How to cite: Erogul, D., D. Çantal & H. Karabıyık, 2022. Effect of foliar treatments of seaweed on fruit quality and yield in almond cultivation. Ege Univ. Ziraat Fak. Derg., 59 (4):591-600, https://doi.org/10.20289/zfdergi.1140350

Research Article
(Araştırma Makalesi)

Ege Üniv. Ziraat Fak. Derg., 2022, 59 (4):591-600
https://doi.org/10.20289/zfdergi.1140350

Effect of foliar treatments of seaweed on fruit quality and yield in almond cultivation

Bademetiştiriciliğinde yapraktan deniz yosunu uygulamalarının meyve kalitesi ve verime etkisi

Deniz EROĞUL [1*]

Dorukhan ÇANTAL [1]

Hafize KARABIYIK [1]

[1] Ege University Agricultural Faculty Horticulture Department, 35100, Bornova, İzmir, Türkiye

* Corresponding author (Sorumlu yazar): deniz.erogul@cbu.edu.tr

Received (Alınış): **12.07.2022** **Accepted** (Kabul Tarihi): **27.10.2022**

ABSTRACT

Objective: The aim of this study was to determine the effect of foliar seaweed treatments on almond cultivation in practice.

Material and Method: The study material consisted of ‘Nonpareil’ and ’Texas' almond varieties grafted on GF-677 rootstock. 4000 ppm seaweed was applied in the form of foliar spraying on the 10th day after full blooming.

Results: While the nut weights were high in the fruits of the control group in both varieties, the kernel weights were the same in the fruits of the control group and seaweed-treated group. Compared with the control, the nut weights of seaweed-treated almonds were low, while kernel weights were high. Therefore, the kernel ratio of seaweed-treated fruits was found to be 6% higher in the ‘Texas’ variety and 14% higher in the ‘Nonpareil’ variety compared to the control group. In addition, seaweed applications increased the yield per tree by 11.18% in the ‘Texas’ variety and 12.12% in the ‘Nonpareil’ variety because of increasing the fruit set in almond trees.

Conclusion: According to the obtained results, it was concluded that 4000 ppm seaweed treatment applied in the form of foliar spraying on the 10th day after full blooming in almond cultivation can make positive contributions to almond cultivation.

Keywords: Almond, fatty acids, foliar fertilization, fruit quality, seaweed, yield

ÖZ

Amaç: Bu çalışma yapraktan deniz yosunu uygulamalarının pratikte badem yetiştiriciliğine etkisini belirlemek amacıyla yürütülmüştür.

Materyal ve Yöntem: Çalışma materyalini GF-677 anacına üzerine aşılı ‘Nonpareil’ ve ’Texas’ badem çeşitleri oluşturmuştur. Tam çiçeklenmeden 10 gün sonra yapraktan spreyleme şeklinde 4000 ppm deniz yosunu uygulaması yapılmıştır.

Araştırma Bulguları: Kabuklu badem ağırlıkları her iki çeşitte de kontrol grubundaki meyvelerde yüksek bulunurken, iç badem ağırlıkları ise kontrol grubu ve deniz yosunu uygulaması yapılan meyvelerde aynı değerde olmuştur. Kontrol ile karşılaştırıldığında, deniz yosunu uygulaması yapılan bademlerin kabuklu ağırlıkları düşük iken, iç ağırlıkları yüksek olmuştur. Bu nedenle deniz yosunu uygulaması yapılan meyvelerin iç doldurma oranları kontrol grubuna göre ‘Texas’ çeşidinde %6, ‘Nonpareil’ çeşidinde %14 daha yüksek bulunmuştur. Bunun yanında, deniz yosunu uygulamaları badem ağaçlarında meyve tutumunu artırarak; Texas çeşidinde %11.18, Nonpareil çeşidinde %12.12 oranında ağaç başına verimi artırmıştır.

Sonuç: Elde edilen sonuçlara göre, badem yetiştiriciliğinde tam çiçeklenmeden 10 gün sonra yapraktan spreyleme şeklinde 4000 ppm uygulanan deniz yosunu uygulamasının olumlu katkıları olacağı sonucuna varılmıştır.

Anahtar sözcükler: Badem, yağ asitleri, yapraktan gübreleme, meyve kalitesi, deniz yosunu, verim

INTRODUCTION

Almond production in Türkiye is increasing day by day. Especially in locations with mild climates in the Aegean Region, closure almond orchards are established. Although almond output is increasing, it is not enough to meet domestic demand, as the country's consumption is high and it is imported. Although there was an increase in production, 56703 tons of imports were realized in 2020 (Trademap, 2020). Therefore, to prevent imports of almonds, it has become mandatory to expand the production areas in our country as well as to carry out applications aimed at improving quality and yield in existing areas.

