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Alternate Bearing and Chemical Thinning Applications in Olives

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A B S T R A C T

In this review, in which the subject of alternance in olives is discussed, the effect of alternance on olive cultivation and the methods of coping with alternans are examined in line with the latest literature. The latest developments in chemical dilution, which is the most effective and most practical among alternative methods of combating alternance, are brought together. Chemical dilution studies on olives conducted in 2021 and before were searched for and presented in this review using various databases. As a result of the literature review, access to 20 scientific research articles directly related to the subject was provided. Because of the alternate bearing discussed in the study, olive production follows a cyclical pattern. Despite the fact that the olive is genetically predisposed to alternate bearing, it can be managed and controlled through horticultural practices; in this regard, chemical fruit thinning is the most commonly used method in olives. NAA, NAAm, Ethephon, Urea and GA_3 are among the most preferred chemicals used for chemical dilution in olives. Chemicals used, their doses, application times and many factors related to them affect the success of chemical applications. These factors include the tree's age, variety, physiological condition and climatic conditions (particularly temperature), full flowering time, and young fruiting period. When we look at the publications on chemical dilution, it is striking that the studies in our country are fewer in number than the studies abroad. This situation can be associated with the fact that there are still some concerns about chemical dilution in our country. The availability of "environmentally friendly" chemicals will be beneficial in reducing these concerns and protecting the environment, and producers will not suffer economically. As a result, there has been an increase in the use of chemicals all over the world in recent years, with an increasing reputation for environmentally friendly chemicals.

1. INTRODUCTION

Olive, an evergreen plant, produces the majority of its flowers and fruits on one-year-old shoots. As with some other fruit species, it produces a large amount of fruit in one year and little or no fruit in the following year or years. Due to this event called 'periodicity' or 'alternate bearing', Olive production shows a fluctuating course based on yield, which changes over the years. The physiological and biochemical mechanism of alternate bearing has not yet been fully elucidated. Alternans are a type of genetic trait that are affected by environmental variables including temperature, water availability, and nutrient availability that impact vegetative and generative development processes (flower bud stimulation, differentiation, fruit set, fruit growth and ripening). It is known that alternance is also controlled by intrinsic factors such as carbohydrates, mineral nutrients and hormones (Marino & Greene, 1981; Monselise & Goldschmidt, 1982; Dağ et al, 2009).

The primary cause of alternate bearing is thought to be the inhibition of flower bud stimulation and differentiation by some hormones synthesized and transported by the developing seed. According to other perspectives on the subject, it is the inhibition of flower bud stimulation by developing seed due to nutrient competition, the cessation of vegetative development due to competition from fruits, which are high carbohydrate consumers, and the emergence of alternans as a result. Basically, the fruit yield of the olive tree that year is determined by the vegetative development level of the previous year. The factor affecting vegetative development is the amount of fruit on the tree at that time. Alternate bearing can also be exacerbated by insufficient or excessive winter cooling in hot climates. From an economic point of view, alternate bearing reduces the producer's income per unit product in the 'on' year, while increasing the cost of harvesting, as well as leading to the marketing of large quantities of poor quality products. The relative price increase in the 'off' year, on the other hand, cannot cover the loss of the producer, and it also causes two important problems such as insufficient supply of goods and insufficient employment. In this context, the control of alternate bearing gains importance (Kailis & Haris, 2000; Krueger et al., 2005; Lavee, 2007; Dağ et al, 2009; Therios, 2009).

In the control of alternate bearing; It is important to cultivate olive varieties that do not show severe alternate bearing and to carry out the cultural processes (irrigation, pruning, fertilization) that will cause a balanced flower bud stimulation. In order to alleviate the alternate bearing first of all, it is necessary to reduce the excessive fruit load of the olive tree. Control of fruit load; consists of chemical thinning, manual thinning and pruning (Krueger et al., 2005; Lavee, 2007; Therios, 2009).

The most often used strategy to manage olive tree fruiting and, as a result, lower the output of alternate fruits, is chemical fruit thinning. In addition, chemical thinning increases fruit size in table varieties; By increasing the leaf/fruit ratio, it provides more nutrients to the fruit; It ensures earlier ripening and harvesting of the fruit, increasing the fruit pulp/seed ratio, increasing the amount of oil in oily varieties, and positively affecting flower bud differentiation (Dağ et al., 2009).

The aim of this review is to review the dilution studies in the national and international literature in recent years and to shed light on our breeders and the studies to be done on this subject.

