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ORIGINAL ARTICLES

Changes in some physical and chemical fruit properties during fruit development stages of some olive cultivars grown in North Sinai.

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ABSTRACT

This work was carried out through 2011 and 2012 seasons on three olive cultivars, namely (Egazy shamy, Egazy and Manzanillo). Trees were 10 years old, growing in sandy soil at planting distance of 5x5 meters apart under drip irrigation system in private orchard in north Sinai governorate (Balozza), Egypt. 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 (5-6 weeks), slow during the second stage (4-5 weeks). The third stage is again one of rapid growth. The increment in fruit size comes mainly from increased moisture content of the fruit. Oil begins to accumulate in the fruit and increases gradually through August. So, it is important for olive trees cultivars Egazy shamy, Egazy and Manzanillo grown under saline irrigated water in sinai have adequate water needs for about 16 to 18 weeks after fruit set tell just before harvest to obtain high fruit and oil quality.

Key words: Olive (*Olea europaea*), Egazy shamy, Egazy, Manzanillo, growth curve,

Introduction

Olive (*Olea europaea L.*) is one of the oldest agricultural tree crops of remarkable cultural and economic importance in the Mediterranean Basin also it represents a widely distributed fruit tree in the world (FAO, 2008). It can thrive and produce in new reclaimed areas where other crops can't grow, beside the nutritional importance of olive fruits, either as a table or for oil production. Although olive trees can survive and grow under low soil fertility and water availability conditions, many research studies have been indicating that improving soil fertility and satisfying water requirement are essential factors to obtain a high production. An appropriate fertilization is important during the first years of growth when the tree has to take in nutrients and produce assimilates for the development of its root system and canopy perennial structures and to prepare itself for future fructification. In this period an adequate nutrition stimulates a fast vegetative growth which presumably reduces the juvenile and non-productive phase (Garcia *et al*., 1999). The olive tree (*Olea europea* L.) is one of the most important plants which have 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. The trees reach bearing age in about 4 years.

After pollination and along with the formation and growth of the pollen tube, the ovary walls enlarge and the fruit shapes. 6-7 months elapse from the time the fruit sets until it grows and matures. During these months, the fruit goes through various developmental stages and its growth pace is the same with all drupes of the stone fruit type. Three growth phases can be discerned. The first phase characterized by a great slope and lasts about two months (June-July). In this phase mostly the nucleus, as opposed to the flesh, develops. During August and September the second phase follows, main feature of which is a slower growth rate of the fruit. The fruit's flesh begins to develop and towards the end of the phase the nucleus hardens and ceases growth. Finally, the third phase begins in October in which the fruit grows again at a rapid pace. In this final phase, a rapid increase in the wet weight is observed which persists until the color changes from green to dark purple or black. Hartmann and. Opitiz (1977) reported that 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 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.

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The fruit weight and fruit volume showed continuous increase from the beginning of fruit development till fruit reached its 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 blackening of the fruit Ezzat and El-Azzouni, (1963).

During the period of fruit growth and development fruit composition varies (Nergiz and Engez,2000), and a small quantity of olive oil is produced while the maximum quantity is produced during ripening. The maximum quantity of olive oil is produced in the mesocarp (96-98%). With remainder in the endocarp.

Boulis and Malaty(1965) reported that, 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 Egazy shamy, Egazy and Manzanillo olive cultivars grown under Sinai condition in order to be a guide for olive growers to determine suitable and adequate time for horticultural practices (i.e fertilization, irrigation, harvest…).

Materials And Methods

The present study was conducted on nine olive trees of the three cultivars (Egazy shamy, Egazy and Manzanillo). The trees were 10 years old, growing in sandy soil under drip irrigation system depending on wills in irrigation **(Table 1)** in private orchard in north Sinai (Balozza) – Egypt. The trees spaced 5 x 5 meter apart (168 trees\ acre) in a sandy soil **(Table 2).** The trees were received the same cultural practices that are recommended. 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.

Table 1: Chemical characteristics of well water used for the present study.