The high yield that producers receive in almond farming, the high kernel ratio of almond fruit, and the low proportion of twin kernels are among the significant quality parameters. In addition, the composition of fatty acids as a biochemical property is, in particular, one of the factors that affect the taste of fruit in almonds and is a very important factor in human health. The most important fatty acids in almonds are myristic acid, palmitic acid, stearic acid, oleic acid, and linoleic acid (Kodad et al., 2004). Fatty acids have a lot of positive effects in terms of human health, providing weight control, anti-carcinogen effect, protecting heart health, inhibiting the formation of gallstones (Aune et al., 2016, Barreca et al., 2020). Along with them, almond oil has found extensive uses in cosmetics (Gite et al., 2013). The range of fertilizers used in organic agriculture has expanded in recent years and fertilizers containing seaweed extracts have begun to be produced commercially (Okur et al., 2007). Seaweed cultivation is one of the applications that have started to be used in fruit cultivation in recent years. Seaweed is found in the oceans, seas, and lakes, it is green, brown, and red in color. Different types of seaweed are used in industries such as agriculture, cosmetics, food, and pharmacy. In addition to direct application in fruit growing, seaweed can also be used in combination with other substances by adding it to compost. It has been observed that when seaweed is applied with this method, it increases the water-holding capacity of the soil (Dede et al., 2011). In the structure of seaweed, there are growth-stimulating substances such as IAA, kinetin, zeatin, gibberellins, auxins, and cytokines, as well as micro and macro elements, amino acids, and vitamins (Strik et al., 2003, Zodape et al., 2010). It has been observed that seaweed extracts increase plant development and yield under certain environmental stress factors such as drought, salinity, and low temperature due to the substances contained in them (Yildirim et al., 2008). It has been reported that seaweed extracts provide more fruit set in pome and stone fruit species (Battacharyya et al., 2015). It has been determined in the studies that seaweed has positive contributions to yield, vegetative development, and fruit quality in olive, plum, pear, and strawberry fruit growing with different application methods (Kaya, 2007; Atasay & Turemis, 2008; Colavita et al., 2014; Dundar, 2019). In addition, when seaweed is applied to the leaves, it prevents losses that will occur during harvest in orange, palm, and apple trees (Blunden et al., 1992; Basak, 2008).

Studies on seaweed in almonds are almost nonexistent. Studies related to the use of seaweed as a biostimulant exist in the literature (Pascoalino et al., 2021). Fatty acids are another of the most important factors that make up the quality of almonds. This study aimed to determine the effect of seaweed on yield, fruit quality, and fatty acid content in almond fruits.

MATERIALS and METHOD

Plant material

The research was carried out in the almond orchard with 8 year-old commercial 'Texas' and 'Nonpareil' varieties established with a 6 x 6 m planting gap and grafted on GF-677 rootstock in the Koprubasi district of Manisa province.

Method

In the study, water-soluble seaweed (ATOCROP_s, Doctor Tarsa) was used. The content of seaweed consists of 30% organic matter, 12% potassium oxide, 1.5% alginic acid, and 1 mg/kg gibberellic acid. The fruits treated with seaweed and control. Applications were carried out in the form of foliar spraying at a rate of 4000 ppm seaweed when foliation began 10 days after full blooming. Applications were made with a pulverizer afternoon. A surfactant was added as 0.04% (Nu-Film-17®, Miller Chemical Corp. USA) including the control treatment. The research was planned as a randomized block design with 3 replicates and 5 trees in each replicate. The pericarp of the almonds harvested from each tree in August was removed, and almonds were dried in a shady place. The yield was determined by weighing the fruits harvested from the trees in each application on a precision scale after drying, and the results were expressed as kg.

The weight of shelled and kernel of almonds were determined by weighting 40 almond samples taken from each replicate using a 0.001 precision scale (Precisa XB320M), the results were given in grams. The width, height, and thickness of the shelled and kernels of almonds were measured on 40 shelled and kernels of almonds using the Mitutoyo MyCAL Lite (700-113) digital caliper, and the results were given in mm. The samples taken from shelled almonds were weighed on a precision scale (Precisa XB 320M) and then these almonds were broken by hand to determine the kernel weights, and the yield percentage (%) was calculated from the formula "weight of kernel*100 / weight of nut". At harvest, total yield was determined as kilograms per tree. The twin (double) kernel ratio was calculated by dividing the number of double kernels determined in broken almonds by the total number of kernels.

The fatty acid composition was determined by using the lipid extracts after methylation to form fatty acid methyl esters (FAME) according to the IUPAC Method No.: 2.301 (IUPOC, 1990) using a Hewlett Packard 6890N gas chromatograph (Agilent, Polo Alto, CA), equipped with a Supelco SP2380 capillary column (60 m x 0.25 mm i.d., 0.20 μm film thickness; Supelco, Bellefonte, PA) and flame ionization detector (FID). Fatty acid™ 37 Component FAME mix (Supelco, Bellefonte, P A) was used for determination of fatty acid fractions. Helium was used as the carrier gas at flow rate of 1.1 ml/min; the split ratio was 1: 20. An autosampler/injector HP7683 B Series was used, and the injector and detector temperatures were 220°C. The oven temperature was programmed at 165°C for 35 min; temperature was then elevated at 5°C per min to 195°C and held for 15 min.

Independent sample t-test has been performed to determine significant differences between varieties and applications. For the two varieties the test has been run regardless of applications, and for the two applications regardless of varieties. Null hypothesis assumes that there is no differences in means between varieties and / or applications (H0: μTexas = μNonpareil; μControl = μSeaweed), whereas the alternative hypothesis assumes that they are significantly differing from each other.

