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Changes in Fruit weight, dry matter, Moisture content and Oil percentage during fruit development stages of two olive cultivars.

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ABSTRACT

This work was carried out through 2011 and 2012 seasons on two olive oil cultivars, namely (Aggizi shame and Aggizi). Trees were 10 years old, grown in sandy soil, planted at 5x5 meters apart under drip irrigation system. The investigation aimed to study the changes in some physical and chemical fruit properties in relation to fruit development stage. Results proved that fruit of the three cultivars exhibited a cycle growth pattern: Growth was rapid during the first fruit growth stage (8-10 weeks), slow during the second stage (6-8 weeks). The third stage is again one of rapid growth and coincides with the change in fruit skin color. The increment in fruit size prior to fruit coloration comes mainly from increased moisture content of the fruit. Oil begins to accumulate in the fruit and increases gradually through July, August and reaches the maximum as fruit become completely black.

Key words: Olive (*Olea europaea*), Aggizi shame and Aggizi, growth curve, physical and chemical fruit properties**,** weight, dry matter, Moisture content and Oil percentage.

Introduction

Olive is an evergreen tree. Leaves are replaced every after 2-3 years. Tree height varies from 5 to 20 m. The plant has either spreading nature or bushy habit in its natural state (basiplastia); but can be trained to a tree. Root system is strong; distributed almost all over top soil but with roots having capability to hint rocky soil. Horizontal growth of roots is almost three times the canopy width. It is a long-lived tree; some trees have been lived for 1000 years. Leaves have stomata nestled in peltate trichomes on their lower surface (star-like hairs) that restrict water loss due to transpiration and make the olive relatively resistant to drought.

The olive (Olea europaeaL.) is indigenous to the Mediterranean basin. It is a small to medium sized tree that is a major crop in the Mediterranean Basin countries and has been grown in other similar climates in the southern hemisphere, south west Asia, africa and elsewhere. This tree crop has played a major role in the culture and diet of peoples in the Mediterranean regions of the world. The olive tree (Olea europea L.) is one of the most important plants which has a great economic value in new reclaimed land in Egypt.

The olive fruit is a green drupe, becoming generally blackish-purple when fully ripe. A few varieties are green when ripe and some turn a shade of copper brown. The cultivars vary considerably in size, shape, oil-content and flavor. The shapes range from almost round to oval or elongated with pointed ends. Raw olives contain an alkaloid that makes them bitter and unpalatable. A few varieties are sweet enough to be eaten after sun drying. Thinning the crop will give larger fruit size. This should be done as soon as possible after fruit set. Thin until remaining fruit average about 2 or 3 per foot of twig. The trees reach bearing age in about 4 years.

Fruit set is considered normal when 2 to 4 % of flowers become fruits. Fruit formation start with pericarp formation followed by epicarp (skin), mesocarp (pulp) and then endocarp (stone) development. One month after fruit formation, about 20% of fruits drop in normal condition. From September (in Northern Hemisphere) there is a change in the colour of epicure (from green to red-violet, black) and such change indicates ripening process occurring inside the fruit.

Olive Fruit development follows a double sigmoid curve, very common in other fruit, having three stages. In the first stage, growth is fast; the growth is exponential and is characterized by cell division, and the pit is still growing. In the second stage the growth slows down or stops. However, at this stage the pit hardens and attains its final size. Finally, in the third stage the fruit grows by cell enlargement. In this respect Desouky, *et. al.* (2010) stated that, the fruit of olea species is a drupe, the term "stone fruit" expresses the fact that the seed is surrounded by a hard shell or stone, the endocarp. This stone develops from the inner part of the ovary wall and the soft flesh from the outer part. When the fruit is very young the stone is soft but after a few weeks it begins to harden. The seed of the mature fruit is the embryo and the large halves. Hartmann and. Opitiz (1977) reported that olive fruit exhibits a cyclic growth pattern. Growth is rapid during the first stage, slower during the second stage, in (July and August). The third stage, just before fruit starting to color, is again one of rapid growth and coincides with the color changes from green to straw to red to black. After few weeks from fruit set, oil begins to accumulate in the fruit. The amount of oil increases gradually through summer and fall, and reaches its

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maximum as fruits become completely black. Oil production, quantity and quality is greatly affected by many factors i.e., cultivar, oil accumulation and harvesting stage.

