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Evaluation of Some Female Jojoba Genotypes under Sandy Land Conditions

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ABSTRACT

This investigation was carried out on female Jojoba (*Simmondsia Chinensis*, (Link) Schneider) shrubs in a private orchard at Hackstep, Zone, Cairo Governorate to evaluate 15 female shrubs, about 8 years old during two successive seasons of 2014 and 2015. The shrubs growing in sandy soil in 4 lines at distances 3 × 3 meter apart and irrigated with drip irrigation system. Through the rigorous assessment of female selected jojoba trees through the measurements of vegetative growth, floral measurements, productivity and the percentage of oil in their seeds. The study recommends the following: Firstly: the strongest shrubs were No. (1, 2, 5, 9, 10, 12 and 15), secondly: the shrub number No 4 was the earliest one in the flowering date in both first and second seasons. Thirdly: the highest yield recorded for female shrubs No. (5, 10, 12 and 15) in the first season, while in the second one were No. 9 and 12 per the branch. Fourthly: the female shrubs No. (2, 5, 7 and 13) gave the highest oil content in the first season, while in the second one, the female shrub No. 11 was the best. Fifthly: genetic fingerprint of different species was made using 15 primers and it resulted in 5 positive primer and unaffected 10 then, when using ISSR marker the results showed that there are differences between breeds. It is clear from the foregoing that the shrubs No. 5,4,12, and 11, 13) were the best in the strength of growth, early harvest, production and oil content percentage and can be more vegetative and cultivated. As for a high value of genetic similarity was No. 8 and 6 and also, the highest similarity value (0.875) was found between the strains (T8 and T6) followed by 0.792 between (T5 & T15, T8 & T13 and T11 & T14), respectively. Generally, genetic similarity value was low among the investigated genotypes and the study.

INTRODUCTION

Jojoba pronounced "Ho-ho-ba" belongs to the genus (*Simmondsia chinensis*, (Link) *Schneider*) is in the family *Simmondsiaceae,* (Benzioni, 1995). It is native to the Sonoran and Mojave deserts of southern Arizona, south California, and northwestern Mexico. It was found that have climatic aspects of arid and semi-arid regions, which are the suitable climate for jojoba shrubs growth and development (Ramonet-Razcon, 1986 and Milthorpe, 2006).

The total cultivated area of jojoba in Egypt reached about 26000 feddans its plantations are concentrated in El-Ismailia and Sinai south governorates. Jojoba is a small multi-stemmed tree that grows 6m, but usually around 2-2.5m, diocious (producing male and female optalous flowers on each separate plants. The jojoba fruit is a capsule of tan or brown in color at maturation stage. It contains one to three dark brown seeds; most of them at maturity vary in size and weight from 700 seeds /kg 3500 seeds/kg (Hogan *et al*., 1980). Seeds contain about 50-60 % oil planting. Jojoba oil is characterized by cosmetic lipid materials, natural or synthetic and also, resists hydrolysis and oxidation for more effective. Planting jojoba shrubs in Egypt has a promising future as an industrial crop specially because of its low water requirements and its high tolerance to salinity, also its ability to be planted in the new reclaimed lands or uncultivated ones (Benzioni, 1997).

Many investigators evaluated various genotypes under different regions of Egypt, they found that vegetative growth, flowering and production (quantity and quality) varied from one genotype to another different years. Thus, the present investigation was carried out to study the morphological characteristics to introduce an accurate evaluation for 15 female shrub genotypes as well as, the objective of Electrophoretic analysis is to identify the degree of genetic relationship among the tested genotypes of jojoba. The field of Jojoba breeding is in important to select the elite parents that could be used in the prediction of the most desirable crosses.

MATERIALS AND METHODS

The present investigation was carried out in two successive seasons of 2014 and 2015 on 15 female jojoba shrubs at a private jojoba orchard located Hackstep Zone in Cairo Governorate, Egypt.

1. Evaluation procedure :

Trees were about 8 years old and established by using seeds, grown in sandy soil at Huckstep Zone. They were planted 3m within rows and 3m apart (466 shrubs /feddan). Drip irrigation system was adopted in this orchard. The trees were of the same age and grown under the same environmental and culture practices, such as weed and pest control pruning, irrigation and fertilization. The experiments were laid out in a randomized complete block design. Fifteen female shrubs were chosen to select the superior ones and each shrub treated individually.