RESULTS

The effect of seaweed applications on pomological properties of nut and kernel fruits of almonds

When the fruit quality values of the nut almonds were examined, a difference was found between the treatments applied to the varieties. When seaweed was applied to the 'Texas' variety, the fruit width was measured as 16.60 mm in the seaweed-treated almonds, and 17.81 mm in the 'Texas' control group. When seaweed was applied to the 'Nonpareil' variety, fruit width was measured as 16.39 mm in the seaweed-treated almonds, and 17.39 mm in the 'Nonpareil' control group. In both varieties, there was a decrease in the fruit width between 5.75-6.79% compared to the control. When seaweed was applied to the 'Texas' variety, the fruit thickness was measured as 14.11 mm in the seaweed-treated almonds and as 14.68 mm in the 'Texas' control group. When seaweed was applied to the 'Nonpareil' variety, the fruit thickness was measured as 12.16 mm in the seaweed-treated almonds and 12.54 mm in the 'Nonpareil' control group. The variation in fruit thickness in both varieties was limited compared to the control (Table 1).

When seaweed was applied to the 'Texas' variety, 26.54 mm fruit length was measured in the seaweed-treated almonds and 29.97 mm was found in the 'Texas' control group, an 11.45% decrease was observed compared to the control. When seaweed was applied to the 'Nonpareil' variety, 29.37 mm fruit length was measured in the seaweed-treated almonds and 32.63 mm in the Nonpareil control group. A 10% reduction in fruit length was found in the 'Nonpareil' variety compared to the control. When the fruit length parameter was examined in both varieties, it was observed that the best group was the control group of the 'Nonpareil' variety and the lowest was observed in 'Texas' seaweed-treated group (Table 1). When seaweed was applied to the 'Texas' variety, the nut weight was measured as 2.56 g in the seaweed-treated almonds and as 3.03 g in the 'Texas' control group. Compared to the control, the kernel weight decreased by 15.50% with the application of seaweed. When seaweed was applied to the 'Nonpareil' variety, the nut weight was measured as 1.81 g in the seaweed-treated almonds and 2.36 g in the 'Nonpareil' control group. There was a 23.30% decrease in the kernel weight in the 'Nonpareil' variety. When the nut weight parameter was examined in both varieties, it was observed that the 'Texas' control group was the best group, followed by the 'Nonpareil' control and 'Texas' seaweed-treated group (Table 1).

Table 1. The effect of seaweed applications on pomological properties of 'Nonpareil' and 'Texas' varieties of shelled almonds

Çizelge 1. *Deniz yosunu uygulamalarının 'Nonpareil' ve 'Texas' kabuklu badem çeşitlerinin pomolojik özelliklerine etkisi*

Varieties	Applications	Width	Thickness	Length	Weight
Texas	Control	17.81*	14.68^{NS}	29.97**	3.03*
	Seaweed	16.60	14.11	26.54	2.56
Nonpareil	Control	17.39*	12.54^{NS}	32.63**	2.36**
	Seaweed	16.39	12.16	29.37	1.81

$^{NS, *, **}$ Nonsignificant, significant at $P \leq 0.05$, or 0.01, respectively.

The kernel quality characteristics of the control almonds and seaweed-treated almonds are given in Table 2. In terms of kernel width, the applications did not create a difference in both varieties. In the 'Texas' variety, the fruit width was determined as 12.69 mm in the control group and 12.47 mm in the seaweed-treated group. In the 'Nonpareil' variety, it was determined as 11.91 mm in control fruits and 11.82 mm in the seaweed-treated group. When the fruit width parameter was examined in both varieties, it was observed that the best group was the control group, but the difference between the varieties and applications was not significant. When seaweed was applied to the 'Texas' variety, fruit thickness was measured as 8.89 mm in the seaweed-treated almonds and 8.07 mm in the 'Texas' control group. The thickness of almond fruits increased by 9.2% in the seaweed-treated 'Texas' fruits. When seaweed was applied to the 'Nonpareil' variety, the kernel thickness was measured as 7.78 mm in the seaweed-treated group and 6.90 mm in the control group. In the 'Nonpareil' variety, fruit thickness increased by 11.31% with the application of seaweed. The kernel thickness in both varieties increased after seaweed treatments.

When seaweed was applied to the 'Texas' variety, the kernel length was found as 22.06 mm, while it was 24.26 mm in the control group. When seaweed was applied to the 'Nonpareil' variety, the kernel length was found to be 22.47 mm in the seaweed-treated almonds and 24.52 mm in the control group. The kernel length decreased by 9.06% in the 'Texas' variety compared to the control and 8.36% in the seaweed-treated 'Nonpareil' variety.

When seaweed was applied to the 'Texas' variety, kernel weight was measured as 1.32 g in the seaweed-treated group and 1.37 g in the 'Texas' control group. When seaweed was applied to the 'Nonpareil' variety, the fruit weight was measured as 1.20 g in the seaweed-treated almonds and 1.23 g in the 'Nonpareil' control group. There was no change in the kernel weights after the treatments.

Also, in the 'Texas' variety, the twin rate was measured as 20% in the control and seaweed-treated almonds. When seaweed was applied to the Nonpareil variety, the growth rate was measured as 0% in the seaweed-treated almonds and 1.5% in the control group. It was observed that the application of seaweed reduces the twin rate only in the Nonpareil variety.