The fruit weight and fruit volume showed continuous increase from the beginning of fruit development till fruit reached it's full weight when it was 26 weeks old (180 days from fruit set) in Hamed variety and about 28 weeks old (195 days from fruit set) in Chemlali variety. However, moisture content in development olive fruits remained constant during the first two weeks. This was followed by intermittent variations until fruit starting to color (reddish-green). At this stage, the moisture content remained constant until the blacking of the fruit Ezzat and El-Azzouni, (1963). The oil began to appear in Chemlali olive fruits after 60 days from fruit setting and reached its maximum (22%) after 185 days Boulis and Malaty, 1965. The fruit weight and fruit volume of eight seedling olive cultivars increased through the season with a reduced rate of growth in the middle period development Hegazi, (1970). The average flesh weight of olive fruit increased from the age of 60 days till the end of the sampling with a slow rate of increase during the middle stages of growth Hassan. (1980).

The aim of this investigation is studding fruit development stages for Aggizi shame and Aggizi, olive cultivars grown under Ismailia – Egypt condition in order to be a guide for olive growers to improve the commercial and qualitative characteristic of fruit and identify the Optimal harvesting time which is the most important factor that determines the olive oil quality and quantity.

Materials And Methods

The present study was conducted on six olive trees of the two cultivars (Aggizi shame and Aggizi). The trees were 10 years old, grown in a sandy soil at planting distance of 5x5 meters apart under drip irrigation system in private orchard in Ismailia – Egypt. The trees apart (168 trees\ acre) in a sandy soil (Table 1). The trees were received the same cultural practices that are recommended. The farm is depending on wills in irrigation (Table 2). The trees were almost similar in vigor, free from any visible pathogenic symptoms and at the same bearing phase. Experimental trees were subjected to the ordinary horticultural practices and the work was conducted during 2011 and 2012 seasons.

For somewhat, similar trees of each olive cultivar were selected. Study the changes in some physical and chemical fruit properties during fruit development stages of the two olive cultivars has a great importance for olive growers to modify some horticultural practices during fruit development.

Fruit sample (100 fruit per tree) was randomly collected at two weeks intervals (from May 14, 2011 and May 5, 2012) until the early September of each season, thereafter fruit samples were weekly collected till the harvest date (September 6 , 2011 and August 29, 2012).

For each studied olive cultivar only healthy fruits, without any kind of infection or physical damage were subjected to the following physical and chemical fruit characteristics determination as follows:

1-Fruit weight:

It was determined by weighing the samples (100 fruits) by ordinary balance with 0.01 gm sensitivity and average weight per fruit was calculated.

2- Moisture content and dry matter content:

were determined by drying the flesh in an oven at 60-80°C until a constant weight A.O.A.C., (1975).

3-Oil percentage:

Fruit oil content was determined by means of the Soxhlett fat extraction apparatus using Hexan of 60-80°C boiling point as described by A.O.A.C., (1975).

4- Weight of Dry Matter other than oil:

It was determined by the following equation (Dry Matter = fruit fresh weight – moisture content)

Statistical analyses:

The data were subjected to analysis of variance and Duncan's multiple rang test was used to differentiate means at 5% Duncan, (1955).