Parameters	Values
pH	7.57
EC(dSm-1)	4
Soluble cations (meq\l)	
Ca++	1.7
Mg++	0.8
Na+	1.6
K+	0.11
Soluble anions (meq\l)	
CO3=	-
HCO3-	0.9
Cl-	1.2
SO4=	2.11

Table 2: Chemical characteristics of sandy soil used for the present study.

parameters	Depth of simple (cm)		
	Surface sample	30 cm depth	60 cm depth
pH	7.76	7.73	7.82
EC(dSm-1)	3.60	2.80	2.80
	Soluble cations (meq\l)		
Ca++	4.0	10.0	11.0
Mg++	2.0	6.40	6.10
Na+	29.20	10.50	10.20
K+	0.49	0.30	0.20
	Soluble anions (meq\l)		
CO3=	-	-	-
HCO3-	6.0	1.0	2.0
Cl-	28.0	13.0	13.50
SO4=	8.09	13.2	12.0

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 three olive cultivars has a great importance for olive growers to modify some horticultural practices during fruit development stages.

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Fruit sample (100 fruit per tree) was randomly collected at two weeks intervals (from May 2, 2011 and April 24, 2012) until late July of each season, thereafter fruit samples were weekly collected till the harvest date (August 29 , 2011 and August 21, 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:

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

3- Weight of Dry Matter other than oil:

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

4-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).

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

1- Fruit weight:

In Tables (3 to 8) and Figs (1 to 6), a considerable rapid increase in fresh fruit weight of Egazyshamy cultivar was noticed during the first stage of fruit development (from May 2 until June 13). 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 have been shown to influence fruit weight. At the end of this stage fruit weight attained (3.11 and 2.54 gm) in the two seasons, respectively. The period between July 11 until August 1 was characterized by slow increase in fruit weight. After this rapid stage, slower increase was noticed (from Aug. 8 to Aug. 29), 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. However, the marked increase in fruit fresh weight in the third stage could be a result of the increase in moisture content in the fruit. Consequently, the exogenous factors such as unavailable moisture, high temperature or sever evaporation conditions may decrease the growth rate of the fruits. Concerning the other cultivars somewhat followed similar fruit growth pattern. Fruit weight at the end of early stage (stage one) for Egazy shamy cultivar recorded (3.57 and 2.54 gm) at June 27 and 19 in the two seasons, respectively. At the beginning of third stage, fresh fruit weight increased from 4.28 to 5.72 gm and from 3.43 to 4.33 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 fruit weight of third stage for Agazy shamy cultivar, similar trained to that of Egazy and Manzanillo cultivars was recorded. 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 cannot take place. The Egazy shamy cultivar fruit exhibited similar cyclic growth curve as did the other two cultivars. 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 in Egazy shamy, Egazy and Manzanillo are presented in Tables (3 to 8) and Figs (1 to 6). For the Egazy shamy in the first season, it could be seen that fruit moisture content markedly increased in the early stage of fruit development from May 5 to June

27, 2011, moisture content value raised from 0.45 to 1.87 gm (more than three folds increase). Increase in Fruit moisture content turned to slow rate during 14 days from July 11 to July 25, 2011 (only about 5% increase), after which the rate of moisture increased sharply for about 7 days from 2.6 gm/fruit at Aug. 1 to 3.28 gm/fruit at Aug. 8, 2011 (about 26% increase), fruit moisture content turned to very slow rate towards the end of the season for about 21 days from August 8 to August 29, 2011 (only about 3.6% increase). Data of the second season show that fruit moisture content markedly increased during the early fruit development stage, followed by a slow increase (about 5% increase) from June 19 till July. 17, then a sharp increase was occurred between July 17 till July 31 (about 32% increase). Fruit moisture content showed a steady increase value towards the ripening stage. Data of the other two cultivars showed somewhat similar growth pattern 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 of Egazy shamy, Egazy and Manzanillo are presented in Tables (3 to 8) and Figs (1 to 6). According to the obtained data in the first season in Egazy shamy, 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 100.0, 95.2, 47.6, and 18.2% for the four 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 1.69, 6.67 and 2.08% 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 Egazy and Manzanillo cultivars, 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. Similar results were obtained by Ezzat and Azzouni, (1963) and Desouky, *et. al.* (2010).