Table 2. The effect of seaweed applications on pomological properties of 'Nonpareil' and 'Texas' varieties of almond kernels

Çizelge 2. *Deniz yosunu uygulamalarının 'Nonpareil' ve 'Texas' çeşitlerinde iç badem pomolojik özelliklerine etkisi*

Varieties	Applications	Width	Thickness	Length	Weight
Texas	Control	12.69^{NS}	8.07*	24.26*	1.37^{NS}
	Seaweed	12.47	8.89	22.06	1.32
Nonpareil	Control	11.91^{NS}	6.90*	24.52*	1.23^{NS}
	Seaweed	11.82	7.78	22.47	1.20

$^{NS., *,}$ Nonsignificant or significant at $P \leq 0.05$, respectively.

The effect of seaweed applications on percentage kernel yield in almonds

Seaweed applications increased the percentage kernel yield of almonds. When applying seaweed to the 'Nonpareil' variety. The percentage kernel yield was found to be 66.30% in the seaweed-treated almonds and 52.12% in the control group. In total, an increase of 14% in the percentage kernel yield was achieved with the application of seaweed. When seaweed was applied to the 'Texas' variety, the percentage kernel yield was found to be 51.56% in the seaweed-treated almonds and 45.21% in the control group. There was also a 6% increase in the 'Texas' variety (Figure 1).

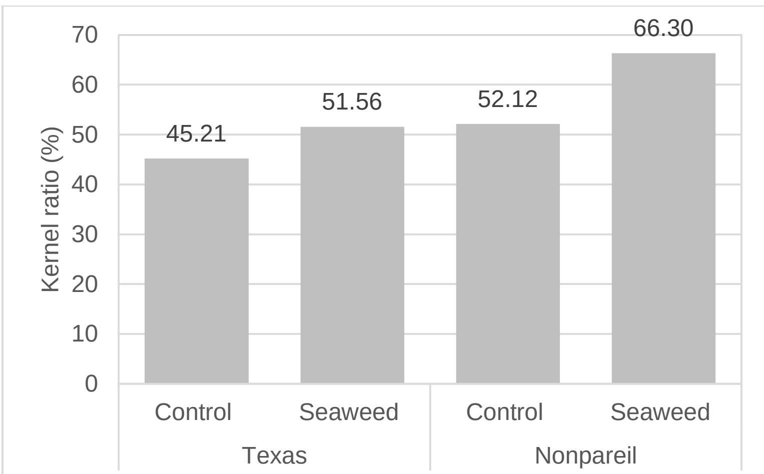

Figure 1. The effect of seaweed applications on kernel ratio of 'Nonpareil' and 'Texas' varieties

Şekil 1. *Deniz yosunu uygulamalarının 'Nonpareil' ve 'Texas' çeşitlerinde iç randımana etkisi*

The effect of seaweed applications on almond yield

When the yield values per tree were examined, a statistically significant difference was determined between the varieties and between the applications (Figure 2). When seaweed was applied to the 'Texas' variety. The yield per tree was measured as 10.00 kg in the seaweed-treated almonds and 8.9 kg in the control group. In other words, it was found that when seaweed was applied to the 'Texas' variety, an increase was achieved in the yield per tree. When seaweed was applied to the 'Nonpareil' variety, 9.9 kg was measured in the seaweed-treated almonds and 8.7 kg in the control group. Thus, it was observed that when seaweed is applied to the 'Nonpareil' variety, it provides an increase in yield per tree. When taking into account both types, the best result was observed in 'Texas' seaweed-treated group, followed by the 'Nonpareil' seaweed-treated group, 'Texas' control group, and 'Nonpareil' control group, respectively (Figure 2).

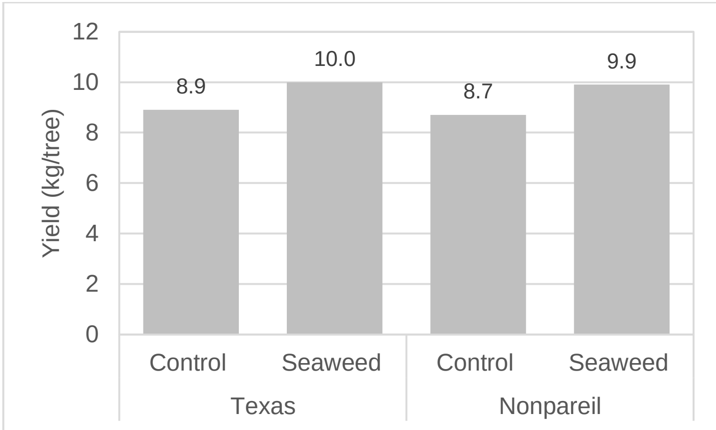

Figure 2. The effect of seaweed applications on yield of 'Nonpareil' and 'Texas' varieties

Şekil 2. *Deniz yosunu uygulamalarının 'Nonpareil' ve 'Texas' çeşitlerinde verime etkisi*

Effect of seaweed applications on fatty acid content in almonds

When the fatty acid composition was analyzed, it was determined that palmitic acid, which has the highest content of saturated fatty acids, was 6.12-6.63%, followed by stearic acid with 1.28-1.90%. Among the unsaturated fatty acids, oleic acid, which is a monounsaturated fatty acid, was found to be the highest with 67.26-70.93%, followed by linoleic acid, which is a polyunsaturated fatty acid, with 20.28-23.87%. Palmitoleic acid from other unsaturated fatty acids varied between 0.16-0.47%, and Linolenic acid was between 0.11-0.14%. The Oleic/Linoleic acid ratio varied between 2.82-3.49% (Table 3).

