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Physical changes During Growth and Development of Khodeiri and Sorani Olive Fruits

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Abstract

This study was carried out during 2015 growing season on ten-year-old khodeiri and Sorani olive cultivars grown at fruit orchard belongs to the Department of Horticulture, Faculty of Agricultural Sciences, University of Sulaimani, Iraqi Kurdistan Region. The trees were planted at 4×4 meters apart under rain-fed condition. The investigation was conducted in order to study the changes occurred in some physical characteristics as well as oil content during growth and development of olive fruits. Results proved that fruit of the two cultivars showed a growth pattern cycle: Growth was rapid during the first growth stage (7-9 weeks), slow in the second stage (5-7 weeks) while the third stage was also one of rapid growth which coincided with the change in fruit skin color. The increment in fruit size prior to fruit development came mainly from the increase in cell numbers and cell enlargement in addition to embryo growth. Oil started to accumulate in the fruit during July and increased gradually during August and reached maximum as soon as the fruit turned completely black.
Key words: olive fruits, physical changes, oil, development, khodeiri, sorani, cultivars

التغيرات الفيزياوية خلال نمو وتطور ثمارصنفي الزيتون : خضيري و صوراني

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الخلاصة

تم تنفيذ هذه الدراسة خلال موسم نمو 2015 على صنفي الزيتون خضيري و صوراني بعمر 10 سنوات والمزروعة في بستان الفاكهة التابع لقسم البستنة- فاكلتي العلوم الزراعية- جامعة السليمانية - أقليم كوردستان العراق. كانت الأشجار مزروعة على مسافات 4×4 أمتار وتحت الظروف الد يمية. تم تنفيذ الدراسة بهدف معرفة التغيرات التي قد تحدث في بعض الصفات الفيزياوية وكذلك تراكم الزيت أثناء نمو وتطور الثمار.

أظهرت الدراسة بأن ثمارالصنفين أبديا دورة سلوك نمو بحيث كان سريعا خلال فترة النمو الأولي (7- 9 أسابيع) بطيء في المرحلة الثانية (5-7 أسابيع) في حين أصبح سريعا أيضا في المرحلة الثالثة والتي تصادف التغيرات التي تحدث للون جلد الثمرة. إن هذه الزيادات لحجم الثمرة قبل تطورها ناتجة من زيادة أنقسام الخلايا وحجمها وتراكم المواد الغذائية فيها أضافة إلى نمو البذورالناتج من نمو الجنين بداخلها. بدأ الزيت بأن تتراكم في الثمار خلال تموز وزادت نسبتها بصورة تدريجية خلال آب ووصلت الحد الأقصى عند تحول اللون إلى الأسود بصورة كلية.
الكلمات المفتاحية : الزيتون، التغيرات الفيزياوية، النمو والتطور.

Introduction

The olive tree, *Olea europaea* L. is an important perennial crop in the world especially many agricultural regions of the Mediterranean countries [Desouki et. al., 2009 (1) and Hagagg et. al., 2013 (2)]. The olive is an evergreen tree belongs to the *Oleaceae* family which includes many cultivars used either for oil extraction or pickling [Desouky et. al., 2009(2)]. The cultivated olive is the most iconic tree of the Mediterranean basin, and its omnipresence in agrosystems makes this species economically significant and a keystone of the traditional Mediterranean agriculture (Martin et. al., 2005). Fruit of Olea species is a drupe which means that the seed is surrounded by a hard shell or stone. Olive oil has a distinguished position among other edible oil because of its pleasant flavor, palatability, stability and health benefits (Al-Maaitah et. al., 2009). The components of the olive oil from fatty acids, nutrients and antioxidants are the main factors

causing the decrease of cardiovascular diseases. In Iraq, olives are generally produced in most climatic zones, however, Iraq is considered a minor producer compared to other neighboring countries (www. Inma- Iraq.Com).

Hartmann et. al., 1959, Hartmann and Opitiz, 1977, Hartmann et. al., 1980, Sibbett et. al., 1986, Doud et. al., 1994 and Hagagg et. al., 2013(2) stated that olive fruit development follows a double sigmoid curve with three stages: Growth is fast, exponential and characterized by cell division in the first stage, while it will slow down in the second stage and finally in the third stage, the fruit growth is by cell enlargement.