2. ALTERNATE BEARING

2.1. Alternate Bearing in Olives

Alternans is found in a variety of fruit species. Olive trees are known to yield products in varying cycles throughout the year. Periodicity is a two-year rotation of 'on' and 'off' seasons. initially, some trees in the same orchard may be in a "on" cycle, while others may be in a severe "off" season. Strong vegetative growth occurs during the "off" season, resulting in large fruiting areas for the following season's crop. Abundant flowers, large fruit set, small fruit size, delayed fruit ripening, and little vegetative growth are observed in the following "on" seasons. Thus, for the next season's crop, the "off" season is characterized by fewer fruit and low flower formation. Even if olives are genetically prone to replication, climatic conditions may still play a large role in explaining reversibility in olives. Cultural practices that reduce olive tree vigor, such as nutrient deficiency and drought stress, suggest secondary causes of alternative transportation (Hackett & Hartmann, 1967; Lavee, 1996; Martin et al., 2005).

2.2. Factors Affecting Alternance

2.2.1. Environmental Impacts

Alternative bedding may develop gradually as trees enter production or may begin abruptly with a climatic trigger. Initially, some trees in the same orchard may be in an "on" cycle, while others may be in a severe "off" season. On the other hand, if alternate bearing is induced by environmental events, the change in trees is usually evenly observed throughout the orchard (Goldschmidt, 2005).

In some areas, climatic factors can increase alternate bearing. Because successful reproductive development (differentiation) occurs as a result of winter cooling, a "off" season can occur when conditions are unfavorable for flower development (Briccoli Bari et al., 2002).

Pinney & Polito (1990) and Rallo & Martin (1991) claimed that trees subjected to insufficient cooling bloom, but the flowers that open have poor quality and low fruit set. They also claimed that winter cooling is extremely important for identifying high quality flower buds. They found that olive fruit set decreased with increasing time spent above 27°C in winter.

Fruit set in olives is largely dependent on the climate. Usually only one fruit is kept per inflorescence. While the fruit is on the tree, any environmental stress can cause the fruit to drop. In addition, cool spring conditions can increase fruit set to five to seven fruits per bloom. Moreover, this increased starting set will not significantly increase the final fruit per tree due to increased natural fruit shedding that may occur at a later stage. High temperatures during flowering do not necessarily prevent fruit set. With this, the combination of low humidity and high temperature can result in high embryo drop and dryness of young fruit (Lavee, 1986).

2.2.2. Carbohydrates

Sugar and starch levels are significantly higher at the start of the 'on' season than during the 'off' season. Even more importantly, after the "off" year, the sugar and starch levels in olive leaves increase from year to year. The high crop load of the "on" season is due to the tree's carbohydrate reserves. As a result, large crops reduce the carbohydrate levels available for distinguishing flower buds, flowers, and young fruit. Apples' high fruit set and low fruit drop are due to adequate carbohydrate reserves and citrus fruits. The presence of carbohydrates appears to be less important for flower formation in olives compared to other parameters. Therefore, after the "on" season, low carbohydrate levels are not a direct cause of alternans in olives. It is seen that reproductive organs in olive have higher sink power than vegetative organs. It was also concluded that heavy crops use carbohydrate sources to induce shoot growth. Since the olive tree bears fruit from its one-year-old shoots, reduced shoot growth will reduce fruiting capacity in the next season (Fahmy, 1958; Hartmann, 1964; Stutte & Martin, 1986; Rallo & Suarez, 1989; Goldschmidt, 1999; Stopar et al., 2000).

2.2.3. Phenolic Acids

Chlorogenic acid (CGA) accumulated in olive leaves in 'on' seasons is higher than in 'off' seasons. Dilution of young fruit after fruit set, prevents CGA accumulation in leaves, resulting in positive flower differentiation and flowering in the following season. Spraying olive trees with CGA before winter significantly reduces flower bud differentiation. On the other hand, it was observed that flower differentiation and fruit set were not affected when CGA was applied after mid-winter. We can deduct from this observation that CGA exerts a direct, non-toxic effect on flower formation in olives (Lavee & Avidan, 1981; Lavee et al., 1986).

2.2.4. Hormones

2.2.4.1. Overall effect on alternate bearing of hormones

The most effective way to neutralize alternans or produce fruit in the 'off' season has to do with its ability to control flower formation. As mentioned earlier, besides the role of carbohydrates, plant hormones also play an important role in controlling the transition from vegetative to generative bud development. Plant hormones, one of the endogenous substances investigated so far, have been found to be most effectively associated with flower formation (Bernier et al., 1993; Bangerth, 2006; Dağ et al., 2009).