Table 3. The effect of seaweed applications on fatty acids of 'Nonpareil' and 'Texas' varieties

Çizelge 3. *Deniz yosunu uygulamalarının 'Nonpareil' ve 'Texas' çeşitlerinde yağ asitlerine etkisi*

Varieties	Applications	Palmitic acid (C16: 0)	Palmitoleik Acid (C16: 1)	Stearic acid C18: 0)	Oleic acid (C18: 1)	Linoleic asid (C18: 2)	Linolenic acid (C18: 3)	Oleic / Linoleic Ratio
Texas	Control	6.12^{NS}	0.16 ^{NS}	1.71^{NS}	69.70^{NS}	21.75^{NS}	0.13^{NS}	3.21^{NS}
	Seaweed	6.27	0.47	1.61	70.93	20.28	0.14	3.49
Nonpareil	Control	6.24^{NS}	0.42^{NS}	1.90^{NS}	67.26^{NS}	23.87^{NS}	0.12^{NS}	2.82^{NS}
	Seaweed	6.63	0.44	1.28	70.26	20.97	0.11	3.35

$^{NS.}$ Nonsignificant.

DISCUSSION

In this study, seaweed applications in almond cultivation were applied on 'Nonpareil' and 'Texas' varieties grafted on GF677 rootstock. The nut weights of seaweed-treated almonds were high in the fruits in the control groups of both varieties, while there was a decrease of 23.30% in the Nonpareil treatment group and a decrease of 15.51% in the Texas treatment group. While the nut weights were higher in the control group, the kernel weights had the same value in the control group and in the seaweed-treated fruits. This shows us that seaweed-treated fruits have higher kernel ratios. And in the 'Nonpareil' variety, this increase was found to be 14% higher, and in the Texas variety, this increase was found to be 6% higher. When fruit sizes were examined, nut lengths of almonds were found to be 10-11.45% higher, fruit width was found to be 5.75-6.79% higher, and fruit thickness was found to be 3.03-3.88% higher in the control group compared to seaweed-treated almonds. But, as for kernel almonds, only the kernel length was found to be 8.36-9.06% higher than in the control group fruits, while there was no change in the fruit width, it was also determined that the fruit thickness increased by 9.2-11.31%. The yield values increased by 11.18-12.12% per tree depending on the varieties.

Seaweed applications increase fruit set in trees, reduce flower and fruit shedding, as well as provide an increase in yield of up to 30% in fruit trees (Blunden et al., 1992). In studies conducted on pistachios and nuts from hard-shelled fruits, it is reported that the quality characteristics of fruits as well as yield increase with seaweed applications (Ahmadi et al., 2019). It has been found that seaweed applications made 3 weeks after peak blooming also increase the fruit size and fruit weight in cherries, as well as reduce fruit cracking which is a very important quality parameter for cherries (Correia et al., 2017). In a study conducted on olives, the application of seaweed increased the fruit size compared to the control (Dundar, 2019).

The effects of seaweed on yield, development, maturity, and quality values of round seedless grape vineyards were investigated, and it is observed that the dose of seaweed of 2000 mg/kg increases the yield and bunch number of grapes, while reducing grain size (Akman, 1995). Grain size increased in the application of 3000 ppm seaweed in the Cabernet Sauvignon grape variety, while the bunch weight also increased along with it (Koc, 2020). In a study conducted in Clemantine mandarin, there was no change in fruit sizes with the foliar applications of seaweed, while the fruit set ratio and yield per plant increased (Sencopur, 1995). In mandarins, an increase in fruit quality, fruit sizes, and yield was observed by preventing fruit shedding with seaweed application performed at the stage of peak blooming and fruit set (Khan et al., 2022). Seaweed applications were also made on strawberries, and higher yield and size in the fruits were obtained from fertilization programs with seaweed (Atasay & Turemis, 2008). It has been determined that seaweed applications made in the Sweet Charlie strawberry variety increase fruit weight by 20%, yield per plant by 21%, and fruit hardness, which is another important quality parameter, by 13.33% (El-Miniawy et al., 2014). While the fruit set increased by 22.71% in the Gala apple variety with seaweed applications performed 4 times from the peak blooming period to harvest, the average fruit weights also increased by 17% (Basak, 2008). In a seaweed spraying study on pomegranate fruit in February and March, fruit size increased by 12.73%, the number of fruits per tree increased by 9.29%, the average fruit weight increased by 13.43%, and the yield per tree increased by 25.34% (Hussein et al., 2021). With 2% seaweed applications made 4 and 8 weeks after anthesis in palm trees, fruit length increased by 11.93%, fruit diameter by 9.4%, fruit weight by 34.29%, and yield by 44.72% (Omar et al., 2017).