Results And Discussions

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1- Fruit weight:

In Tables (3 to 6) and Figs (1 to 4), a considerable rapid increase in fresh fruit weight of Aggizi shame was noticed during the first stage of fruit development (from May 14 until June 25). This increase in fresh fruit weight was mainly due to cell division and cell enlargement prevailing in this early stage. Therefore, vigor of tree, adequate nutrients, availability of soil moisture, crop density and fruit leaf ratio has been shown to influence fruit weight. At the end of this stage fruit weight attained (3.60 and 4.91 gm) in the two seasons, respectively. The period between June 25 until July 23 was characterized by slow increase in fruit weight. After this rapid stage, slower increase was noticed (from Aug. 6 to Sep. 10), it could be a result of the decrease in auxin level in the fruit or the competition on the auxin between embryo and fruit flesh tissue. As a result of this competition the enlargement of the flesh is slow. After this time a sharp expand in the fleshy part was occurred (from 3.64 to 6.19 gm) and (from 6.8 to 11.92 gm) from July 9 to Aug. 13 and from July 1 to Aug. 15, in the two season, respectively. This marked increase in fruit fresh weight could be a result of the increase in moisture content in the fruit. Consequently, the exogenous factors such as non available moisture, high temperature or sever evaporation conditions may decrease the growth rate of the fruits. Concerning the Aggizi shame cultivar somewhat similar fruit growth pattern. Fruit weight at the end of early stage (stage one) was (3.64 and 6.8 gm) at June 9 and 1 in the two seasons, respectively. At the beginning of third stage, fresh fruit weight increased from 3.64 to 6.19 gm and from 7.23 to 11.92 gm in the two seasons, respectively. The increment in flesh weight seems to be connected with the fruit moisture content, the higher the fresh fruit weight the higher the fruit content. As for the Aggizi shame cultivar results obtained were similar to those of the Aggizi cultivar. Fruit size increase in the third stage comes mainly from increased moisture content of the fruit, if the tree lacks soil moisture during this period, or if strong desiccating winds occur, the expected increase in fruit size can not take place. The Aggizi shame cultivar fruit exhibited similar cyclic growth curve as did the other cultivar. These findings are in line with those reported by Hartmann and Opitiz, (1977) and Desouky, *et. al.* (2010).

2- Moisture content:

Data concerning the changes in fruit moisture content and its rate of change are presented in Tables (3 to 6) and Figs (1 to 4). For the "Aggizi shame" in the first season, it could be seen that fruit moisture content markedly increased in the early stage of fruit development from May 14 to June 25, 2011, moisture content value raised from 0.43 to 2.51 gm (about 483 % increase). Fruit moisture content turned to very slow rate for about 29 days from June 25 to July 23, 2011 (only about 12% increase), after which the rate of moisture sharply increased for about 15 days from 2.53 gm/fruit at July 9 to 4.49 gm/fruit at Aug. 13, 2011 (about 77% increase). Fruit moisture content tended to fluctuate towards the end of the season. Data of the second season show that fruit moisture content increased markedly during the early fruit development stage, followed by a very slow increase from July 1 till August 1, then a sharp increase was occurred between August 1 till August 15 (about 59% increase). Fruit moisture content showed a steady increase value towards the ripening stage. Data of the other cultivar showed somewhat similar growth pattern which showed a sizeable increase in fruit moisture content, followed by a period of decreasing develop rate, while the last phase was characterized by a rapid rate of moisture increase. Generally, it can be mentioned that the timing of each phase and its duration differed according to the cultivar and season. It is interesting to note that the change in fruit moisture content is greatly connected with the fruit growth development in fresh weight. These findings are in harmony with those of Hassan, (1980), Fouad, *et. al.* (1992) and Kaynas, *et. al.* (1992) who mentioned that moisture content showed wide variation according to cultivars and seasons. Similar results were obtained by Ezzat and Azzouni, (1963) and Desouky, et. *al*. (2010).

3-Dry matter content:

Data concerning the changes in dry matter other than oil during fruit development are presented in Tables (3 to 6) and Figs (1 to 4). According to the obtained data in the first season of Aggizi shame cultivar, it could be seen that, the early phase was characterized by a rapid rate of increase. The rate of increment in fruit dry matter content was 115.8, 85.4 and 38.2 for the three sampling data, respectively. Thereafter the increment in dry matter turned to the slow rate till the fruit attained the harvesting stage. The rate of increase was 0.67, 1.32 and 1.95 % in the latest three sampling dates respectively. Data of the second season, whereas the rate of increase reached its highest value during the early fruit development stage after which the rate of increase was characterized by a slow rate of increase. Regarding the Aggizi cultivar, the same pattern was found whereas timing of each phase and its duration differed according to cultivar and season. The high rate of increase in the dry matter other than the oil probably due to carbohydrate accumulation during the early development stage. Therefore, a sizable amount of metabolic compounds goes into fatty acids and oil.