2.2.4.2. The importance of the seed for alternans

Flower induction with the aid of gibberellic acids (GAs) released by developing seeds is suppressed by high fruit loads. The importance of the seed for alternans is also emphasized for many other tree species. Demonstrated in their study that the effect of seedless apple fruit on flower induction of nearby shoot meristems did not have the same inhibitory effect as seedless fruit. An inhibitory signal emerges from the seeds and is then carried over to attract meristems where it inhibits flower formation (Chan & Cain, 1967; Ebert & Bangerth, 1981; Stutte & Martin, 1986; Bangerth, 1997; Fabbri & Benelli, 2000).

2.2.4.3. Hormonal interactions

GAs are thought to have an effect on the flower development of seeds which are a rich source. Exogenous application of GAs may additionally inhibit flower formation, which may turn hormones into optimal candidates for seed signaling. GAs are known to be persistent in shoot tips and seeds, where they stimulate auxin (IAA) synthesis/transport as primary messengers involved in flower induction. IAA suppresses flower induction as a secondary messenger, and the application of GAs stimulates polar IAA transport from fruit and shoot tips (Kuraiski & Muir, 1962; Bangerth, 1997; Stopar et al., 2000).

Concentration and/or transport of IAA in annual plants may be associated with inhibition of flower formation. This could be related to other effects as well, such as apical bud dominance. The observed increase in a tree's apical bud dominance indicates that the inhibitory organ's IAA flux increases at the expense of the inhibited organs' IAA fluxes. A smaller overall transport system for assimilates, minerals, water, and other substances required for floral induction results from the creation of a reduced IAA flow. Application of IAA-transport inhibitors such as 2,3,5-triiodobenzoic acid has been observed to stimulate flower formation in both annual and perennial plants. In addition, more compelling evidence has been found that IAA is a signal that inhibits flower formation (Daie, 1985; Bangerth, 1989; Tsujikawa et al., 1990; Bernier et al., 1993).

Numerous GA biosynthesis inhibitors also lessen IAA export from fruit and shoot tips. It has been discovered that paclobutrazol prevents the oxidation of caurene to caurenic acid, interfering with the production of GA. In doing so, it works by inhibiting GA biosynthesis in the secondary-apical bud meristem. As a result of foliar applications of this inhibitor, it was observed that fruit bud differentiation and yield increased more than 50% in apples in the second year. Conversely, in the Manzanillo olive, spraying of paclobutrazol from the tree no longer had a significant effect on flowering, fruit set or fruit size (Dalziel & Lawrence, 1984; Ebert & Bangerth, 1981; Sansavini et al., 1986; Fernandez-Escobar et al., 1992).

Cytokinins stimulate flower induction in both annual and perennial plants. These hormones have been shown to play a positive role in flower induction. According to molecular biologists, high IAA concentrations typically lower the cytokinin concentration of a specific organ. IAA concentration has an impact on cytokinin concentration as well as IAA transport. He emphasized that an optimal cytokinin concentration is required for the meristem to produce flowers, most likely due to cytokinins' stimulatory effect on meristematic activity (cell division). Low activity usually results in drowsiness, whereas high activity can cause new vegetative reddening. In light of this information, it seems that a critical cytokinin concentration is required for flower induction in a resting but not dormant meristem (Bernier et al., 1993; Muday & DeLong, 2001; Akça Uçkun, 2017).

2.2.5. Factors Affecting Alternate Bearing: General Inference

The factors involved in both vegetative and reproductive development of olive buds are the continuous and complex interaction between temperature and other environmental factors as a result of the factors discussed in this section. The increase in fruit number and thus seeds will increase

GAs, exacerbating IAA's negative effect on flower induction. IAA either directly inhibits flower formation through a signal or indirectly through a negative effect on cytokinins. Crop potential for the following season can be guaranteed up to a certain point by removing fruit before seed-produced GAs come into play (Lavee, 2006; Crous, 2012).

Although olives are genetically predisposed to periodicity, horticultural practices can manage and control it. Controlling the interaction of fruit load and vegetative growth are the two most important parameters in the alternate bed. Because the olive tree produces fruit on one-year-old shoots, shoot development is required to create enough flowering areas. As a result, it is critical to maintain a healthy balance between fruit load and shoot/vegetative growth. Under favorable climatic conditions, horticultural practices such as pruning, thinning, covering, and other cultural and nutritional means can reduce or even eliminate periodicity; however, keep in mind that alternans are extremely difficult to control under changing environmental conditions (Crous, 2012).