Since all the carbon bonds in saturated fatty acids are saturated with hydrogen, they have a fairly stable structure, and there are no double bonds in their structure. Some saturated fatty acids commonly found in foods are palmitic and stearic acids, which increase the fat content in the blood (Semma, 2002). In this study, the palmitic acid content in the ‘Nonpareil’ variety was determined as 6.24% in control, 6.63% in the Nonpareil treatment group; Also, in the ‘Texas’ variety, it was 6.12% in the control and 6.27% in the seaweed-treated fruits in this study. The palmitic acid contents of the fruits obtained in the control and seaweed-treated almonds were found to be similar to each other. Another saturated fatty acid content, stearic acid, differed after the application of seaweed in the "Nonpareil" variety. The stearic acid content of the almonds of the ‘Nonpareil’ variety, which was treated with seaweed, was found to be 32.63% lower. Reducing the consumption of saturated fats is important for human health in terms of reducing cardiovascular diseases, lowering cholesterol, and preventing weight accumulation (Samur, 2006). In the study, the stearic acid content decreased with seaweed applications in the ‘Nonpareil’ variety. But there was no difference between the treatments in the Texas variety.

Those with a pair of bonds on the chain of unsaturated fatty acids are monounsaturated, and those with more than one pair of bonds are polyunsaturated fatty acids. Palmitoleic acid, one of the unsaturated fatty acids, ranged from 0.42 to 0.44% in the 'Nonpareil' variety. However, with the application of seaweed, it was determined as 0.16% in the control fruits of the 'Texas' variety and 0.47% in the seaweed-treated fruits. Oleic acid is from monounsaturated fatty acids, while linoleic and linolenic acids are from polyunsaturated fatty acids. In this study, the amount of oleic acid was found to be 67.50% and 69.70% in Nonpareil and Texas control fruits, respectively; But in the seaweed-treated fruits, it was found to be 70.26% and 70.93%, showing a very slight increase. The amount of linoleic acid was found to be 23.87% and 21.75% in Nonpareil and Texas control fruits, respectively, and 20.97% and 20.28% with seaweed applications, which showed a very slight decrease. There was no difference in the amounts of linolenic acid ranging from 0.11 to 0.14%. Oleic/Linoleic acid ranged from 2.82 to 3.35% in the Nonpareil variety and from 3.20 to 3.49% in the 'Texas' variety. A slight increase was observed with seaweed treatment.

In a study on the Texas variety, oleic, linoleic, palmitic, stearic, palmitoleic, and myristic acid ratio was 69.15%, 20.47%, 7.37%, 2.13%, 0.19%, and 0.03%, respectively (Gulsoy & Balta, 2014). In another study conducted in the Texas variety, the ratio of oleic, linoleic, palmitic, stearic, and oleic/linoleic acid was 74.8%, 15.9%, 5.84%, 2.13%, 4.7%, respectively (Nanos et al., 2002).

There was no significant change in the fatty acid content of almond varieties with seaweed applications. It was reported that there was no change in fatty acids in the seaweed-treated Vairo' almond variety, and only linoleic acid amounted to 16.9% and a slight decrease (17.2%) was determined compared to the control (Pascoalino et al., 2021).

The content of fatty acids varies according to the climatic conditions in the region where almonds are grown. In a study conducted in Pozantı-Kamışlı valley and Şanlıurfa-Koruklu regions, the researchers investigated the oil quality in some domestic and foreign almond varieties. It was also reported that the oleic and linoleic acid contents differ between the two regions and this is closely related to climatic conditions (Kafkas et al., 1995).

Fatty acids vary in almonds according to genotypes. The palmitic acid content in almond genotypes selected from the Isparta region was between 6.18 - 8.33%, palmitoleic acid content between 0.33 - 0.91%; stearic acid content between 1.20-2.74%; oleic acid ratio between 64.60-75.47%, and the linoleic acid ratio between 16.05-24.06% (Yildirim et al., 2008). Differences between almond varieties can affect fatty acid content. In a study, different genotypes had the content of oleic acid ranged between from 63.14% to 77.37%, linoleic acid from 15.57% to 28.69%, palmitic acid from 4.68% to 6.48%, stearic acid from 1.45% to 2.56%, linolenic acid from 0.02% to -0.72%, and palmitoleic acid from 0.24 to 0.56%. Also, in the 'Texas' culture variety, oleic acid was 74.59%, linoleic acid 16.60%, palmitic acid 5.77%, stearic acid 2.17%, linolenic acid 0.03%, and palmitoleic acid 0.38%. In the study, which examined the fatty acids of different genotypes together with the 'Texas' variety, there was a high degree of variation between genotypes and culture varieties (Colic et al., 2017).

Oleic/linoleic acid ratio (O/L rate) is employed in detecting the quality of kernels because of its protective effect on lipid oxidation and high oleic acid percentage to enhance the resistance of almond kernels to oxidation during processing, storage, and transport (Zacheo et al., 2000). In this study, the oleic/linoleic acid ratio increased by 15.82% with seaweed applications in the "Nonpareil" variety and by 8.30% in the "Texas" variety.

According to Kodad et al. (2014), almond oil content and composition are primarily determined by genotype, but also by environmental factors. Different regions, different ecological conditions, different growing conditions, and different genetic characteristics are reported to affect the fat content in almonds (Kafkas et al., 1995, Yildirim et al., 2008; Zhu et al., 2015; Colic et al., 2017).

CONCLUSION

The seaweed-treated nut weights were found to be less than that of the the control. However, the kernel ratio was increased with the application of seaweed. This suggests that the application of seaweed promotes cell growth, thereby increasing the kernel ratio. The growth of fruit in almond fruits was positively affected by seaweed treatments. The thickness of the kernels increased with seaweed treatments. The yield per tree is very important for producers. This application was found to increase the yield per tree.