4-Oil content:

According to Tables (3 to 8) and Figs (1 to 6), for the Egazy shamy in the first season, it could be seen that the period from May 5 till July 25, the fruit oil content was rather low. It never exceeded 0.12 gm/fruit. Oil begins to accumulate in the fruit in August. Fruit oil content increased from 0.12 to 0.27 gm/fruit from July 25th till August 15th and reached its maximum (0.36 gm/fruit) at the end of August. Data of the second season showed similar pattern for the other two olive cultivars and the two other olive cultivars showed similar pattern where the rate of oil accumulation was rather slight that no significant increment in fruit oil content was observed. Rate of oil accumulation differed according to tested cultivar and season of study. Results obtained in this work are in conformity with those of Tous, *et. al.* (1997) who found that oil accumulation in Arbequina cultivar fruits ranged 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 Egazy shamy, Egazy and Manzanillo olive trees cultivars grown under salin irrigated water in sinai have adequate water needs for about 16 to 18 weeks after fruit set tell just before harvest to obtain high fruit and oil quality.

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Table 3: Fruit weight, moisture, oil and dry matter contents of Agazy shamy olive during 2011 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
2/5	0.66 k	-	0.45 j	-	0.21 h	-	0.00 e	-
16/5	1.37 j	107.58	0.95 i	111.11	0.42 g	100.00	0.00 e	-
30/5	2.28 i	66.42	1.45 h	52.63	0.82 f	95.24	0.01 e	0.01
13/6	3.11 h	36.40	1.87 g	28.97	1.21 e	47.56	0.03 de	200.00
27/6	3.57 g	14.79	2.08 f	11.23	1.43 d	18.18	0.06 de	100.00
11/7	3.67 fg	2.80	2.13 ef	2.40	1.45 cd	1.40	0.09 de	50.00
25/7	3.76 f	2.45	2.19 e	2.82	1.45 cd	0.00	0.12 cde	33.33
1/8	4.28 e	13.83	2.60 d	18.72	1.52 c	4.83	0.16 bcd	33.33
8/8	5.27 d	23.13	3.28 c	26.15	1.77 b	16.45	0.22 abcd	37.50
15/8	5.41 c	2.66	3.34 bc	1.83	1.8 b	1.69	0.27 abc	22.73
22/8	5.61 b	3.70	3.38 ab	1.20	1.92 a	6.67	0.31 ab	14.81
29/8	5.72 a	1.96	3.40 a	0.59	1.96 a	2.08	0.36 a	16.13

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

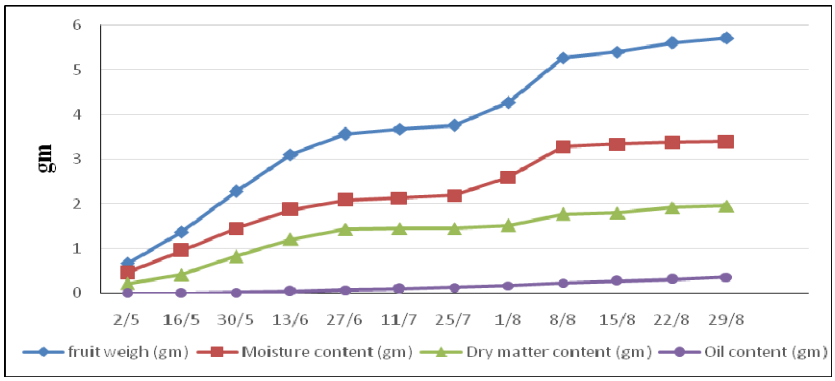

Fig. 1: Fruit weight, moisture, oil and dry matter contents of Agazy shamy olive during 2011 season

Table 4: Fruit weight, moisture, oil and dry matter contents of Agazy shamy olive during 2012 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
24/4	0.57 i	-	0.39 f	-	0.18 g	-	0.00 i	-
8/5	0.89 h	56.14	0.58 e	48.72	0.31 f	72.22	0.00 i	-
22/5	1.07 g	20.22	0.69 e	18.97	0.37 f	19.35	0.01 i	0.01
5/6	1.58 f	47.66	1.00 d	44.93	0.62 e	67.57	0.02 h	100.00
19/6	2.54 e	60.76	1.55 c	55.00	0.93 d	50.00	0.06 g	200.00
3/7	2.64 de	3.94	1.57 c	1.29	0.99 d	6.45	0.08 f	33.33
17/7	2.75 d	4.17	1.63 c	3.82	1.01 d	2.02	0.11 e	37.5
31/7	3.43 c	24.73	2.16 b	32.52	1.12 c	10.89	0.15 d	36.36
7/8	3.95 b	15.16	2.42 a	12.04	1.33 b	18.75	0.20 c	33.33
14/8	4.22 a	6.83	2.49 a	2.89	1.50 a	12.78	0.23 b	15.00
21/8	4.33 a	2.61	2.52 a	1.20	1.52 a	1.33	0.29 a	26.09