3. FRUIT THINNING IN OLIVES

3.1. What Is Fruit Thinning?

Fruit thinning is the process of removing buds, flowers or fruits that are more than normal on the tree by different methods. Fruit thinning, which has a significant effect on fruit quality in the 'on' year and fruit yield in the next season. It is a method applied to increase fruit quality and reduce periodicity, and its application is common in fruit trees (Bangerth & Quinlan, 2000; Link, 2000; Wertheim, 2000; Webster, 2002).

3.2. Methods Used to Control Fruit Load

In the control of fruit load; pruning and thinning methods are used. The thinning methods used are in the literature as manual, mechanical and chemical thinning. In this section, the methods are discussed in order.

3.2.1. Pruning

One of the oldest methods applied to control the fruit load in olive orchards is pruning. Pruning; it is used because it provides benefits in forming the crown of the tree, controlling vegetative growth, increasing light, stimulating flower bud differentiation, spraying applications, and mechanization of harvest. Olive pruning (especially hard pruning) should be applied before the year of "on". The amount of fruit on the tree is limited by pruning before the year of "on year". It causes the elongation of vegetative shoots on pruned branches. Pruning provides only light penetration in the "off year", where the growing crown is very dense. In regions with stable climatic conditions, alternans can be controlled quite successfully by pruning. However, in regions with very unstable climatic conditions, especially in slow growing varieties, the expected benefit from pruning may not be obtained and therefore additional methods such as fruit thinning may be required (Lavee, 2007).

Compared to thinning and pruning, fruit thinning is more effective. This is because pruning removes both fruit and leaves, so applying fruit thinning will result in an increased leaf-to-fruit ratio. It has been determined that fruit thinning performed two weeks after full flowering in olives increases vegetative development, flower bud differentiation, fruit size and yield. In fruit growing, a certain proportion of the flowers formed are required to set fruit. Crop load affects the fruit quality and physiological condition of the tree, as well as the next year's crop. Thinning does not reduce the amount of product obtained from the unit area, on the contrary, it improves the fruit quality and increases the rate of salable product (Westwood, 1995; Tromp, 2000; Dağ et al., 2009; Kaçal, 2011)

3.2.2. Thinning Methods

Control of fruit load; It can be achieved by manual thinning, mechanical thinning and chemical thinning. Fruit thinning in olive trees aims to reduce branch breakage due to next year's fruit load, increase fruit size, increase fruit yield and promote flower bud induction. Advantages of chemical thinning are: increase in fruit size, regular fruiting, early ripening of the fruit, increase in meat/seed ratio, increase in olive fruit quality, flower bud differentiation is in the form (Krueger et al., 2005; Therios, 2009). These methods are listed in Table 1.

Table 1. Comparison of thinning methods

Thinning methods	How is it applied?	Advantages and Disadvantages
Manual Thinning	*Manual thinning of fruit is the process of removing fruit or flowers from branches by hand. *Delay in thinning time should be avoided. Otherwise, there will be no decrease in alternate bearing and no increase in fruit size.	*It causes excessive increase in labor cost. *Thinning in the early period has a greater effect on the size of the fruits.
Mechanical Thinning	*During flowering, high pressure water spraying on the trees can cause the flowers to fall or the fruit to fall with the shakers used in fruit harvest.	Disadvantages: *Leads to uneven product distribution. *Shedding of larger fruits, *Damage to long-stemmed fruits by hitting each other. *Shedding more of the fruits at the shaking point is in the form.
Chemical Thinning	*With the help of chemicals, thinning is done in 2 different periods, namely the thinning of flowers or small fruits. *Sometimes these two methods are used together.	*Also, prices for chemicals used in thinning applications have increased significantly in recent years.

3.2.2.1. Chemical thinning

Chemical thinning studies are carried out in many fruit species such as apple, peach, apricot and pear. Chemical thinning of fruits was first realized in 1939 with the use of DNOC (Dinitro-ortho-cresol). In the studies, it is seen that the chemical thinning studies in apples and peaches are more than in other fruits, but the chemical thinning studies in olive are relatively less compared to the studies in other fruits. Chemical fruit thinning is one of the most widely used methods in olive to alleviate periodicity and control fruit yield of the tree (Weiss et al., 1993; Tromp, 2000; Gadner, 2003; Krueger et al., 2005; Therios, 2009; Çiğdem, 2014).