The work was carried out in order to study the growth and development of Khodeiri and Sorani olive fruit cultivars regarding some physical characteristics after fruit set and up to harvest time in addition to the determination of oil percentage during various growth behavior. Changes in some physical and chemical fruit properties during fruit development of the two olive cultivars are of special concern in modifying some cultural practices during fruit development [Hagagg et. al., 2013 (2)]

Materials and Methods

This study was carried out at olive fruit orchard belongs to the Department of Horticulture, Faculty of Agricultural Sciences at Bakrajo, Sulaimani, Iraqi Kurdistan Region. Ten-year-old, sixteen synonymous trees in vigor and free from visible pathogens of each Sorani and Khodeiri olive cultivars planted at 4×4 m apart were chosen under rain-fed condition. Cultural practices such as: cultivation, weed control, winter pruning and suckering were conducted when they were necessary.

Fruit Set %:

In mid-May, 2015, the average percentages of fruit set were determined for the two cultivars. For this purpose, number of flowers existed on four labeled branches of the sixteen trees for each cultivar was counted and then the average numbers of the fruit set from the flowers were calculated and changed into percentages according to the following formula:

$$\textbf{Fruit set \%} = \frac{\textit{number of fruit sets on all the branches}}{\textit{total number of flowers on all the branches}} \times 100$$

Fruit samples were collected randomly in the morning at two week intervals from June 23 and up to the end of the study on November 10, 2015. At each collection or harvesting date, 80 fruits were taken randomly from each cultivar and the following parameters were taken:

Fruit Weight:

Mettler balance with 0.0001 g was used and average fruit weight was calculated.

Length and Width:

Vernier was used for measuring both characteristics and the averages were found out.

Volume:

Archimedes′ principle was applied.

Moisture and Dry Matter Contents:

Determined by drying fresh fruits in an oven at 70^0C until a constant weight according to A.O.A.C. (1975), the difference between fresh and dry weight is the moisture content, the averages per fruit were then calculated.

moisture content (g) = fruit fresh weight (g)– dry matter weight (g)

Oil Percentage:

The oven dried (70^0C) flesh was grinded in a porcelain mortar and oil content was extracted with diethyl ether (b.p. 34-35^0C) using Soxhlet fat extraction apparatus as described by A.O.A.C. (1975). Percentage of oil in the fruit was calculated on the dry weight basis according to the following formula:

$$\textbf{Oil \%} = \frac{\textit{weight of oil in the dry sample fruit}}{\textit{weight of dry fruit}} \times 100$$

Statistical Analysis:

Sixteen synonymous trees were chosen from each cultivar and arranged in a randomized complete block design with four replicates, each of four trees and from each tree four branches were labeled for taking fruit samples. At each harvesting date, 80 healthy fruits were taken randomly from the same branches on each cultivar. Analysis of variance was carried out and the sample means were compared using least significant differences test at 0.05 levels according to Snedecor and Cochran (1980).

Results and Discussion

1-Percentage of fruit set:

The fruit sets were 1.98% and 1.33% for Khodeiri and Sorani consequently. The result agrees with Martin et. al., 2005 as mentioned by Noori et. al., 2015 who stated that if only 1% or 2% of the existing flowers remain as developing fruit it would achieve a commercial yield. Several factors affect fruit set such as levels of nutrients in leaves in particular N and K, types of soil (Noori et. al., 2015) as well as environmental conditions especially temperature and kinds of pollination either self or cross pollination (https://www. oliveoilsource//.com/page/olive)

2- Fruit Parameters:

Table 1 and figure 1 show that weights of Khodeiri fruits were low (1.44gm) at the beginning of recording data on June 23, 2015 then the weights started to increase rather sharply until July 7 (2.18 g). Later, the weights started to increase rather slowly up to September 15, such result agrees with Doud et. al.,1994 who found that when the hardening of olive pit fruit occurs around mid-July, its stone weight becomes almost constant until harvesting. The weights continued to increase rather faster until the end of the study on November 10. Both length and width of the fruit were relatively low in the beginning on June 23and increased rather sharply on July 7 then they increased slowly until the end of the study on November 10. Volume of the fruit behaved the same pattern as that of the weight (high in the beginning, moderate from July 7 to September 15 and then started to increase rather sharply until the end of the study i.e. the fruit growth behaved double sigmoid curve).