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

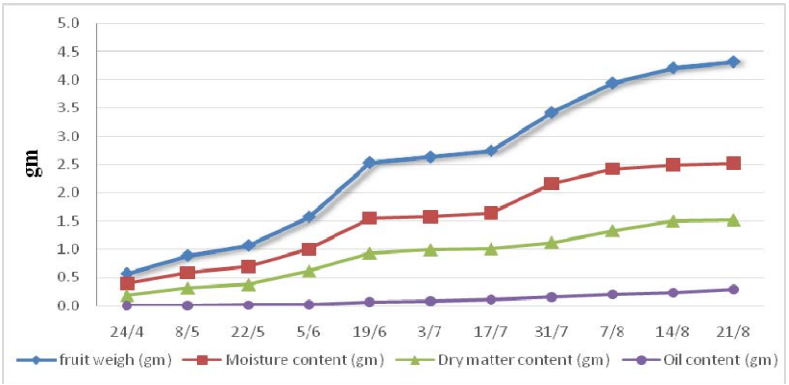

Fig. 2: Fruit weight, moisture, oil and dry matter contents of Agazy shamy olive during 2012 season.

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

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
2/5	0.51 k	-	0.35 i	-	0.16 h	-	0.00 j	0.51
16/5	1.52 j	198.04	0.98 h	180.00	0.54 g	237.5	0.00 j	1.52
30/5	2.33 i	53.29	1.45 g	47.96	0.87 f	61.11	0.01 j	2.33
13/6	3.43 h	47.21	2.14 fg	47.59	1.25 e	43.68	0.04 i	3.43
27/6	3.78 g	10.20	2.22 ef	3.74	1.49 d	19.20	0.07 h	3.78
11/7	4.04 f	6.88	2.34 de	5.41	1.60 c	7.38	0.10 g	4.04
25/7	4.15 f	2.72	2.39 d	2.14	1.62 c	1.25	0.14 f	4.15
1/8	4.34 e	4.58	2.53 c	5.86	1.63 c	0.62	0.18 e	4.34
8/8	5.34 d	23.04	3.41 b	34.78	1.70 c	4.29	0.23 d	5.34
15/8	5.81 c	8.80	3.62 ab	6.16	1.89 b	11.18	0.30 c	5.81
22/8	6.09 b	4.82	3.68 a	1.66	2.05 a	8.47	0.36 b	6.09
29/8	6.24 a	2.46	3.70 a	0.05	2.12 a	3.41	0.42 a	6.24

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

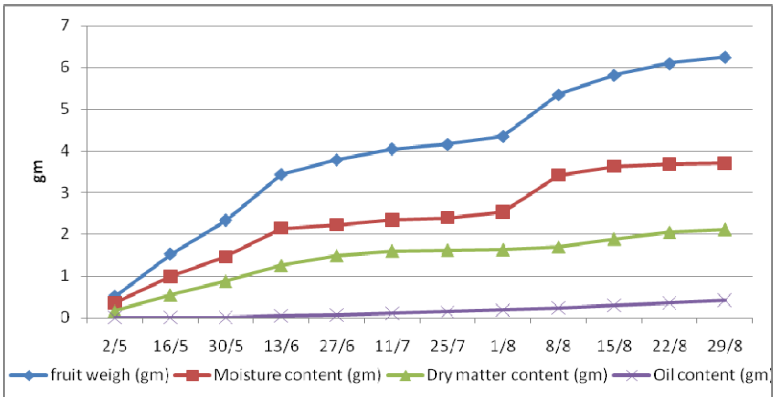

Fig. 3: Fruit weight, moisture, oil and dry matter contents of Egazy olive during 2011 season.