Table 1: Chemical characteristics of sandy soil used for the present study.

parameters	Depth of simple (cm)		
	Surface sample	30 cm depth	60 cm depth
pH	8.02	8.70	8.11
EC(dSm-1)	3.80	0.80	1.70
	Soluble cations (meq\l)		
Ca++	6.00	2.50	3.00
Mg++	4.00	1.50	1.50
Na+	28.60	4.40	12.90
K+	0.12	0.14	0.78
	Soluble anions (meq\l)		
CO3=	-	-	-
HCO3-	4.40	2.40	2.00
Cl-	27.20	5.00	13.00
SO4=	7.12	1.14	3.18

Table 2: Chemical characteristics of water weal used for the present study.

parameters	values
pH	7.49
EC(dSm-1)	4.40
Soluble cations (meq\l)	
Ca++	7.50
Mg++	5.00
Na+	33.10
K+	0.16
Soluble anions (meq\l)	
CO3=	-
HCO3-	1.60
Cl-	40.00
SO4=	4.16

Table 3: Fruit weight, moisture, oil and dry matter contents of "Aggizi shame"Olive during 2011 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
14/5	0.62 k	-	0.43h	-	0.19 h	-	0.00 j	-
28/5	1.60 j	158.06	1.19 g	176.74	0.41 g	115.79	0.00 j	-
11/6	2.67 i	66.88	1.90 f	56.66	0.76 f	85.37	0.01 j	-
25/6	3.60 h	34.83	2.51 e	32.11	1.05 e	38.16	0.04 i	300.00
9/7	3.64 h	1.11	2.53 e	0.80	1.05 e	0.00	0.06 hi	50.00
23/7	4.03 g	10.71	2.81 e	11.07	1.15 d	9.52	0.07 h	16.67
6/8	5.61 f	39.21	4.18 d	48.75	1.30 c	13.04	0.13 g	85.71
13/8	6.19 e	10.34	4.49 c	7.42	1.50 b	15.38	0.20 f	53.84
20/8	6.50 d	5.00	4.74 bc	5.57	1.51 b	0.67	0.25 e	25.00
27/8	6.81 c	4.77	5.00 ab	5.49	1.52 ab	0.67	0.29 d	16.00
3/9	6.96 bc	2.02	5.07 ab	1.40	1.54 ab	1.32	0.35 c	20.69
6/9	7.11 ab	2.16	5.14 a	1.38	1.57 ab	1.95	0.40 b	14.29

Means having the same letters within a column are not significantly different at 5% level

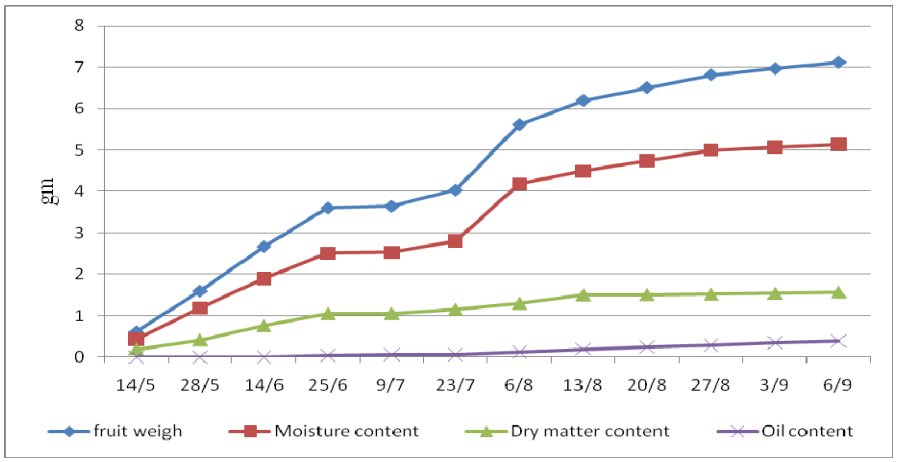

Fig. 1: Fruit weight, moisture, oil and dry matter contents of " Aggizi shame "olive during 2011 season.

