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RESEARCH ARTICLE

The Timing of Vegetative and Generative Development of 'Memecik' and 'Gemlik' Olive Cultivars

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ABSTRACT

The research is carried out to determine the effects of different dates and temperatures on shoot length, fruit weight, oil content %, and maturity index of Gemlik and Memecik olive cultivars. The phenological growth stages of cultivars in 'yield' year were also described in the study using the BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) scale. The shoot length observations were made on trees in the 'on' and 'off' periods between March 15, 2017, and December 29, 2017, every 15 days. It was determined that the shoot elongation of the trees in the 'off' period was even longer compared to the trees in the 'on' year. While the fruit weight of Gemlik had the highest value (3.775 g) on October 30, it had the highest value (3.330 g) on November 15 in Memecik. While fruit weight increased for 153 days for Gemlik, this period was determined as 122 days for Memecik. The maximum oil contents (%) were determined in Gemlik with 29.071 % on December 30 and in Memecik with 22.180 % on December 15. The maturity index of olive fruits reached its maximum level on December 15 in both varieties. As a result, it has been revealed that there is no serious difference between the phenological stages of the trees in the period of 'on' and 'off' depending on the periodic fruit yield. Moreover, the shoot development is generally more in the trees with 'off'in terms of the course of shoot development, and when the pomological analysis regarding the productivity status are examined, there are some serious differences.

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Introduction

Olive, whose origin is Anatolia, is among agricultural products, it is a very important fruit in terms of both production value and the area it covers. Although Turkey ranks fourth or fifth in terms of production amount in the world conjuncture, it can be said that the yield per tree is low. The reason for this can be shown as 'alternate bearing' in trees. In the national olive collection, it has been revealed that many olive varieties in Turkey show severe 'alternate bearing' (Kaya et al., 2011).

Memecik and Gemlik varieties, which are important oil and table varieties, show severe and moderate 'alternate bearing', respectively (Canozer, 1991). It is known that the lack or excess of basic climatic factors (temperature, precipitation, etc.) in the generative stage (flowering and fruit set) of olive increases the 'alternate bearing'. The world's largest olive-producing countries have evaluated the effects of production by examining the correlations between yield and climate parameters (Osborne et al., 2000; Fornaciari et al., 2002; Orlandi et al., 2005b; Motisi et al., 2008). Efe et al. (2009) reported that the places where the annual average temperature is 16.7 °C and close are the places where olives can be grown under optimum conditions. According to the findings obtained in a study aiming to determine the relationship between climate variables that are effective in olive production, it has been determined that the

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olive tree in Aydın province has an average total temperature demand of 392.08 days-degrees during the period from resting to fruit harvest (Colakoglu, 2009).

Correlative studies in olives using data from different locations or years suggest that temperature can modulate crop oil yield and oil composition (Garcia-Inza et al., 2014). In addition, a negative relationship between oil synthesis duration and temperature was found and data from different years and varieties were used, covering a narrow range of variation in average temperature (29.5-31.5 °C).

In this study, it is aimed to reveal the vegetative and generative development progress of the Memecik and Gemlik olive cultivars, which are important cultivars of Turkey, in terms of periodic shoot length and fruit stages in the period of 'on' and 'off'. Additionally, this paper describes the phenological growth stages of olive trees using the BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) scale.

Materials and Methods

The research was carried out at Bornova Olive Research Institute, Bornova, Izmir, Turkey in 2017 and 2018. The average and minimum temperature data were supplied from Bornova Meteorology Station, Izmir, Turkey. The study was carried out with five replicates of Memecik and Gemlik cultivars. All measurements and observations were made from December to March. Representative trees were photographed to illustrate the primary and secondary phenological stages by using the BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) scale (Sanz-Cortes et al., 2002).

Shoot length (cm) measurements were made in each tree after the shoot development activity of four shoots in different directions (north, south, east, and west). The length was determined by measuring the part from the beginning of the development of the branch to the tip of the shoot in centimeters (cm with the help of a tape measure). In this way, it is aimed to reveal shoot development courses in on and off years in olive trees. At the same time, the first measurements were made at the beginning of the vegetation period, and the last measurement was carried out at the end of the vegetation.