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

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
24/4	1.08 i	-	0.74 g	-	0.34 h	-	0.00 d	1.08
8/5	2.21 h	104.63	1.40 f	89.19	0.81 g	138.24	0.00 d	2.21
22/5	3.45 g	56.11	2.11 e	50.71	1.32 f	62.96	0.02 d	3.45
5/6	3.80 f	10.14	2.24 de	6.16	1.50 e	13.64	0.06 cd	3.80
19/6	3.94 f	3.68	2.27 de	1.33	1.57 de	4.67	0.10 bcd	3.94
3/7	4.04 f	2.54	2.31 d	1.76	1.59 de	1.27	0.14 bcde	4.04
17/7	5.12 e	26.73	3.19 c	38.1	1.71 d	7.54	0.22 abc	5.12
31/7	6.06 d	18.36	3.89 b	21.94	1.87 c	9.36	0.30 ab	6.06
7/8	6.54 c	7.92	3.92 b	0.77	2.27 b	21.39	0.35 ab	6.54
14/8	7.01 b	7.19	4.05 b	3.32	2.54 a	11.89	0.42 ab	7.01
21/8	7.34 a	4.71	4.27 a	5.43	2.57 a	1.18	0.50 a	7.34

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

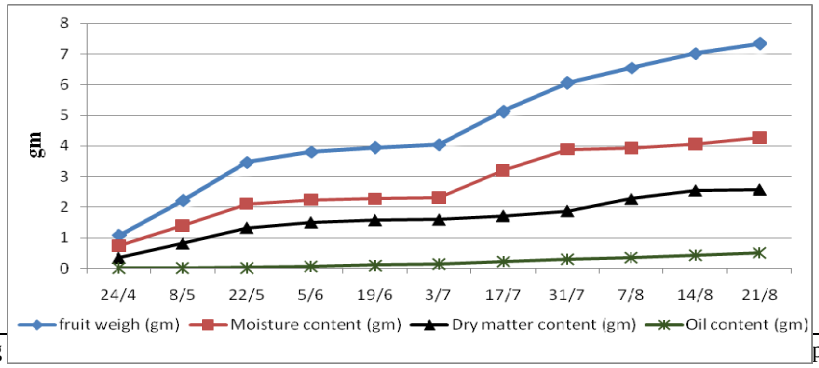

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Fig. 4: Fruit weight, moisture, oil and dry matter contents of Egazy olive during 2012 season.

Table 7: Fruit weight, moisture, oil and dry matter contents of Manzanilo olive during 2011 season.

Day	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
2/5	0.67 l	-	0.45 i	-	0.22 h	-	0.00 h	-
16/5	0.85 k	26.87	0.55 i	22.22	0.30 h	36.36	0.00 h	-
30/5	2.12 j	149.41	1.32 h	140.00	0.76 g	153.30	0.04 g	0.04
13/6	2.52 i	18.87	1.54 g	16.67	0.92 f	21.05	0.06 g	50.00
27/6	3.41 h	35.32	2.15 f	39.61	1.14 e	23.91	0.12 f	100.00
11/7	4.42 g	29.62	2.58 e	20.00	1.66 d	45.61	0.18 e	50.00
25/7	4.82 f	9.05	2.83 d	9.87	1.78 c	7.23	0.21 e	16.67
1/8	5.09 e	5.60	3.00 d	6.00	1.83 c	2.81	0.26 d	23.81
8/8	5.76 d	13.16	3.60 c	20.00	1.85 c	1.09	0.31 c	19.23
15/8	6.34 c	10.07	3.98 b	10.56	1.99 b	7.57	0.37 b	19.35
22/8	6.95 b	9.62	4.16 ab	4.52	2.33 a	17.09	0.46 a	24.32
29/8	7.20 a	3.60	4.35 a	4.57	2.39 a	2.58	0.46 a	0.00