As it is clear in the table 1 and figure 1, the highest weight value (3.10 g) was recorded on November 10 which is superior significantly to all other dates except October 27, also the highest length (1.842 cm) was on the last date and dominate significantly all other dates, the same pattern of dominant significances were noticed for the last date concerning each width (1.630 cm) and volume (3.41cm^3) which exceed significantly majority of the other dates.

Fruit dimensions increased continually after fruit setting, showing a cyclic behavior of growth like some other varieties [Hartmann, 1949, Ezzat and El-Azzouni, 1965, Minessy et al., 1971, Doud et. al., 1994, Al-maaitah et. al., 2009, Desouki et. al., 2010 and Hagagg et. al., 2013 (1 and 2)]. The main reason for fresh fruit weight and its components (length, width and volume) increase during the early stage resulted from cell division and cell enlargement which prevail during this stage (Schroeder, 1958 and Doud et al., 1994). Several factors such as adequate nutrients, vigor of trees, availability of soil moisture, crop density and fruit leaf ratio were shown to affect fruit weight and its components [Doud et. al., 1994 and Hagagg et. al., 2013 (1 and 2)]. The fruit turgor pressure increased due to sufficient amount of moisture (Chandler, 1958). Fruit growth rate is also affected by fruit load and environmental conditions such as lacking available moisture, high temperature and severe evaporation that may result in the reduction of the growth rate of the fruits [Chandler, 1958 and Sibbett et. al., 1986].

Slower increase both in weight and fruit volumes in the second stage (July 7 until September 15) could be related to the decrease in auxin level in the fruit or the reduction of competition between embryo and fruit flesh tissue to obtain such hormone while the marked increase in both weight and volume of the fruit (September 15 to the end of the study on November 10) may be due to the increase of auxin in the fruits.

Table 1 and figure 2 indicate that the highest percentage of oil (29.6%) was noticed on October 13 which is superior significantly to some other dates such as June 23, July 7 and 21 as well as August 4 and 18 in addition to September 1.

Results are in agreement with those of Tous et.al., 1997 who found that maximum oil content in Arbequina olive cultivar fruit occurred between 165 and 195 days after fruit set. The results are also in agreement with Hagagg et. al., 2013 (2), they also agree with Ezzat and El- Azzouni, 1965 and Desouki et .al., 2010. Rate of oil accumulation differs according to the cultivars, locations and harvesting dates; the more delaying the harvest the better quality and quantity of oil would be obtained (Al-Maaitah et. al., 2009). On contrary, the highest moisture percentage (58.3%) was recorded for June 23 which dominates significantly some other dates particularly the later dates.

The change in fruit moisture content is related somehow to the pattern of fruit growth development in terms of fresh weight. The results agree with Hassan (1980), Fouad et. al. (1992), Kaynas et. al. (1992) and Hagagg et. al., 2013 (2) who stated that moisture content exhibited great variations according to cultivars and seasons of growth. While, dry matter percentage was highest (60.3%) on November 10 and superior significantly to all other dates. The results in terms of dry matter are in harmony with results obtained by Ezzat and El-Azzouni, (1965) and Desouki et. al. (2010). The high rate of increase in dry matter may be due to carbohydrate accumulation during the early development stage, so that quite a few metabolic compounds converts into fatty acids and oil.