Table 1. Physical and chemical properties of the experimental soil were

Physical properties		Chemical properties		
Sandy	90.35%	Particle size distribution (%)		
Silt	3.00%	EC (mm./cm)		1.14
Clay	6.65%	pH (1:2.5)		7.43
Texture	Sandy	SP		17.50
Available macro and micro elements			Ca^{++}	3.55
N (mg/kg)	144.55	Cations	Mg^{++}	1.50
P (mg/kg)	15.22	(meq./L)	Na^{+}	5.85
K (mg/kg)	115.02		K^{+}	0.49
Fe (mg/kg)	3.28		HCO_3^{-}	1.00
Mn (mg/kg)	1.35	Anions	Cl^{-}	9.50
Zn (mg/kg)	1.19	(meq./L)	SO_4^{--}	0.89
Cu (mg/kg)	0.62		CO_3^{--}	-

EC = Electrical conductivity.
SP = Saturation percentage.

Morphological studies.

A- Height (m^3), circumference (m^3), growth vigour and habit of shrub:

Height, stem diameter, circumference, growth vigor and habit of each shrub were measured at the end of both growing seasons on October of 2014 and 2015.

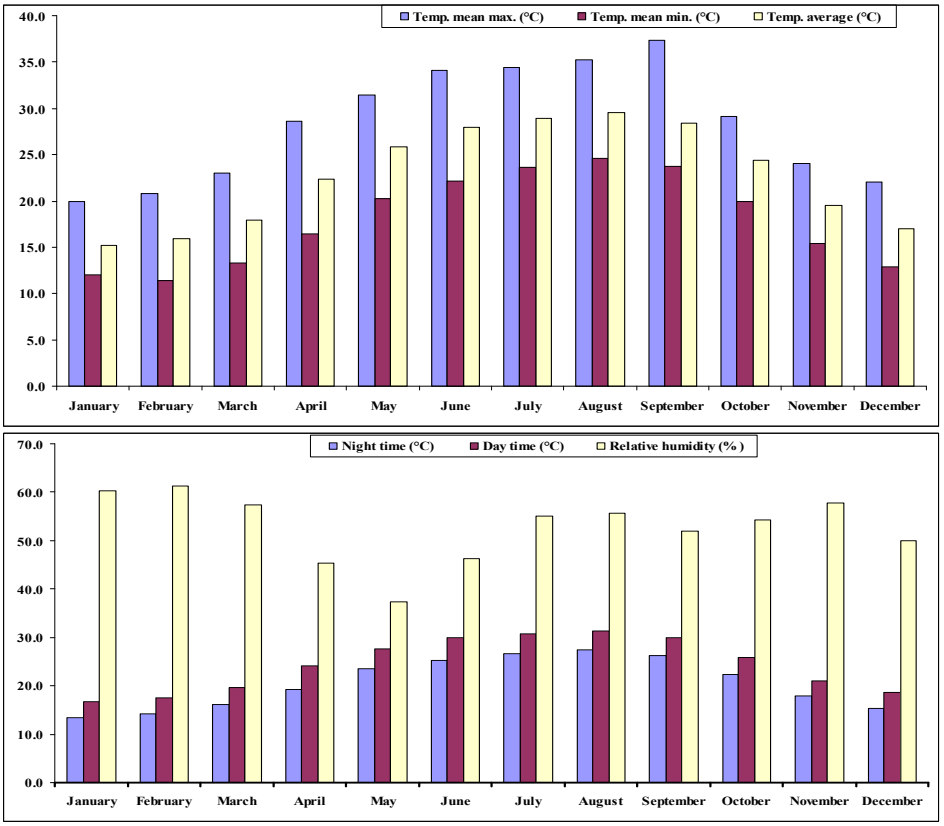

Fig. 1. Average monthly temperature (Temp.) and relative humidity (%) of Jojoba in Huckstep orchard during the study from 2014 season.