Chemical thinning in olives is an important tool in increasing the product quality in the “on year”. NAA is a synthetic form of auxin, a plant growth regulator that increases the formation of olive grains, and has been used for fruit thinning in olives since the 1950s. Chemical thinning with NAA has been practiced for more than 50 years. However, widespread adoption of chemical thinning has been slow. Because thinning is done before the exact estimation of fruit load. However, there is a risk of excessive or insufficient thinning. Also, prices for chemicals used in thinning applications have increased significantly in recent years. NAA is the only registered chemical today and is recommended for olive thinning. The potassium salt formulation of NAA has the same effect, but its use is not common today (Krueger et al., 2005).

Chemicals such as NAA (Naphthalene Acetic Acid), NAAm (Naphthalene Acetamide), and Ethephon ((2-Chloroethyl) phosphonic acid) have been tested for table olive thinning. On the other hand, it increases the amount of oil in olive varieties for oil purposes and positively affects flower bud differentiation. Its use in olive is generally in the period when 70-80% of the flowers bloom in some countries, depending on the variety. The use of NAA is mainly in olive; It brings low thinning cost, and it also enables to reduce alternate bearing. It is also used to increase fruit size, early ripening and better quality (Weis et al., 1988).

Chemical thinning has advantages over manual or mechanical thinning, such as lower thinning cost, increased fruit size, early ripening, better quality product, and reduced periodicity. Fruit varieties that are easy to thinning fruit are overthinning by NAA. Generally, NAA is mixed with other chemicals to achieve optimum thinning. Because various studies show that chemicals used in combination are more effective than when used alone**.** As the dose of NAA used increases, the amount of thinning also increases. However, high doses of NAA both damage the leaves and cause small fruit formation (the fruit remains on the tree before it becomes large). Therefore, it is emphasized that the use of high doses of NAA should be avoided. At the same time, excessive chemical fruit thinning is a convenient method to reduce the severity of alternate bearing in regions where stable fruiting is not observed. Although excessive fruit thinning occurs with many chemical thinners, the main factors effective in excessive thinning are listed in Table 2 (Williams, 1979; Faust, 1989; Burak et al., 1997).

With the help of chemicals, thinning is done in 2 different periods, namely the thinning of flowers or small fruits. Sometimes these two methods are used together. DNOC, which has a caustic effect, is used as a chemical substance in flower thinning. In small fruit thinning, Carbaryl (Sevin), a broad-spectrum insecticide, is used either alone or mixed with hormone-structured chemicals (NAA, NAAm, BA)**.** Some other chemicals such as Hydrogen Cyanamide, Ethephon and Thidiazuron are also considered for thinning (Williams, 1979; Ryugo, 1988; Childers et al., 1995; Krueger et al., 2005)

3.2.2.2. NAA application

The timing of NAA applications is extremely important to get the best results. Following full bloom, 10 ppm NAA solution is applied at 10-15 liters per tree per day. Full bloom is when 80% of the flowers open. In areas where the weather is unusually cold or hot, the thinning time is determined by fruit size. The applied NAA is absorbed by the leaves, and during the second week of application, a separation layer develops on the olive stems, resulting in some immature olives being shed. Trees are stressed after NAA application, with the shedding of a significant portion of the leaves. Therefore, NAA should only be applied to healthy trees. Early or late NAA applications may result in excessive or insufficient fruit set (Figure, 1). (Therios, 2009).

Figure.1. NAA application (Çiğdem, 2014)

Fruits begin to fall 10-14 days after NAA applications. In order for NAA to be absorbed by the leaves, it must be very well dissolved in water. For this purpose, spreader and adhesive (surfactant, adjuvant) should be added to the solution. The most effective application time is warm and windless morning hours with slow drying conditions where hormone absorption is highest. NAA is not effective at temperatures below 10°C. However, chemical thinning methods can sometimes show unstable results and excessive thinning may occur due to various factors. These factors are; age of the tree, growth strength of the tree, severity of pruning, intense flowering, poor pollination, high humidity or high temperature, and high concentrations of chemicals used in thinning. Two main methods are used to determine the NAA application time: A. Fruit Size B. Number of days after full bloom (Westwood, 1978; Therios, 2009).