Table 1 Effect of harvesting dates on some physical characteristics and oil percentages of Khodeiri fruit cultivar during 2015 growing season

Dates	Weights (g)	Lengths (cm)	Widths (cm)	Volumes (cm^3)	Oil %	Moisture %	Dry matter %
23/6	1.44^{h}	1.337^{g}	1.233^{f}	1.31^{e}	12.4^{f}	58.3^{a}	41.7^{f}
7/7	2.18^{g}	1.425^{f}	1.289^{f}	1.91^{d}	17.9^{e}	56.5^{a}	43.5^{ef}
21/7	2.24^{fg}	1.595^{e}	1.393^{e}	1.96^{d}	24.4^{d}	56.8^{a}	43.2^{ef}
4/8	2.37^{e-g}	1.597^{e}	1.413^{de}	1.99^{cd}	26.6^{c}	55.8^{a}	44.2^{e}
18/8	2.43^{ef}	1.644^{d}	1.441^{de}	2.10^{cd}	26.8^{c}	55.5^{a}	44.5^{e}
1/9	2.53^{de}	1.692^{c}	1.460^{cd}	2.19^{cd}	27.4^{bc}	50.7^{b}	49.3^{d}
15/9	2.57^{c-e}	1.740^{b}	1.498^{b-d}	2.33^{c}	28.1^{a-c}	55.4^{a}	44.6^{e}
29/9	2.67^{cd}	1.744^{b}	1.546^{a-c}	2.94^{b}	28.2^{a-c}	47.2^{b}	52.8^{c}
13/10	2.78^{bc}	1.750^{b}	1.596^{ab}	3.20^{ab}	29.6^{a}	42.9^{c}	57.1^{b}
27/10	2.93^{ab}	1.775^{b}	1.617^{a}	3.33^{a}	29.4^{a}	42.2^{c}	57.8^{b}
10/11	3.10^{a}	1.842^{a}	1.630^{a}	3.41^{a}	28.9^{ab}	39.7^{c}	60.3^{a}

Means having the same letters within a column are not significantly different at 0.05 level according to LSD.

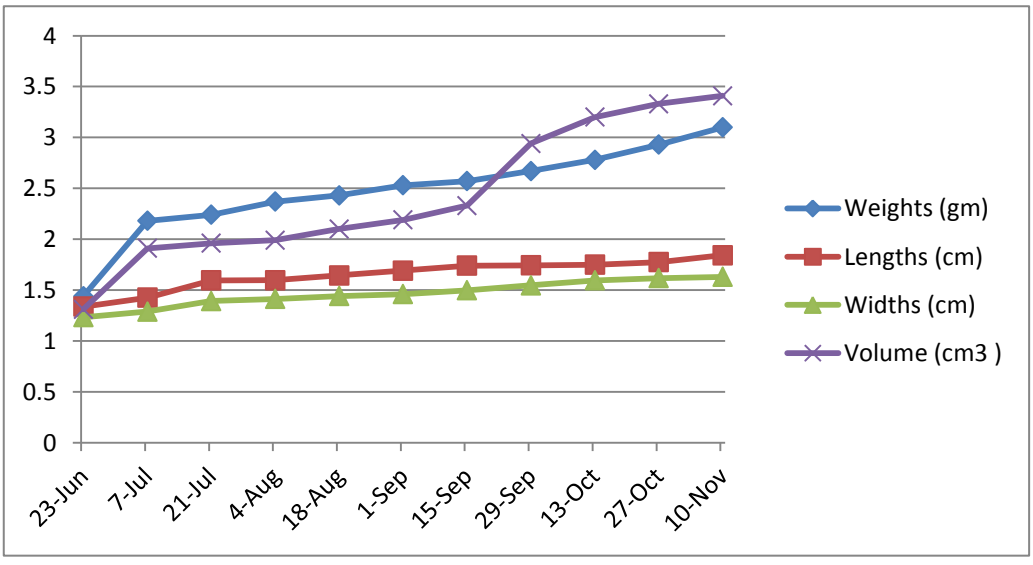

Fig.1: Effect of harvesting dates on fruit weights, lengths, widths and volumes of Khodeiri **fruit cultivar during 2015 growing season.**