Determination of the maturity index (MI) is based on the calculation made using the following formula on a 100 olive fruit samples recommended by Boskou (1996). In the formula, the same letters that determine the color classes are used as a multiplier to evaluate the development of the fruit. This index can assist in determining when a certain time, for each region, has been reached in the formation of other maturity-related features (Solinas, 1990).

$$MI = (a \times 0 + b \times 1 + c \times 2 + d \times 3 + e \times 4 + f \times 5 + g \times 6 + h \times 7) / 100$$

a, b, c,…h are the number of olives belonging to each of the 8 categories below;

a: Olives with dark green skin

b: Olives with yellow or yellowish skin color

c: Olives with yellowish skin color with reddish spots

d: Olives with reddish or light violet skin color

e: Olives with black skin color and fruit still completely green

f: Olives with black skin color and violet up to half the thickness of the fruit

g: Olives with black skin color and violet flesh almost to the core

h: Olives with black skin color and completely dark flesh.

The oil ratio of olive (%) samples was determined by the Soxhlet extraction method as specified in TS EN ISO 659:2010, using n-hexane as a solvent, and the results were stated as ratio (%) (Anonymous, 2010).

Results

The phenological growth stages of Memecik and Gemlik olive cultivars in on year were described in the study using the BBCH scale. In Table 1, some important vegetative and generative stages of Memecik and Gemlik cultivars according to the BBCH scale are given according to dates. Figure 1 contains visuals of the cultivars.

The shoot length observations were made on trees in the 'on' and 'off' periods, between March 15, 2017, and December 29, 2017. Observations were made on trees every 15 days. Bud development is seen in Figures 1a-1b. The bud bursts of Gemlik and Memecik varieties were started on March 15th, 2017, and March 16th, in 2017, respectively.

The shoot length values of the cultivars are given in Figure 2 according to the year of 'on' and 'off'. While shoot elongation continued until September, 30 in Gemlik (73.50 cm), it continued until August, 15th in Memecik (60.00 cm). In both cultivars, shoot length remained the same until the end of the vegetation period. According to Figure 3, it was observed that the minimum (24.88°C) and average (30.63°C) temperature peaked on August, 30. While Memecik continued to elongate shoots up to the highest temperature, Gemlik cultivar continued after the decrease in temperature. Moreover, Gemlik continued its shoot elongation until September 30th (average temp. 14.28°C and minimum temp. 19.27°C) when September temperatures peaked. It was determined that the shoot elongation of the trees in the 'off' period was even longer compared to the trees in the yield year. The Gemlik reached a length of 110.250 cm on July 30th, while Memecik reached a length of 162.50 cm on October, 30th. Shoot elongation continued until September 30 in the yield period in Gemlik. Although Gemlik trees in the period of 'off' had a longer shoot

length, the shoot elongation period continued only until July 30th. That is, there was a 45-day difference between the plants that lived during the two periods. When Memecik is examined, that difference was 15 days, unlike Gemlik. Moreover, Memecik trees in the 'off' period continued shoot elongation longer than Gemlik trees in the 'off' period.

Table 1. BBCH scale of Gemlik and Memecik olive cultivars

BBHC Scale	Stages	Dates
Principal growth stage 0: Bud development	00: Foliar buds at the apex of shoots grown the previous crop-year are completely closed, sharp-pointed, stemless and ochrecoloured (Figure 1a- 1b)	Gemlik-March 15, 2017 Memecik-March 16, 2017
Principal growth stage 1: Leaf development	11: First leaves completely separated. Grey-greenish coloured	Gemlik-March 30, 2017 Memecik-April 4 2017
Principal growth stage 3: Shoot development	37: Shoots reach 70 % of final size.	Gemlik-May 11, 2017 Memecik-May 23, 2017
Principal growth stage 5: Inflorescence emergence.	50: Inflorescence buds in leaf axiles are completely closed. They are sharp-pointed, stemless and ochre-coloured.	Gemlik-May 16, 2017 Memecik-May 30, 2017
Principal growth stage 6: Flowering	60: First flowers open	Gemlik-May 16, 2017 Memecik-May 30, 2017
Principal growth stage 7: Fruit development	79: Fruit size about 90 % of final size. Fruit suitable for picking green olives	Gemlik-October 10, 2017 Memecik-October 13, 2017
Principal growth stage 8: Maturity of fruit	89: Harvest maturity: fruits get the typical variety colour, remaining turgid, suitable for oil extraction	Gemlik-November 15, 2017 Memecik-November 30, 2017

