemical fruit thinning is a common practice that has been applied since 1950's in California olive growing sector (Hartmann, 1952; Krueger et al., 2002). Excess fruit production in olive results in small fruit and reduced fruit oil content (Lavee, 2007). This reduction is in relation with the smaller flesh/pip ratio induced by excess fruit setting (Lavee and Wonder, 2004). As by reducing fruit number, their size and amount of mesocarp containing the oil is augmented ((Lavee, 2007). Reduced crop load in 'Cassanese' olive significantly increased the oil accumulation in fruits, together with the amount of polyphenols and organic acids in oil (Barone et al., 1994). But chemical thinning with NAA, gave rise to decrease in physiochemical properties and storage stability in 'Picual' and 'Manzanillo' olive oils (El Badry, 2012; Ali and El-Wasseif, 2015).

Turkey shared the 75 % of entire olive production to olive oils. Difficulties in providing high quality oil both for domestic consumption and export is the prominent problem of oil sector.

The aim of this work to clear out the effects of chemical thinning, using NAA, on the oil yield and some quality parameters of 'Gemlik' olive which is one of the important dual purpose cultivar of Turkey.

MATERIAL and METHOD

'Gemlik' olive variety was used as plant material in this work. Trees subjected to chemical thinning were grown under irrigated conditions in experimental plots of Olive Research Institute, İzmir/TURKEY. They are 35 years old and self-rooted individuals. Planting density is 6x6 m.

Fruit thinnings were conducted in two consecutive years (2012 and 2013). Two methods were used to accurately time NAA applications. In May 2012, 12 and 18 days after full bloom (AFB) (Full Bloom in 2012: 10 May; in 2013: 1 May), thinning applications were done as dilute sprays of NAA-K (1-Naphtalene Acetic Acid, Potassium Salt, Amvac, USA) as 120 and 180 ppm respectively (10 ppm per each day was calculated for final concentration) when the tree appears to be white, with shoots containing 80 to 90 percent open, fresh flowers, with bright yellow anthers exposed, accepted as in full bloom (Krueger et al., 2005; Dag et al., 2009). Moreover, two different levels of NAA were also applied when average fruit size is between 3 to 5 mm in diameter (in 2012: 29 May; in 2013: 20 May) (Krueger et al., 2005).

In the second year (2013), all the treatments were done 9 days earlier following the phenology of olive trees. In two successive thinning years, treatments of 100, 150 and 180 ppm coincided almost the same time according to time schedule. Wetting agent was used in dilute solutions of NAA. In the first and second years of experiments, on the basis of fruit maturity index, trees were harvested in 15 November 2012 and 14 November 2013, respectively. Olives were harvested by hand and processed by an Abencor system (Sevim et al., 2013).

Determination of the effects of NAA treatments on oil yield and quality: free fatty acids (as oleic acid %), peroxide value (meq/kg oil), fruit moisture (%), oil contents (on fresh and dry weight basis %) were determined. For determination of maturity level, calculation of maturity index was used on the basis of fruit skin and flesh color (Hermoso et al., 1991).

The design of the experiments was a completely randomized block design with tree replicates of a tree. Data were analyzed by ANOVA. Duncan's Multiple Range Test was used to identify differences between the treatments. All calculations were performed using SPSS software.

RESULTS

During the experiments, calculated monthly temperature and relative humidity figures did not show marked differences when two experiment years were compared. However, winter (January-March) temperatures of 2013 seemed to be a few degrees higher than previous years'. The highest yearly difference of calculated temperature was measured in October when the fruit skin color started to turn to black (Table 1).

Results showed that the mean free acidity level was nearly doubled in the second year (on year). NAA concentrations significantly influenced (P<0.001) the acidity levels and 150 ppm gave the lowest value, while 100 ppm gave the highest. Significant interactions found between years and concentrations (P<0.001). In the second year (on year), the highest acidity figures were obtained with 100 and 120 ppm NAA respectively. But 150 ppm markedly decreased oil acidity together with 180 ppm compared to control (Table 2).

Mean peroxide (PO) value of olive oils significantly (P<0.001) influenced by years and it showed nearly two fold decrease in the second year. Effects of NAA concentration on PO values were found to be insignificant. Interaction of year x concentration did not significantly influence the mean PO values. However, 180 ppm NAA slightly increased the PO value while 150 ppm was markedly decreased compared to unsprayed trees in the first year. In the second year (on year), entire NAA concentrations increased the PO values as opposed to the first year (Table 3).

Different treatment years did not significantly affect the percent fruit moisture. Effect of NAA concentrations found to be significant (P<0.01), 180 ppm NAA gave rise to remarkable increase in moisture rate compared to the rest concentrations together with control. Year x concentration significantly (P<0.001) affected the moisture figures. In the first year, 100 ppm gave the highest fruit moisture followed by 120 ppm. But in the "on year", only 180 ppm NAA gave rise to marked increase in moisture level compared to control (Table 4).