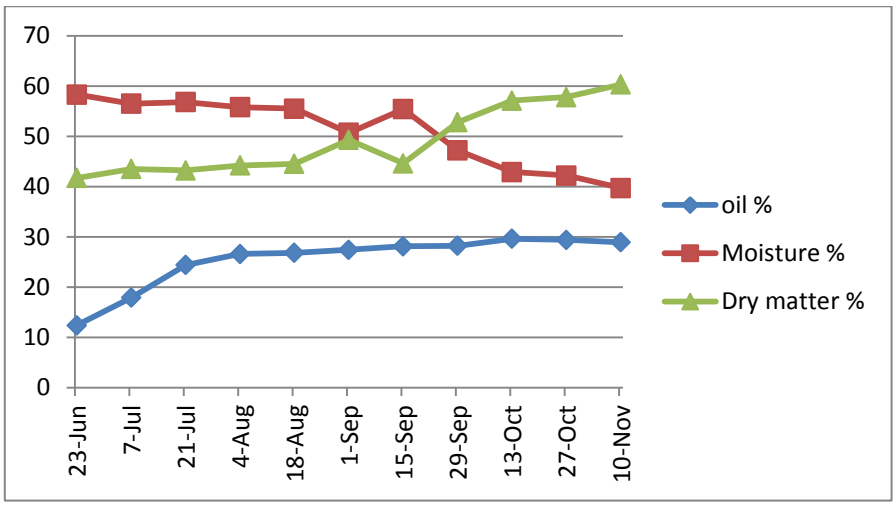

Fig. 2 Effect of harvesting dates on fruit moisture, dry matter and oil percentages of Khodeiri fruit cultivar during 2015 growing season.

Table 2 and figure 3 show that weight of the Sorani fruits recorded the lowest (1.50 g) in the beginning of growth on June 23 and increased rather sharply until reached 2.24 g on July 7 then it started to increase rather slowly until reached 2.45 g on September 15, later it started to increase rather sharply until reached 3.60 g at the end of the study on November 10 which is superior significantly to all other dates.

The lowest length was 1.407 cm at the beginning on June 23 then started to increase gradually until reached 1.825 cm on November 10 which is superior significantly to the dates preceding September 1. Width followed the same behavior as that of length with lowest value (1.133 cm) on June 23 and highest (1.617 cm) on November 10 which dominates significantly all other dates except October 27 and October 13. Volume was also the lowest (1.44 cm^3) on June 23 then started to increase in the same manner as that of the weight until reached the maximum (3.48 cm^3) on November 10 which dominates significantly the other dates except October 27 and October 13.

Table 2 and figure 4 indicate that oil percentage was 10.89 % on June 23 which was the lowest then it started to increase gradually until reached the maximum (30.41%) on November 10 which is superior significantly to all other dates except October 27. On contrary, moisture percentage was maximum (51.12%) on June 23 which is superior significantly to all other dates and started to decrease until reached the minimum (33.43%) on November 10. On the other hand, dry matter percentage was 48.88% on June 23 and started to increase until reached 66.57% which is maximum and superior to the majority of other dates.

Growth and development of Sorani cultivar as well as the oil content was identical to a great extent to that of Khodeiri, so the same sources and interpretation could be pointed out for the results obtained.

Table 2 Effect of harvesting dates on some physical characteristics and oil percentages of Sorani fruit cultivar during 2015 growing season

Dates	Weights (g)	Lengths (cm)	Widths (cm)	Volumes (cm^3)	Oil (%)	Moisture (%)	Dry Matter (%)
23/6	1.50^{i}	1.407^{e}	1.133^{g}	1.44^{e}	10.89^{j}	51.12^{a}	48.88^{e}
7/7	2.24^{h}	1.500^{d}	1.289^{f}	1.98^{d}	13.72^{i}	49.72^{b}	50.28^{de}
21/7	2.37^{g}	1.635^{c}	1.393^{e}	2.03^{d}	17.37^{h}	47.37^{c}	52.63^{d}
4/8	2.41^{f}	1.730^{b}	1.413^{e}	2.06^{d}	19.55^{g}	41.55^{d}	58.45^{c}
18/8	2.42^{ef}	1.735^{b}	1.441^{d}	2.18^{cd}	21.43^{f}	38.43^{e}	61.57^{b}
1/9	2.43^{ef}	1.810^{a}	1.450^{d}	2.22^{cd}	23.06^{e}	38.06^{e}	61.94^{b}
15/9	2.45^{e}	1.814^{a}	1.481^{c}	2.43^{bc}	25.76^{d}	37.80^{e}	62.20^{b}
29/9	2.86^{d}	1.820^{a}	1.546^{b}	2.64^{b}	27.05^{c}	35.58^{f}	64.42^{ab}
13/10	3.13^{c}	1.821^{a}	1.596^{a}	3.20^{a}	28.82^{b}	34.65^{fg}	65.35^{a}
27/10	3.40^{b}	1.824^{a}	1.610^{a}	3.33^{a}	29.62^{ab}	33.91^{g}	66.09^{a}
10/11	3.60^{a}	1.825^{a}	1.617^{a}	3.48^{a}	30.41^{a}	33.43^{g}	66.57^{a}

Means having the same letters within a column are not significantly different at 0.05 level according to LSD.