Table. 2. Factors effective in excessive chemical thinning

Tree Factors	Environmental Factors
Weak trees with weak fruit branches and thin-textured trees	High relative humidity conditions in the days prior to application
Trees that are planted too tightly or in the shade of hedge screens	High humidity on the day of application leads to low drying
Badly pruned trees	High temperatures
Insufficient pollination	Average rainfall in the days following the application
Young trees	Leaves affected by frost

3.2.2.3. Young fruit period

Fruit size is a widely used method. NAA is applied when the average fruit size is between 3-5 mm. Fruit size varies within the orchard and tree. Therefore, in orchards and in the north-south sections of trees, measurements should be made from different locations on the crown to obtain an average value. The stated size is usually reached 12 to 18 days after full bloom, but this time may vary according to climatic conditions (Therios, 2009)

3.2.2.4. Number of days after full flowering (NDAFF)

In the use of this method, the time of full bloom should be determined for each orchard. The date of full bloom is determined when the contrast between the green leaves and the white flowers can be observed at a certain distance from the garden as the flowers begin to open. During this period, the trees appear white with 80-90% of the flowers opening and the appearance of bright yellow anthers. The remaining 10 to 20% of the flowers have not yet opened and their leaves have not fallen. In full bloom, pollen dispersal is high and by shaking the shoots by hand, this pollen can be collected. Also, full bloom is indicated by the shedding of yellow pollen when the branch is hit and the petals falling. These events indicate the time of full bloom. 3 or 4 days after full bloom, the trees acquire a yellow-bronze appearance. For the estimation of NAA application time, it is necessary to determine and record the full bloom day. NAA should be applied 12 to 18 days after full bloom. The fact that the air temperatures after flowering can vary according to the years makes it difficult to use this criterion. Spraying should be done earlier as the hot weather leads to a faster development after flowering; on the contrary, if the weather is cold, spraying should be done a little later. Therefore, for successful thinning, the orchard owner must closely monitor air temperatures and accurately determine the timing of spraying (Krueger et al., 2005).

4. CONCLUSION AND RECOMMENDATIONS

When the studies conducted from the past to the present are examined, the prominent topics are alternate bearing, factors affecting alternate bearing, thinning and its methods, and finally chemical thinning applications.

Alternate bearing is one of the important problems to be considered in olives. From an economic point of view, it ultimately reduces the producer's income per unit product in the 'on' year, increases the cost of harvesting, and also leads to the marketing of large quantities of poor quality products. The relative price increase in the 'off' year, on the other hand, could not cover the loss of the producer, and it also caused two important problems such as insufficient supply of goods and insufficient employment. In order to control the alternate bearing that causes such problems, thinning applications are inevitable in olives. In some regions, even if it cannot be completely prevented, chemical thinning can be said to be important in terms of controlling the alternate bearing to a certain extent and mitigating the yield loss, especially in the "off" years.

Studies dealing with thinning applications show that different thinning methods come to the fore, showing that mechanical and manual thinning are used less frequently in fruits such as olives. Chemical thinning has advantages over manual or mechanical thinning, such as lower thinning cost, increased fruit size, early ripening, better quality product, and reduced alternate bearing. In this context, chemical thinning is used more frequently in research compared to other methods, and many different chemical diluents are applied in trials. To list these chemical thinners, they are NAA, NAAm, Ethephon, Urea and GA_3.

The apparent alternans status in olives is not related to nutrient consumption. Fluctuation in crop (between crop and no crop years) appears to be controlled by induction and differentiation stimuli and inhibitors. Production of these regulators is initiated by growing fruit and their effectiveness is controlled by environmental conditions, mainly weather and climatic conditions. In today's climate change, the chemical applications described will be beneficial in reducing the difference between the years of product and no product. The external application of plant growth regulators promotes flower bud induction and differentiation in many fruit species. This will reduce the periodicity in olives.

When we look at the publications on chemical dilution, it is striking that the studies in our country are less in number than the studies abroad. This situation can be associated with the fact that there are still some concerns about chemical dilution in our country. The availability of "environmentally friendly" chemicals will be beneficial in reducing these concerns and protecting the environment, and producers will not suffer economically. In addition, in future studies, researchers can try different chemical thinners in different doses and olive varieties, thus deepening the research and eliminating this gap in the field. Finding environmentally friendly chemicals can also be done faster with these different researches.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

ZÇ: Manuscript design, Literature research

MA: Drafting, Literature research, Writing, Review and editing.

All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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