Table 1. Changes in monthly mean temperature and humidity data during experiments.

Month	1	2	3	4	5	6	7	8	9	10	11	12
						2012						
Temperature (°C)	6.8	7.6	11.5	17.5	20.5	27.3	30.1	29.2	24.3	21.8	16.4	10.8
Humidity (%)	67.9	67.0	58.0	58.7	62.9	48.3	45.1	39.7	55.3	59.7	65.2	71.4
						2013						
Temperature (°C)	9.4	11.2	14.0	17.2	22.7	25.7	28.4	28.8	24.0	17.3	15.1	8.5
Humidity (%)	70.9	70.3	58.6	54.4	54.7	50.7	42.1	45.2	48.7	60.6	70.1	59.30

Table 2. Effect of year and NAA concentration on free fatty acidity (%).

Year	Concentration (ppm)					Mean
	0	100	120	150	180	
2012	0.88 bc	0.60 d	0.54 d	0.62 d	0.52 d	0.63 B
2013	1.00 b	1.75 a	1.74 a	0.36 c	0.80 c	1.13 A
Mean	0.94 B	1.18 A	1.14 A	0.49 D	0.66 C	

P(year) ≤ 0.01; P(concentration) ≤ 0.001; P(year x concentration) ≤ 0.001

Table 3. Effect of year and NAA concentration on peroxide value (meq/kg oil).

Year	Concentration (ppm)					Mean
	0	100	120	150	180	
2012	9.96	8.25	6.17	6.15	11.41	8.39 A
2013	3.62	4.99	4.83	5.45	4.42	4.66 B
Mean	6.79	6.62	5.50	5.80	7.92	

P(year) ≤ 0.001; P(concentration): nonsignificant *; P(year x concentration)):* nonsignificant

Table 4. Effect of year and NAA concentration on fruit moisture (%).

Year	Concentration (ppm)					Mean
	0	100	120	150	180	
2012	43.18 d	51.28 b	49.89 bc	47.17 bcd	47.06 bcd	47.72
2013	46.46 bcd	44.46 d	43.84 d	46.17 cd	55.79 a	47.34
Mean	44.82 B	47.87 B	46.87 B	46.67 B	51.43 A	

P(year): nonsignificant *; P(concentration) ≤ 0.01; P(year x concentration) ≤ 0.001*

Oil contents of fresh fruits significantly ($P<0.001$) affected by different spraying years. In the second year (on year), oil rate was more high compared with the "off year". NAA concentrations also significantly affected the mean oil contents, and 180 ppm gave the highest figure. Interactions of year x concentration significantly ($P<0.05$) affected the oil content. NAA sprayings slightly increased the oil contents in the "off year". In the "on year", oil accumulation of fruits had the highest rate with 180 ppm NAA (applied at 18 days AFB) (Table 5).

Oil content in dry fruit weight did not significantly affected by spraying years. However, oil content slightly increased in "on year". NAA concentrations significantly ($P<0.01$) affected the mean oil contents and 180 ppm gave the highest figure. Significant ($P<0.01$) interactions found between spraying years and concentrations. 100 ppm NAA gave the highest rate while the unsprayed trees gave the lowest figure in the "off year". In the second year, 180 ppm NAA provided 48 % more oil than control trees. 100 ppm gave the lowest figure as opposed to the first year (Table 6).

Table 5. Effect of year and NAA concentration on fruit oil content (fresh weight) (%).

Year	Concentration (ppm)					Mean
	0	100	120	150	180	
2012	18.58 d	21.36 bcd	20.81 bcd	18.69 d	20.10 cd	19.91 B
2013	22.18 bc	21.00 bcd	23.51 b	21.42 bcd	27.03 a	23.03 A
Mean	20.38 B	21.18 B	22.16 AB	20.05 B	23.57 A	

P(year) ≤ 0.001; P(concentration) ≤ 0.01; P(year x concentration) ≤ 0.05

Table 6. Effect of year and NAA concentration on fruit oil content (dry weight) (%).

Year	Concentration (ppm)					Mean
	0	100	120	150	180	
2012	32.81 c	43.90 b	41.62 ab	35.83 ab	38.54 ab	38.54
2013	41.52 ab	37.81ab	41.85 ab	39.80 ab	61.54 a	44.51
Mean	37.17 B	40.85 B	41.74 B	37.82 B	50.04 A	

P(year): nonsignificant ; *P(concentration) ≤ 0.01; P(year x concentration) ≤0.01*

DISCUSSION

Calculated mean monthly temperatures belonging to January, February and March 2013 were measured as higher than the same months of the previous year. The chilling requirement has been known as crucial for flower bud differentiation and fluctuations between 2-15°C are necessary for sufficient flower bud differentiation in olive (Rallo and Martin, 1991; Martin et al., 2005; Therios, 2009). The relatively higher temperatures of 2013 were probably not determinant on fruit yield of the "on year".