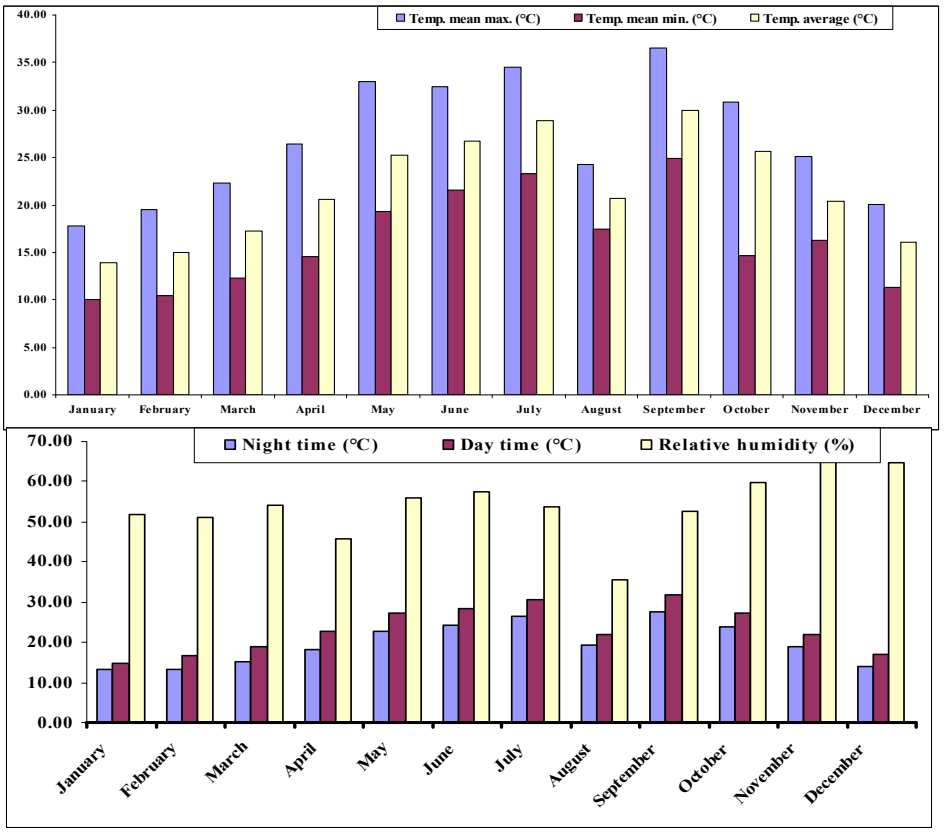

Fig. 2. Average monthly temperature (Temp.) and relative humidity (%) of Jojoba in Huckstep orchard during the study from 2015 season.

B-Number of leaves per shoot:

The number of leaves per shoot was counted on the labeled branches and calculated per meter; samples of 30 leaves (The 4th and 5th leaves from the top of the brunch) were collected from different directions of shrub to use for the following measurements at the end of first and second seasons (Chen, *et al*., 1985; Kohorn, 1994 & 1995 and Hassan, 2007)

3- Leaf area (cm^2):

The leaf surface was estimated from the following equation:

Leaf area = 0.717×- 0.095, which × is the product of length by width. (Chen, *et al*. 1985 & Kohorn, 1994 and 1995).

The results were expressed as an average leaf area per shoot per shrub.

3-1- leaf L/W ratio = leaf length /leaf width

C- Shoot length (cm) and leaf characteristics.

Ten shoots were randomly selected at different sides on each female shrub/genotypes labeled and used to study the following characteristics.

1-Shoot length (cm)

Length of the growing shoots was measured for each shrub at the end of growing seasons.

2- No. of laterals/shoot.

The number of laterals per shoot was counted at the end of both growing seasons.

3-Stem diameter= one Stem diameter was determined per meter length of Stem.

4- No. of internodes of the shoot.

Average No. of internodes was determined per one meter length of shoot.

D-Leaf pigments

At the first week of August in both seasons, 50 mature leaves per replicate were collected from the medium position of the current season's shoots. Chlorophyll A, B and carotenoids were determined in fresh leaves samples calorimetrically at wave length of 660, 640 and 440 nm respectively according to AOAC (2012).