Figure 1. Some bud, leaf, shoot and fruit development stages according to the BBCH scale. 1.a.- 1b. Bud development, 2.a.-2b. Leaf development, 3.a.-3b. First leaves completely separated. Grey-greenish coloured, 4.a.-4.b. Inflorescence buds in leaf axiles are completely closed. They are sharp-pointed, stemless and ochre-coloured, 5.a.-5.b. The corolla changes from green to white colour, 6.a.-6.b. Full flowering: at least 50 % of flowers open, 7.a.-7.b. Fruit size about 10 % of final size, 8.a.-8.b. Fruit size about 50 % of final size. Stone starts to lignificate (it shows cutting resistance), 9.a.-9.b. Fruit size about 90 % of final size. Fruit suitable for picking green olives, 10.a. Harvest maturity: fruits get the typical variety colour, remaining turgid, suitable for oil extraction -10.b. Overripe: fruits lose turgidity and start to fall.

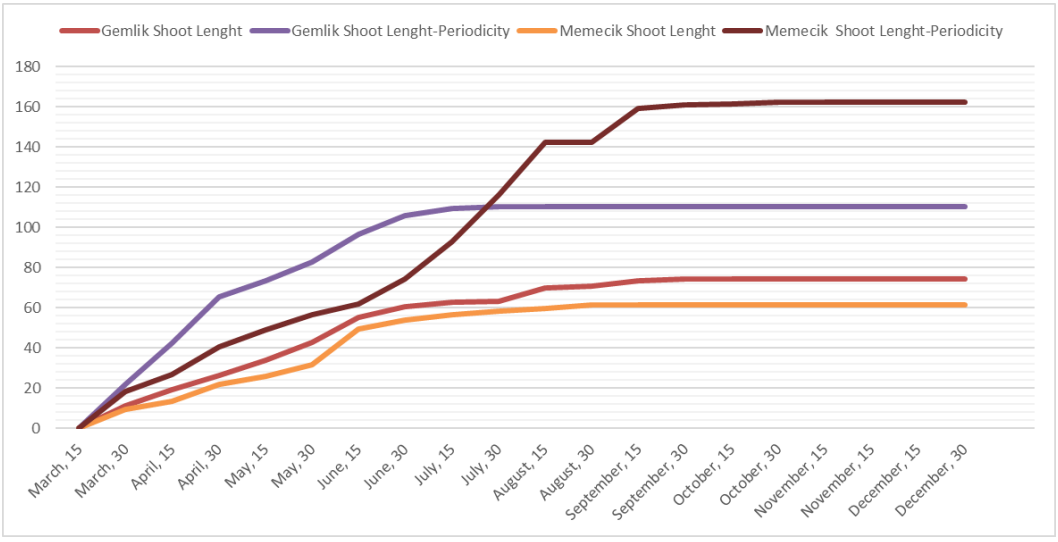

Figure 2. The shoot lenghts of Gemlik and Memecik varieties according to the 'on' and 'off' periods.