Free acidity level is an indicator of the quality of olive oil and of the procedures from harvesting to milling (Therios, 2009). In 'Cassanese' olive oil, no significant effect found between acidity level and crop load was reported (Barone et al., 1994). In 'Gemlik' olive trees, NAA applications tended to decrease acidity levels of oil in "off year" compared to untreated trees. In "on year", 150 ppm NAA markedly decreased the acidity together with 180 ppm while the lower concentrations (100 and 120 ppm) did increase (Table 2). However, free acidity levels at 100-120 ppm NAA are below the limit value predicted for virgin olive oils (Uceda et al., 2010). Post bloom applications 10 days after fruit set (AFS) of NAA (135 ppm) did not significantly alter the acidity of 'Picual' olive oil (El Badry, 2012). But in 'Manzanillo' olive, 75 ppm NAA significantly increased the acidity when applied at the same time (10 days AFS) (Ali and El-Waseif, 2015). In 'Gemlik' olive, NAA concentrations were more efficient on oil free acidity in "on year" (Table 2). Thus, the crop load might be an important determinant on the effect of concentration used was thought.

One of the important parameters of olive oil quality and longevity of shelf-life is PO value (Wiesman, 2009). In 'Gemlik' olive, applied NAA concentrations in two successive years did not significantly alter the PO values. In "off year" 180 ppm NAA slightly increased the peroxide value (15 % more than control), while 150 ppm gave rise to 38 % decrease. In "on year", measured peroxide values were seemed quite lower than the previous year. The highest value was obtained from the trees sprayed with 150 ppm, which is 51 % more than control. The rest concentrations were also increased the PO values compared to control (Table 3). Post bloom applications (10 days AFS) of NAA significantly increased the PO values of oils from 'Picual' and 'Manzanillo' olives without regarding the fruit load (El Badry, 2012; Ali and El-Waseif, 2015). However, PO value of 'Cassanese' olive did not significantly alter even when the crop load was high (Barone et al., 1994). In 'Gemlik' olive, higher crop load in the "on year" is probably responsible from relatively low PO values and also slight increases by entire concentrations of NAA. However, those figures obtained from 'Gemlik' olive oil were quite less than the limit value (20 mEq O_2/kg) predicted for extra virgin olive oils (Uceda et al., 2010).

As for the fruit moisture, in the first year NAA treatments increased the moisture rates compared to unsprayed trees, particularly with 100 ppm (19 % more than control). In the second year, only 180 ppm NAA did significantly increase the moisture content (20 % of control) (Table 4). NAA applied at 10 days AFS did not alter the moisture value (66 %) in 'Manzanillo' olive (Ali and El-Waseif, 2015). But in 'Picual' olive fruit moisture increased with NAA spraying (El Badry, 2012). In 'Gemlik' olive, fruit moisture seems to be quite low compared to varieties that formerly assessed and probably influenced by both varietal characteristics and fruit load of tree.

Significant interactions found between spraying years and concentrations on oil content of fresh fruits. In the "off year", NAA sprayings generally tended to increase the oil content of fresh fruits. As for the "on year", post bloom applications seemed to be effective on oil content and 180 ppm NAA gave rise to 22 % increment of oil compared to control (Table 5). As in dry weight basis, NAA treatments in two consecutive years significantly affected the oil content of olive fruits. In the first year (off year), 100 ppm NAA gave rise to 34 % augmentation in oil content followed by 120 ppm. In the second year, 180 ppm spraying gave rise to almost 50 % more oil accumulation in fruits (Table 6). Post bloom sprayings of NAA did generally increased the oil content together with weight and flesh/pip ratio in olive fruits was formerly reported (Hartmann, 1952). But in 'Ashrasie' olive, the effectiveness of NAA (50 and 100 $mg.l^{-1}$) on increment of fruit oil found to be significantly higher in "off year" (Nafea and Abdulfatah, 2014). In 'Gemlik' olive, entire NAA sprayings tended to increase the oil content of fresh and dried olive fruits particularly in "off year" (Table 5, 6) as reported in 'Ashrasie' olive. On the other hand, varietal differences also predict the effects of NAA sprayings on oil content (El Badry, 2012; Abdrabboh, 2013; El-Waseif, 2015). From this point of view, timing of NAA sprayings seems to be crucial in 'Gemlik' olive. In "off year", lower concentrations (i.e. 100 ppm or less) in both timing method was thought to be more effective to increase the oil content of fruits. Moreover, applications at 18 th day of full blooming or onward might be more useful rather than the applications after small fruit setting particularly in "on years".

CONCLUSION

In conclusion, results of two consecutive years pointed out significant differences of some oil yield and quality parameters. NAA applications were rather useful to augment the oil content of fruits particularly in "off year". Regardless of fruit load and return bloom, in "on years", NAA used 18 days or more later (e.g. 20-24 days) than full blooming might be useful on augmentation of fruit oil contents, without changing some other oil quality parameters such as free fatty acidity and peroxide values in 'Gemlik' olive.

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