Table 4: Fruit weight, moisture, oil and dry matter contents of " Aggizi shame "olive during 2012 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
5/5	0.56h	-	0.43 h	-	0.13 i	-	0.00 h	-
19/5	1.53 g	173.21	1.13 g	162.79	0.39 h	200.00	0.01 h	-
3/6	3.30 f	115.69	2.25 f	99.12	0.96 g	146.15	0.04 h	300.00
17/6	4.91 e	48.79	3.39 e	50.67	1.40 f	45.83	0.12 g	200.00
1/7	6.80 d	38.49	4.68 d	38.05	1.90 e	35.71	0.22 f	83.33
15/7	7.23 cd	6.32	4.80 d	2.56	2.14 d	12.63	0.29 e	31.82
1/8	8.13 c	12.45	5.40 c	12.50	2.35 c	9.81	0.38 d	31.03
8/8	10.07 b	23.86	7.10 b	31.48	2.45 c	4.26	0.52 c	36.84
15/8	11.92 a	18.37	8.6 a	21.13	2.65 b	8.16	0.67 b	28.84
22/8	12.19 a	2.27	8.64 a	0.47	2.80 a	5.66	0.75 a	11.94
29/8	12.35 a	1.31	8.69 a	0.58	2.90 a	3.57	0.76 a	1.33

Means having the same letters within a column are not significantly different at 5% level

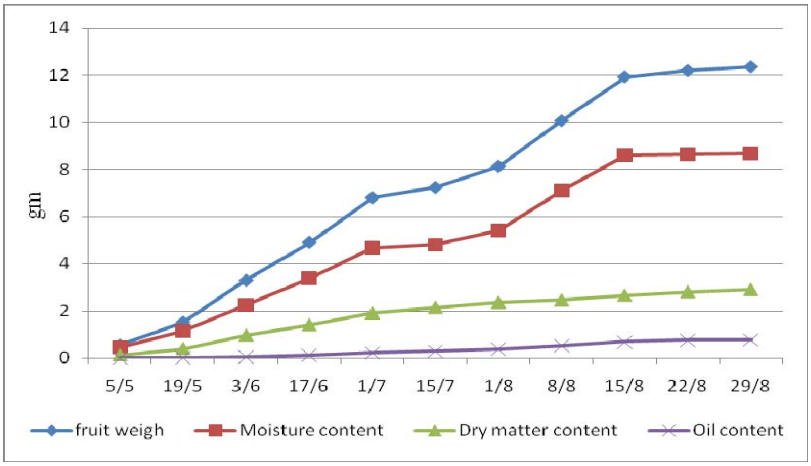

Fig. 2: Fruit weight, moisture, oil and dry matter contents of " Aggizi shame "olive during 2012 season.

Table 5: Fruit weight, moisture, oil and dry matter contents of " Aggizi "olive during 2011 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
14/5	0.79 h	-	0.59 h	-	0.20 k	-	0.00 i	-
28/5	1.66 g	110.13	1.27 g	115.25	0.38 j	90.00	0.01 hi	-
11/6	2.78 f	67.47	1.99 f	56.69	0.77 i	102.63	0.02 ghi	100.00
25/6	4.04 e	45.32	2.85 e	43.22	1.14 h	48.05	0.05 gh	150.00
9/7	4.40 e	8.91	3.07 de	7.72	1.27 g	11.40	0.06 g	20.00
23/7	4.70 de	6.82	3.00d	4.34	1.40 f	10.24	0.10 f	66.67
6/8	5.82 cd	23.83	4.10 c	28.13	1.60 e	14.29	0.12 f	20.00
13/8	6.25 c	7.39	4.35 c	6.10	1.69 d	5.63	0.21 e	75.00
20/8	6.39 bc	2.24	4.36 c	0.22	1.73 cd	2.37	0.30 d	42.86
27/8	6.73 ab	5.32	4.56c	4.13	1.8 bc	4.05	0.37 c	30.00
3/9	7.21 a	7.13	4.95 b	9.03	1.83 ab	1.67	0.43 b	10.56
6/9	7.56 a	4.85	5.15 a	4.04	1.91 a	4.37	0.50 a	16.28