Differences in variety and environmental conditions affect the composition of almond fatty acids. In this study, there was a decrease in stearic acid from saturated fatty acids in only the seaweed-treated 'Nonpareil' variety, and although the 'Texas' variety was grown in the same ecological and environmental conditions, there was no change. The oleic/linoleic acid ratio, which is a quality criterion in almonds, increased by 15.82% in the 'Nonpareil' variety and by 8.30% in the 'Texas' variety with seaweed treatments. In this study, seaweed treatments did not cause a significant change in the composition of fatty acids of varieties.

When all these results were examined, it was determined that seaweed treatment, which was carried out in the form of foliar spraying at 4000 ppm when foliation begins 10 days after peak blooming, increases the kernel ratio and yield in almonds. In commercial cultivation, foliar seaweed treatments contribute positively to almond cultivation and are recommended to be applied.

REFERENCES

Ahmadi, S.T., B. Abedy & S.F. Saberali, 2019. Effect of foliar spray with a fertilizer containing amino acids and seaweed extract on quality and yield components of Ahmad Aghaei pistachio. Pomology Research Scientific Journal, 4 (2): 95-106.

Akman, I., 1995. Studies on the Effects of Some Growth Regulators on Round Seedless Vineyards and American Vine Cuttings. E.U. Graduate School of Natural and Applied Sciences, Department of Horticulture, (Unpublished) PhD Thesis, Bornova, İzmir, 52 pp.

Atasay, A. & N. Turemiş, 2008. A study on the applicability of organic strawberry cultivation in Egirdir conditions. Cukurova University Journal of Natural and Applied Sciences, 18 (3): 72-81.

Aune, D., N. Keum, E. Giovannucci, L.T. Fadnes, P. Boffetta & D.C. Greenwood, 2016. Nut consumption and risk of cardiovascular disease, total cancer, all-cause and cause-specific mortality: a systematic review and dose-response meta-analysis of prospective studies. BMC Medicine, 14 (1): 1-14.

Barreca, D., S.M. Nabavi, A. Sureda, M. Rasekhian, R. Raciti & A.S. Silva, 2020. Almonds (*Prunus Dulcis* Mill. D. A. Webb): A source of nutrients and health-promoting compounds. Nutrients, 12 (3): 672 (1-22).

Battacharyya, D., M.Z. Babgohari, P. Rathor & B. Prithivraj, 2015. Seaweed extracts as biostimulants in horticulture. Scientia Horticulturae, 196:39-48.

Basak, A., 2008. Effect of preharvest treatment with seaweed Products, Kelpak® and Goëmar BM 86®, on fruit quality in apple. International Journal of Fruit Science, 8 (1-2): 1-14.

Blunden, G., C. Whapham & T. Jenkyns, 1992. Seaweed Extracts in Agriculture and Horticulture: Their Origins, Uses and Modes of Action. School of Pharmacy and Biomedical Science and "School of Biological Sciences, University of Portsmouth, King Henry John Street, Portsmouth, Hampshire P01, U.K., 202 pp

Colavita, G.M., N. Spera, V. Blackhall & G.M. Sepulveda, 2014. Effect of seaweed extract on pear fruit quality and yield. XI International Pear Symposium, Acta Horticulturae, 9092: 601-607.

Colic, D.S., M.M.F. Asic., K.B. Lazarevic., G.N. Zec, U.M. Gasi, D.C.D. Zagorac& M.M. Natic, 2017. Fatty acid and phenolic profiles of almond grown in Serbia. Food Chemistry, 234: 455-463

Correia, S., Schouten, R., A.P. Silva & B. Gonçalves, 2017. Factors affecting quality and health promoting compounds during growth and postharvest life of sweet cherry (*Prunus avium* L.). Frontiers in Plant Science 8: 2166.

Dede, OH., G. Dede & S. Ozdemir, 2011. Water retention effect of seaweed. Sakarya University Journal of Science, 15 (1): 30-35.

Dundar, A., 2019. The Effect of Different Soil Improvers on Tree Growth and Fruit Yield and Quality in Organic Olive Cultivation. Adnan Menderes University, Graduate School of Natural and Applied Sciences, Department of Horticulture, (Unpublished) Master Thesis, Aydın, 63 pp.

El-Miniawy, S.M., M.E. Ragab, S.M. Youssef & A.A Metwally, 2014. Influence of foliar spraying of seaweed extract on growth, yield and quality of strawberry plants. Journal of Applied Sciences Research, 10 (2): 88-94.

Gite, S.S., J.A. Jadhav, G.A. Zalte & B.R. Saudagar, 2013. A review on oils used in herbal cosmetics research. J. Topical and Cosmetic Sciences. 4 (2): 61-64.

Gulsoy. E. & F. Balta, 2014. Selected from Yenipazar, Bozdogan and Karacasu districts of Aydin province of almond (*Prunus amygdalus* Batch) genotypes, determination of fatty and fatty acid compositions. Journal of Igdir University Graduate School of Natural and Applied Sciences, 4 (1): 9-14.