E-Flowering and fruiting characteristics

Ten shoots were randomly selected at different sides on each female shrub, labeled and used to study the following flowering and fruiting characteristics:

1- Flowering date of jojoba shrubs

In both seasons, it was assessed during flowering period per shrub (from First of Feb).

2- Number of flowers:

The number of flowers which was counted by number flowers on selected branches which tagged before flowering stage.

3- Number of fruits

In both seasons of study it was assessed during fruiting period shrub (from 1-May to 1-July).

F- Seed Yield, seed length, seed width and seed weight.

Yield/shrub (kg) was recorded at the harvesting date for every shrub.

The seeds are considered fruits in jojoba shrubs. They were harvested at the harvesting date for each shrub solely.

Seed length and seed width in cm were determined of per meter, seed weight in gm,

G- Determination of ridges, No. grooves, oil and moisture content:

1-Number of ridges and grooves were calculated.

2-The moisture content was determined according to the method of the Association of Official Analytical Chemists (AOAC, 2012) by drying the samples in an oven at 105˚C ± 5˚C to constant weight.

3- Determination of total lipids:

Jojoba seeds were crushed separately several times in an experimental mill, and dried in an oven at 70˚C for 6 hours. Then the crude lipids content in the samples were determined according to the procedure by AOAC (2012). Whereas known weight of dry sample (10g) was finally grinded and extracted with N-hexane (b.p. 60-70˚C) using Soxhelt apparatus. The solvent was removed and the percentage of total lipids was calculated.

H- Polymerase Chain Reaction (PCR).

In order to obtain clear reproducible amplification products, different preliminary experiments were carried out in which a number of factors were optimized. These factors included PCR temperature cycle profile and concentration of each of the template DNA, primer, MgCl and Taq polymerase. A total of fifteen random DNA oligonucleotide primers were independently used according to Williams et al. (1990) in the PCR reaction. Only five primers succeeded to generate reproducible polymorphic DNA products. The PCR amplification was performed in a 25 µl reaction volume containing the following: 2.5 µl of dNTPs (2.5 mm), 1.5µl of Mg Cl2 (25 mm), 2.5 µl of 10x buffer, 2.0 µl of primer (2.5 µM), 2.0 µl of template DNA (50 ng/µl), 0.3 µl of Taq polymerase (5 U/µl) and 14.7 µl of sterile ddH2O. The reaction mixtures were overlaid with a drop of light mineral oil per sample. Amplification was carried out in Techni TC-512 PCR System. The reaction was subjected to one cycle at 95 ºC for 5 minutes, followed by 35 cycles at 96 ºC for 30 seconds, 37 ºC for 30 seconds, and 72 ºC for 30 seconds, then a final cycle of 72 ºC for 5 minutes. PCR products were run at 100 V for one hour on 1.5 % agarose gels to detect polymorphism between the jojoba strains under study. Only five primers succeeded to generate reproducible polymorphic DNA products. Table (2) lists the base sequences of these DNA primers that produced informative polymorphic bands. The PCR products were separated on a 1.5 % agarose gels and fragments sizes were estimated with the 100bp ladder marker (1500, 1000, 900, 800, 700, 600, 500, 400,300,200 and 100bp).

Statistical analysis:

The DNA bands generated by each primer were counted and their molecular sizes were compared with those of the DNA markers. The bands scored from DNA profiles generated by each primer were pooled together. Then the presence or absence of each DNA band was treated as a binary character in a data matrix (coded 1 and 0, respectively) to calculate genetic similarity and to construct dendrogram tree among the studied strains. Calculation was achieved using Dice similarity coefficients (Dice, 1945) as implemented in the computer program SPSS-10.

Table 2. The primer names and their nucleotide sequences list used in this investigation for RAPD procedure.

No	Primer code	Sequence
1	OP-A07	5´GAAACGGGTG3´
2	OP-A18	5´AGGTGACCGT3´`
3	OP-C04	5´CCGCATCTAC3`
4	OP-C19	5` GTTGCCAGCC3`
5-	OP-Z03	5` CAGCACCGCA3

Statistical analysis:

The obtained data of 2014 and 2015 experimental seasons were analyzed according to the methods described by Snedecor and Cochran (1980) and differences between shrubs were compared by using Duncan multiple tests as recorded by Duncan (1955).