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

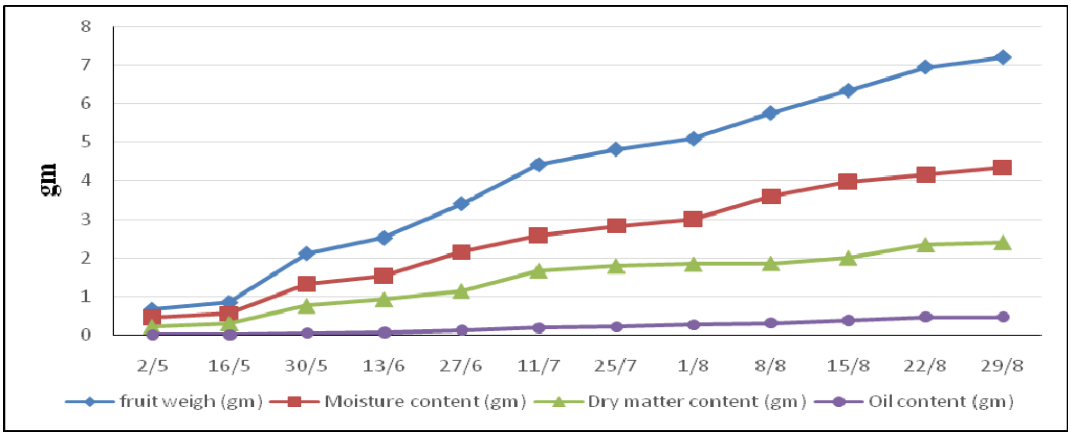

Fig. 5: Fruit weight, moisture, oil and dry matter contents of Manzanilo olive during 2011 season.

Table 8: Fruit weight, moisture, oil and dry matter contents of Manzanilo olive during 2012 season.

Da	Fruit weight (gm)	Increase (%)	Moisture content (gm)	Increase (%)	Dry matter content (gm)	Increase (%)	Oil content (gm)	Increase (%)
24/4	0.45 j	-	0.28 g	-	0.17 h	-	0.00 i	-
8/5	1.26 i	180.00	0.80 f	185.71	0.45 g	164.71	0.01 i	-
22/5	1.67 h	32.54	1.02 e	27.50	0.60 f	33.33	0.05 h	400.00
5/6	2.65 g	58.68	1.65 d	61.76	0.89 e	48.33	0.11 g	120.00
19/6	3.45 f	30.19	1.96 c	18.79	1.34 d	50.56	0.15 f	36.36
3/7	3.74 e	8.41	2.11 c	7.65	1.43 cd	6.72	0.20 e	33.33
17/7	4.15 d	10.96	2.42 b	14.69	1.49 c	4.20	0.24 d	20.00
31/7	5.74 c	38.31	3.53 b	45.87	1.87 b	25.50	0.34 c	41.67
7/8	6.30 b	9.76	3.91 a	10.76	2.00 a	6.95	0.39 b	14.71
14/8	6.50 a	3.17	3.99 a	2.05	2.06 a	3.00	0.45 a	15.38
21/8	6.60 a	1.54	4.04 a	1.25	2.09 a	1.46	0.47 a	4.44

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

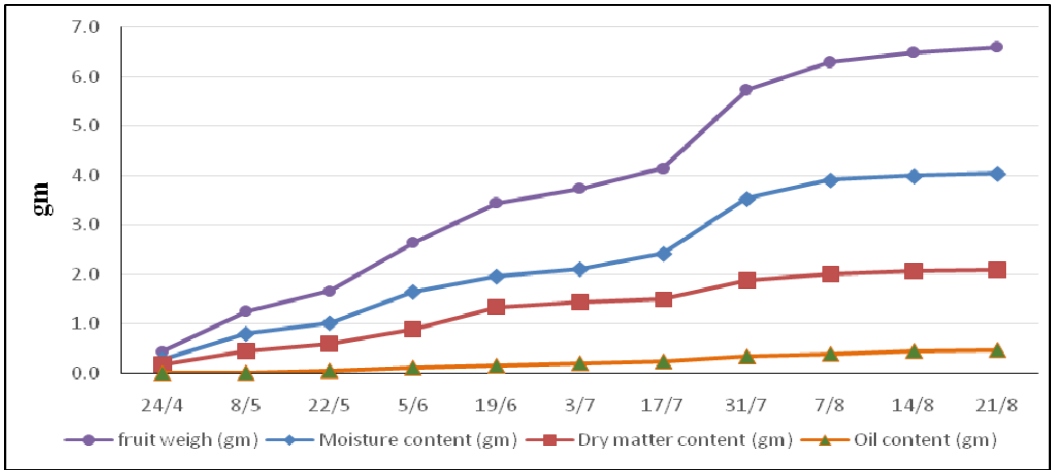

Fig. 6: Fruit weight, moisture, oil and dry matter contents of Manzanilo olive during 2012 season.

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