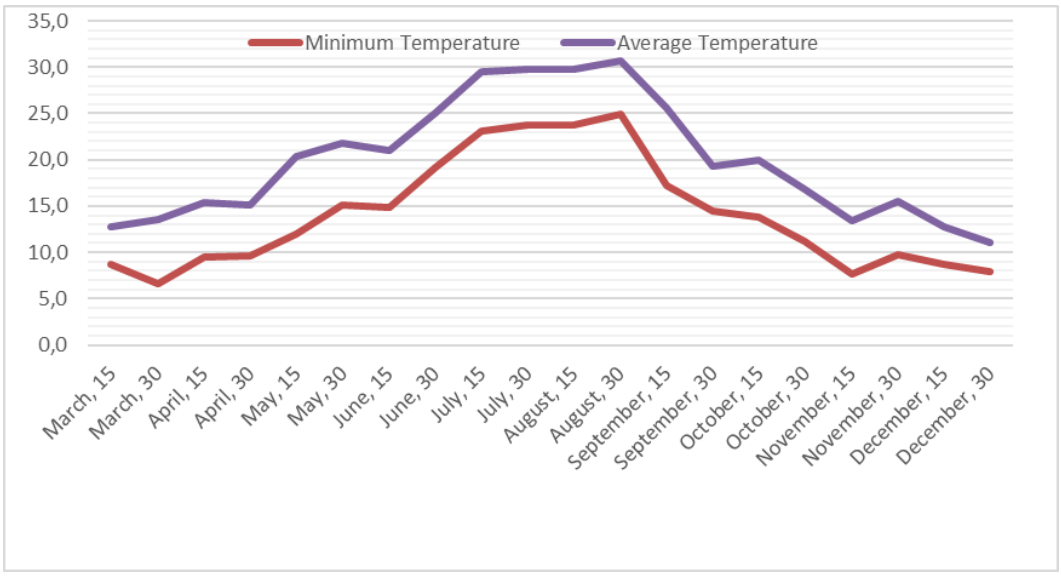

Figure 3. The average and minimum temperatures of vegetation period

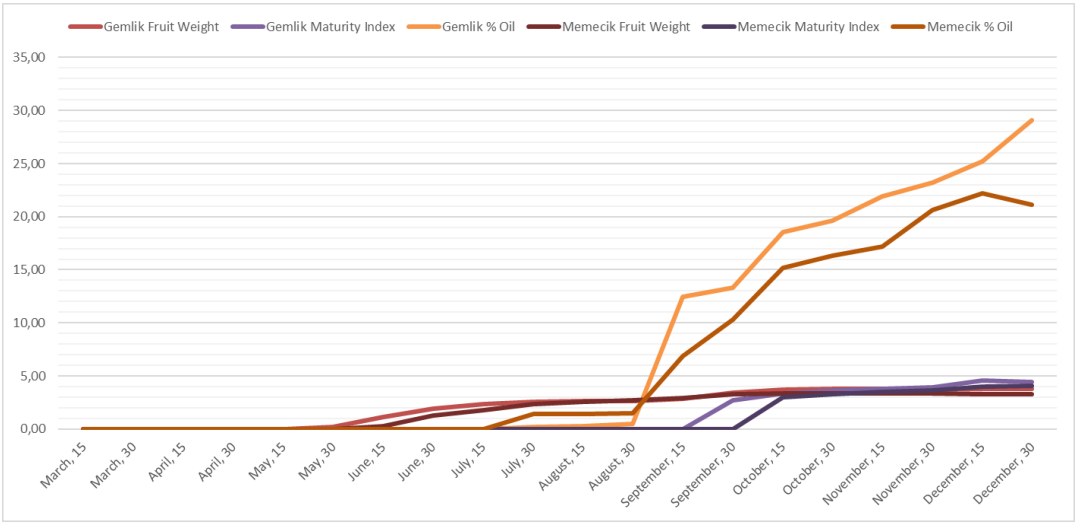

Figure 4. The fruit weights, fruit maturity indexes, and oil contents (%) of Gemlik and Memecik varieties according to the 'on' periods.

The fruit weight, fruit mature index, and oil content ratios (%)of the varieties are given in Figure 4 according to the period of yield. The average fruit weight of the Gemlik was 0.221 g on May 30, while the fruit of the Memecik has not yet formed. The average fruit weight of Memecik was 0.24 g on June 15th. While the fruit weight of Gemlik had the highest value (3.775 g) on October 30, it had the highest value (3.330 g) on November 15th in Memecik. While fruit weight increased for 153 days for Gemlik, this period was determined as 122 days for Memecik. After these dates, fruit weights decreased partially. From the date when the temperature was highest (August 30th), the oil content of the fruits increased rapidly. The oil content (%) increased in both varieties until December 15th. The maximum oil content ratios were determined in Gemlik with 29.071% on December 30th and in Memecik with 22.180% on December 15th. The maturity index of olive fruits reached its maximum level on December 15th in both varieties.