RESULTS AND DISCUSSION

A-Vegetative growth characters of shrubs:

1- Growth vigor:

Data presented in Table 3 showed that shrubs No. 1, 2, 5, 9, 10, 12 and 15 had a strong growth, whereas Shrubs No.3, 4, 6, 7, 8, 11, 13 and 14 had a medium growth.

2- Growth habit:

As presented in Table 3, it is clear that most of the studied shrubs had a spread growth habit, while only five shrubs No.3,10 and 14 had a straight growth habit whereas shrubs No. 4 and 7 was dropping growth. This characterization can be coinciding with the bases of identification (Abou El-Khashab *et al*., 2007 and El-Sayed, 2010) it is known that Jojoba is a dioecious, cross-pollinated species (Gentry, 1058). This result in high variability in most characteristics between the different jojoba genotypes (Abou El-Khashab *et al*., 2007)

3-Shrub height:

It's clear from the concerned data in Table 3 that shrub No.1 measured the highest values in shrub length with (3.00 and 3.10 m) followed by these of No. (12, 10 and 14), while shrub No. (9, 13) had the lowest values (1.67 & 1.90m) in 2014 & 2015 seasons respectively. Local jojoba and seeded plantations over the world show great variability among plants (Palzkill1987).

Table 3. Vegetative growth measurements, growth vigor, growth habit, shrub height (m3) and Shrub circumference (m3) in the 15 trees females Jojoba shrubs in 2014 & 2015 seasons.

No. of shrubs	Growth vigor	Growth habit	Shrub height (m^3)		Shrub circumference(m^3)	
			2014	2015	2014	2015
1	Strong	Spread	3.00	3.10	3.10	4.00
2	Strong	Spread	1.70	2.50	4.70	5.00
3	Medium	Straight	2.20	2.24	3.67	4.00
4	Medium	Dropping	2.00	2.23	5.60	7.00
5	Strong	Spread	1.40	1.70	3.70	5.20
6	Medium	Spread	1.73	2.00	3.64	4.00
7	Medium	Dropping	2.10	2.45	5.50	6.00
8	Medium	Spread	2.00	2.27	3.10	4.00
9	Strong	Spread	1.67	1.90	4.25	5.00
10	Strong	Straight	2.30	2.37	7.10	8.20
11	Medium	Spread	1.70	2.45	6.97	8.00
12	Strong	Spread	2.80	2.95	4.80	6.00
13	Medium	Spread	1.70	1.90	3.92	4.00
14	Medium	Straight	2.30	2.45	7.30	7.60
15	Strong	Spread	2.00	2.30	4.80	5.80

4-Shrub circumference:

From the data in Table 3 indicted also that shrub No. 4, 10, 11 and 14 had the highest circumference (5.60 & 7.00m), (7.10 & 8.20 m), (6.97 & 8.00 m), (7.30 & 7.60 m), while shrubs No. (1, 2, 3, 5, 6, 7, 8, 9, 12, 13 and 15) had the lowest circumference in both seasons respectively, whereas the rest genotypes were in between. Ayanoglu (2000) on Jojoba and Hosseini *et al*., (2004) on olive, reported that morphological and biological characters are used to evaluate germplasm cultivars. These result can be coincide with the base of identification described by Ayerza (1996) and Botti *et al*. (1996 & 1998) on Jojoba evaluation. Ramonet-Razcon, (1988) showed that the cultivated jojoba communities propagated by seed, are composed of multiple genotypes.

B-Characterizes of leaves per shoot:

1-Number of leaves:

Data in Table 4 indicated that, there was an obvious significant different among studied shrubs; the tree No. 11 has the highest number of leaves/shoot (65.90) in the first season, while in the second season the highest value was No. 6.(47.00), Botti *et al*. (1998) mentioned that the variations in the morphological parameters such as; number of leaves were due to genetic variations.