Means having the same letters within a column are not significantly different at 5% level

4-Oil content:

According to Tables (1 to 6) and Figs (1 to 4), for the " Aggizi shame " in the first season, it could be seen that the period from May 14 till August 6, the fruit oil content was rather low. It never exceeded 0.13 gm/fruit. Oil begins to accumulate in the fruit in August. Fruit oil content increased from 0.20 to 0.40 gm/fruit from August 6th till September 6th. Data of the second season and the other olive cultivar showed similar pattern where the rate of oil accumulation was rather slight that no in fruit oil content was observed till early August. Rate of oil accumulation differed according to tested cultivar and season of study. Results obtained in this work are in conformity with those of Hartmann and Opitiz, (1977) who reported that the amount of oil increases gradually through fall and winter, and reaches its maximum in late December and January, as fruits becomes completely black. Similar observations were recorded by Tous *et. al.* 1997 who found that Arbequina cultivar fruits between (165 and 195 days after fruit set) seems to be an optimum harvesting period, where oil content is

high enough. Also, the obtained results are in line with the findings of Ezzat and Azzouni, (1963) and and Desouky, *et. al*. (2010). So, it is important for olive growers to supply adequate water for several weeks just before harvest (about 15 to 16 weeks) after fruit set to obtain high fruit and oil quality.

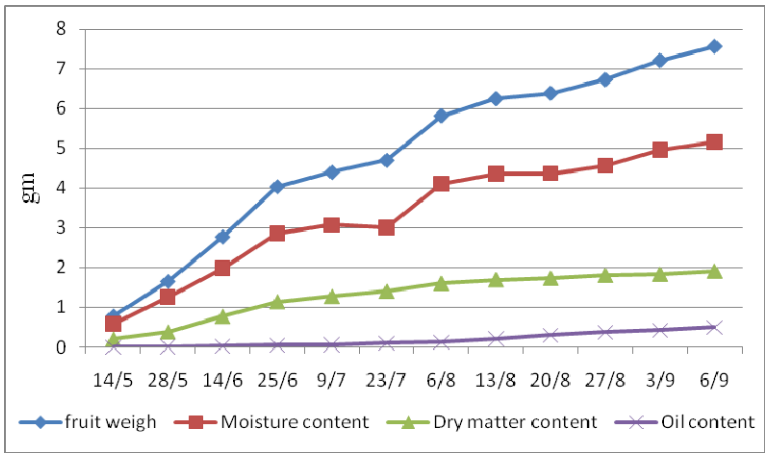

Fig. 3: Fruit weight, moisture, oil and dry matter contents of " Aggizi "olive during 2011 season.

Table 6: Fruit weight, moisture, oil and dry matter contents of " Aggizi " olive during 2012 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
5/5	0.94 i	-	0.69 h	-	0.25 h	-	0.00 i	-
19/5	1.82 h	93.62	1.33 g	92.75	0.46 g	84.00	0.03 hi	0.03
3/6	2.90 g	59.34	1.91 f	43.61	0.93 f	102.17	0.06 h	100.00
17/6	5.02 f	73.10	3.57 e	86.91	1.28 e	37.63	0.17 g	183.33
1/7	7.20 e	43.43	5.01 d	40.34	1.95 d	52.34	0.24 f	41.18
15/7	7.38 e	2.50	5.15 d	2.79	1.96 d	51.28	0.27 f	12.50
1/8	7.86 d	6.50	5.42 d	5.24	2.08 c	6.122	0.36 e	33.33
8/8	8.95 c	13.87	6.32 c	16.61	2.21 b	6.25	0.42 d	16.67
15/8	10.75 b	20.11	7.86 b	24.37	2.41 a	9.05	0.48 c	14.28
22/8	11.30 a	5.11	8.22 a	4.58	2.42 a	0.41	0.66 b	37.50
29/8	11.56 a	2.30	8.31 a	1.09	2.50 a	3.31	0.75 a	13.64