Hussein, S.A., A.M. Noori, M.A. Lateef & C.R. Ismael, 2021. Effect of foliar spray of seaweed (Alga300) and licorice extracts on growth, yield and fruit quality of pomegranate trees *Punica granatum* L. cv. Salimi. Earth Environ. Sciences, 761 (1): 1-5.

Kafkas, S., I.T. Agar., N. Kaska & Y. Tatar, 1995. Pozantı-Kamisli valley and some domestic and foreign adaptation studies were carried out in Sanliurfa-Koruklu lipid content of almond (*Amygdalus communis* L.) cultivars studies on their characterization. Turkey II. Garden Plants Congress, 1: 398-402.

Kaya A., 2007. Effects of Different Organic Fertilizer Applications on Tree and Fruit Characteristics of Giant Plum Varieties. Gaziosmanpasa University Institute of Science and Technology, Department of Horticulture, (Unpublished) Master Thesis, Tokat, 101 pp.

Khan, A.S., M. Munir, T. Shaheen, T. Tassawar, M.A. Rafiq, S. Ali, R. Anwar, R.N.U. Rehman, M.U. Hasan & A.U. Malik, 2022. Supplemental foliar applied mixture of amino acids and seaweed extract improved vegetative growth, yield and quality of citrus fruit. Scientia Horticulturae, 296: 10903.

Koc, M., 2020. The effects of Foliar Seaweed Applied at Different Times and Doses on the Phytochemical Properties of Cabernet Sauvignon Grape Varieties. Tekirdag Namik Kemal University, Graduate School of Natural and Applied Sciences, Department of Horticulture, (Unpublished) Master Thesis, Tekirdağ, 62 pp.

Kodad, O., G. Estopanán, T. Juan, J.M., Alonso, M.T. Espia & R.S.I. Socias, 2014. Oil content, fatty acid composition and tocopherol concentration in the Spanish Almond Genebank Collection. Scientia Horticulturae, 177: 99-107.

Kodad, O., M.S. Gracia Gomez, I. Socias & R. Company, 2004. Fatty acid composition as evaluation criterion for kernel quality in almond breeding. Acta Horticulturae, 663: 301-304.

Nanos. G.D., J. Kazantzis, P. Kefalas, C. Petrakis & G.G. Stavroulakis, 2002. Irrigation and harvest time affect almond kernel quality and composition. Scientia Horticulturae, 96: 249-256.

Okur, N., H.H. Kayikcioglu., G. Tunc & Y. Tuzel, 2007 The effect of some organic amendments using in organic agriculture on microbial activity in soil. Journal of Agriculture Faculty of Ege University, 44 (2): 65-80.

Omar, A.E.D.K., M.A. Ahmed & A.M. Al-Saif, 2017. Influences of seaweed extract and potassium nitrate foliar application on yield and fruit quality of date palms (*Phoenix dactylifera* L. cv. Sukary). Advances in Agricultural Science, 5 (3): 16-22.

Pascoalino, L.A., F.S. Reis, L. Barros, M.A. Rodrigues, C.M. Correia. L.A. Vieira. I.C.F.R. Ferreira & J.C.M. Barreira, 2021. Effect of plant biostimulants on nutritional and chemical profiles of almond and hazelnut. Applied Science, 11 (17): 7778.

Samur, G., 2006. Nutrition in Cardiovascular Diseases. ISBN: 975-590-181-7, Sinem Printing Press, Ankara, 20 pp.

Semma, M., 2002. Trans fatty acids: Properties, benefits and risks. Journal of Health Science, 48 (1): 7-13.

Sencopur, A., 1995. Effects of GA_3 Foliar Fertilizer Liquid and Powder Seaweed Extract Applications on Yield and Quality in Clementine Mandarin. Akdeniz University Graduate School of Natural and Applied Sciences, (Unpublished) Master Thesis, Antalya, 69 pp.

Strik, W. A., M. S. Novak & J. Van Staden, 2003. Cytokinins in macroalgae. Plant Growth Regulation, 41: 13-24.

TRADEMAP, 2020. Trade Statistics for International Business Development. Monthly, quarterly and yearly trade data. Import&export values, volumes, growth rates, market shares, etc. (Web page: https: //www.trademap.org/Index.aspx) (Date accessed: June, 2022).

Yildirim, F.A., A.N. Yildirim, F. Koyuncu & E. Tekintas, 2008. Almond (*Prunus amygdalus* Batsch.) selected in the Isparta region. Some Chemical Properties of Genotypes and Compositions of Fatty Acids1. Adnan Menderes University Journal of Faculty of Agriculture, 5 (1): 19-25.

Zacheo, G., M.S. Cappello, A. Gallo, A. Santino & A.R. Cappello, 2000. Changes associated with post-harvest ageing in almond seeds. LWT Food Science and Technology, 33 (6): 415-423.

Zhu, Y., K.L. Wilkinson & M.G. Wirthensohn, 2015. Lipophilic antioxidant content of almonds (*Prunus dulcis*). A regional and varietal study. Journal of Food Composition and Analysis, 39: 120-127.

Zodape, S. T., Mukhopadhyay, S., Eswaran, K., M.P. Reddy & J. Chikara, 2010. Enhanced yield and nutritional quality in greengram (*Phaseolus radiata*) treated with seaweed (*Kappapyucus alvarezii*) extract. Journal of Industrial Research, 70: 215-219.