Discussion

The common problem encountered in the identification of olive varieties is the variability of the investigated characters depending on ecological conditions. The BBCH scale was used for the phenological observations. Sanz-Cortes et al. (2002) reported that the BBCH scale had advantages in identifying cultivars. For example, in the evaluation we made with the scale, it was determined that Memecik bloomed earlier and reached harvest maturity faster than Gemlik. Garrido et al. (2021) reported that the average vegetation period was 259 days in their study with Arbequina variety in North-Western Spain. In our study, it took approximately 261 days. The period from inflorescence to harvest was determined as approximately 184 days. Garrido et al. (2020), in their study using the BBCH scale, determined the time from the inflorescence emergence to the harvest as 216 (Arbequina), 221 (Frantoio) days in 2016, and 195 (Arbequina), 195 (Frantoio) days in 2017. It was observed that the cultivars used in our study had a shorter generative period. At this point, it can be said that there are other variables (temperature, soil, variety, harvest time, etc.) that affect cultivation.

The flowering date is mainly dependent on spring and summer temperatures. Many authors report that spring temperatures have a significant influence on the flowering date in olives (Alcala & Barranco, 1992; Recio et al., 1997; Galan et al., 2001, Perez-Lopez et al., 2008), and our data confirm the important influence of April and May temperatures (Figure 4). Because during these dates the temperature has started to rise rapidly.

In olive drupes, endocarp expansion is complete within 8-10 weeks (Rallo and Rapoport, 2001), while the mesocarp continues to grow for much longer (Rallo & Rapoport, 2001; Costagli et al., 2003). For common drupes such as plum, apricot, sour cherry, and peach, the period of mesocarp cell division typically lasts approximately 15 to 20% of the total fruit growth period (Bollard, 1970). The six-week period of cell number increase for Manzanilla variety corresponds with this pattern (Rallo & Rapoport, 2001). Contrary to these studies, fruit weight increase, that is, endocarp and mesocarp growth, took about 20 weeks in Gemlik and 18 weeks in Memecik in the study. In parallel with our study, Tombesi (1994) also reported that mesocarp development continued from the beginning to the end.

Several studies have highlighted the importance of shoot length (i.e., spur shoots vs long shoots) in determining a tree's ability to support fruit production (Johnson & Lakso, 1986). In our study, longer shoot structure was determined in the trees in the period of 'off' in both cultivars. Recent studies have suggested that short shoots are prone to flowering and fruiting, while long shoots tend to be vegetative (Bell, 1991). Previous authors reported that this situation may be related to the different wood to leaf biomass ratios of long and short shoots, affecting the timing and intensity of carbon export (Lauri & Terouanne 1991; Lauri 1992; Lauri & Kelner 2001).

Temperature regulates growth and development in plants. In a correlative study in olive, the duration of the fruit growth phase was shown to be reduced by high temperature while no effect of temperature on fruit growth rate was detected (Trentacoste et al., 2012). In addition, a negative relationship between oil synthesis duration and the temperature was found (Garcia-Inza et al., 2014). In our study, with the month of July, when the temperatures reached the highest level, percentage of oil in both varieties started to increase. However, when the temperatures started to decrease, the oil content (%) continued to increase partially. Here, the air temperature was expected to approach almost 30°C for oil formation.

Maturity index values varied every month in the study. Although all cultivars are grown under the same ecological conditions, the fact that the maturity indexes differ in all of them as a result of monthly controls shows that genetic characteristics have a greater effect on olives than ecological conditions. When the maturity indexes of the cultivars were compared, it is observed that Gemlik is the most mature cultivar. Similar to the results of our study, Gundogdu & Seker (2012) reported that in their study on Arbequina, Ascolana, Gordales, Hojiblanca, Manzanilla de Carmona, Manzanilla de dos Hermanas, Negral, and Verdial cultivars, all cultivars were almost immature (green-yellow) in August and took mature (purple-violet color) in November. Many studies are showing that the oil content of olive fruit increases as maturity progresses (Barone et al., 1994; Nergiz & Engez, 2000; Salvador et al., 2001; Shibasaki, 2005; Al-Maaitah et al., 2009). Colakoglu (1986) also stated that the highest oil level is reached when there is no green fruit on the tree.

Conclusion

The relationship between climate and yield is important in estimating the amount of olive product in the world. In the study, the flowering date in olives has depended on the temperatures recorded mainly in April and May and it was also determined that the temperatures of August and July are important for oil formation.

As a result of our study, we found that in the 'yield' period, generative development is high and vegetative development is low in olive trees; In the 'on' or 'off' period, it is seen that there is no generative development as well as excessive vegetative growth.

Conflict of Interest

The authors declare that they have no conflict of interest.

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