Means having the same letters within a column are not significantly different at 5% level

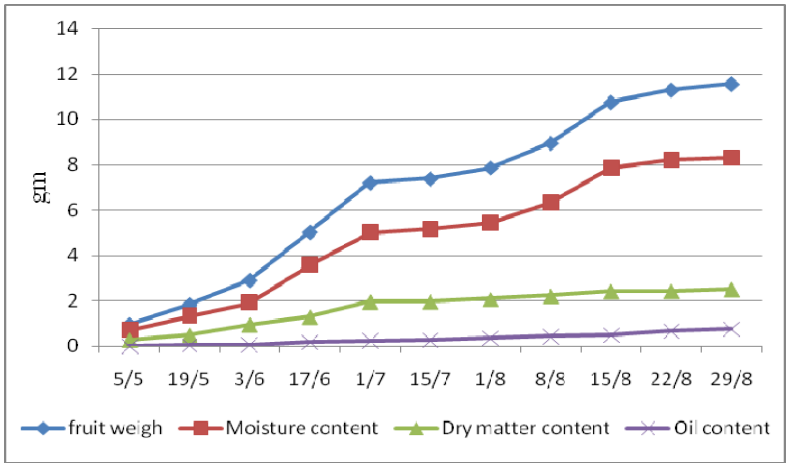

Fig. 4: Fruit weight, moisture, oil and dry matter contents of " Aggizi " olive during 2012 season.

References

A.O.A.C., 1975. Association of Official Agricultural Chemists. Official Methods of Analysis, 12th ed., P. O. Box 450, Benjamin Franklin station, Washington, D.C., pp: 832.

Boulis, S.T. and B.R. Malaty, 1965. Fruit growth and development of Chemlali olive and co. agulation of oil in arid zones. The Egyptian Society of Horticulture in fifty years, pp: 1615-1965.

Desouky, I.M., F. Laila Haggag, 2. M.M.M. Abd El-Migeed and E.S. El-Hady, 2010. Changes in some physical and chemical fruit properties during fruit development stage of some olive oil cultivars.American-Evrasian J.Agric. &Environ.sci., 7(1): 12-17.

Duncan, D.B., 1955. Multiple range and multiple "F" tests. Biometrics, 11: 1-42.

Ezzat, A.H. and M.M. El-Azzouni, 1963. Studies on the determination of fruit maturity of some olive varieties. Agric. Rev. Cairo, 43(1): 20-60.

Fouad, M.M., O.A. Kilany and M.E. El-Said, 1992. Comparative studies on fruit characters of some olive cultivars under Giza condition. Egypt. J. Appl. Sci., 7(5): 645-656.

Hartmann, H.T. and K.W. Opitiz, 1977. Olive production in California. Calif. Agr. Expt. Sta. Bul., pp: 2474.

Hassan, L.H., 1980. Evaluation of some olive varieties in middle Egypt. M. Sc. Thesis, Fac. of Agric.,Al. Azhar Univ., Egypt.

Hegazi, E.S., 1970. Studies on growth, flowering and fruiting in some new olive seedling strains under Giza conditions. M. Sc. Thesis, Fac. of Agric. Cairo Univ., Egypt.

Kaynas, N., A.E. Sutcu, and A.E. Fidan, 1992. Studies on pomological characteristics of olive cultivars grown in the Marmara region. Bachce., 21(1-2): 38 (Hort. Abst. 16:9925, 1994).

Tous, J., A. Romero, J. Plana, L. Guerrero, I. Diaz and F. Hermoso, 1997. Caracteristicas quimico-sensoriales de los aceites de oliva Arbequina obtenidos en distintas zonas de Espana. Grasas y Aceites., 48(6): 415-424.