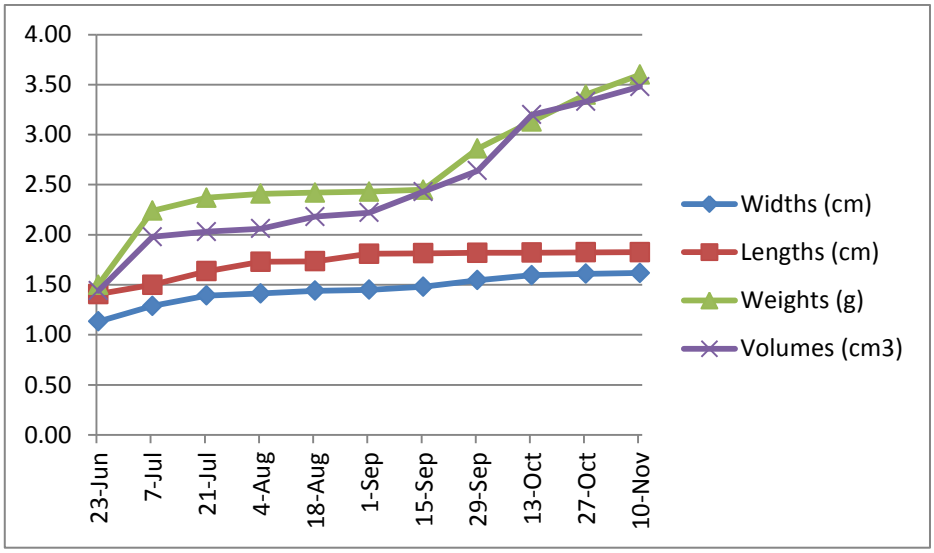

Fig.3: Effect of harvesting dates on fruit weights, lengths, widths and volumes of Sorani fruit cultivar during 2015 growing season.

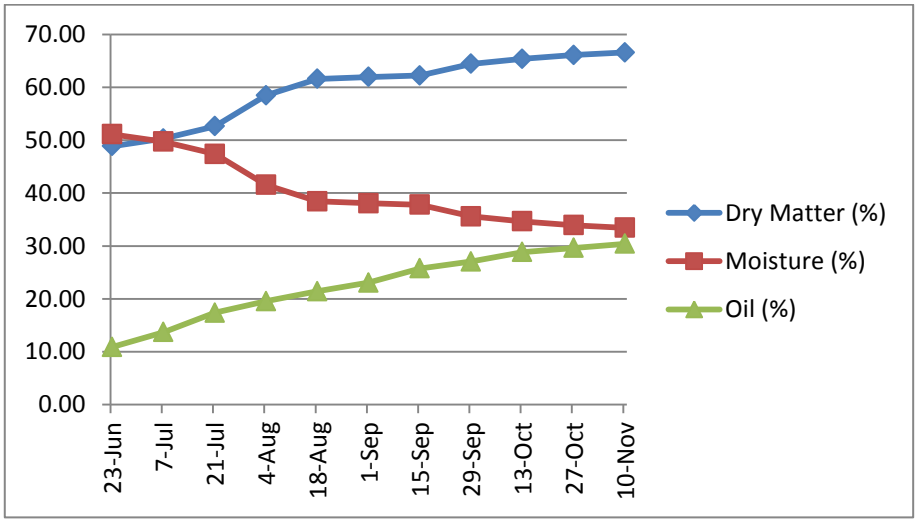

Fig.4 Effect of harvesting dates on fruit moisture, dry matter and oil percentages of Sorani fruit cultivar during 2015 growing season

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