2- Leaf area (m^2) and Leaf L/W ratio

Results in Table 4 showed that significant variations occurred among parameters of the jojoba trees in the present study. The highest values of leaf area were shown with genotype No.13 in the first season, while in the second season was obtained in shrub No.3. The shrub No. 6 has the highest values of Leaf L/W ratio in the first season. Whereas shrub No. 12 and14 has the highest number in the second season. Botti *et al*. (1998) found that all leaf parameters s showed differences among clones; leaf area and Leaf L/W ratio.

Table 4. Measurement of leaves No., leaf area (cm^2) and leaf L/W ratio in the 15 trees females Jojoba shrubs in 2014 & 2015 seasons.

No. of shrubs	No. of leaves		Leaf area (cm^2)		Leaf L/W ratio	
	2014	2015	2014	2015	2014	2015
1	55.55cd	38.27c	3.14ef	5.46e	2.35ef	2.14de
2	53.60d	27.78fg	4.09c-e	7.03cd	2.53c-e	2.21de
3	48.02f	34.22d	5.01bc	9.38a	2.31ef	2.07ef
4	45.47g	37.77c	5.60b	6.53d	2.37d-f	2.22de
5	48.85ef	40.11c	3.97de	5.39e	2.34ef	2.06ef
6	60.48b	47.00a	4.17c-e	6.53d	2.95a	2.55b
7	42.97g	43.00b	3.66d-f	5.27e	2.81ab	2.54b
8	50.92e	25.83hi	3.24ef	4.62e	2.79ab	2.51bc
9	56.48c	31.89e	2.56d-f	6.76cd	2.62b-d	1.88f
10	48.17f	30.67ef	3.24ef	5.13e	2.56b-e	2.30d
11	65.90a	28.22gh	3.67d-f	6.88cd	2.66bc	2.61b
12	57.93bc	20.22j	2.77f	3.35f	2.48c-e	2.94a
13	48.85ef	23.67i	6.98a	7.65bc	2.69bc	2.29d
14	43.07g	20.44j	3.82d-f	4.82e	2.38d-f	2.81a
15	58.15bc	28.11gh	4.33cd	8.28b	2.17f	2.34cd

Values in the same column having different letters showed statistically significant differences (P < 0.05).

C- Characterizes of shoot length, No. of laterals/shoo, stem diameter and No. of internodes:

Data in Table 5 revealed that the highest average of shoot length was apparent in female shrubs No.14 in the first season, while the highest shoot length in the second one was in female shrubs No.1, 4 and 11. Concerning No. of laterals/shoot, female shrubs No. 11 recorded the highest values for number of laterals/shoot in the first season. While in the second one the highest No. of laterals/shoot recorded for No. 5,10,11,12,13 and 14. Regarding the stem diameter, the highest values of stem diameter was recorded in female shrubs No. 3, 4, 6, 8, 9, 10, 11, 14 and 15 in the first season. Whereas the female shrub No. 4 had the highest value in the second one. As for No. of internodes, the highest No. of internodes was recorded in female No.4 in the both seasons. Botti *et al*. (1998); Benzioni *et al*. (1999) and El-Sayed (2010), they mentioned that different shrubs of jojoba varied greatly in their growth rate that appeared clear from length of their shoots and number of internodes.

Table 5. Measurements of shoot length, No. of laterals/shoot stem diameter and No. of internodes: in the 15 trees females Jojoba shrubs during seasons 2014 & 2015.

No. of shrubs	Shoot length (cm)		No. of laterals/shoot		Stem diameter (cm)		No. of Internodes	
	2014	2015	2014	2015	2014	2015	2014	2015
1	40.42d-f	38.33a	2.44fg	2.89bc	0.200b	0.250bc	7.83d	8.17e-g
2	42.22cd	25.61e	2.05g	2.50c	0.217b	0.300ab	8.67d	8.33d-g
3	45.58bc	31.33b	2.00g	2.39c	0.300a	0.283a-c	9.00d	9.50c-e
4	47.32ab	40.55a	2.39fg	2.67c	0.300a	0.317a	13.67a	13.50a
5	37.94e-g	29.44b-d	5.67b	4.17a	0.217b	0.233c	8.00d	7.33g
6	43.97b-d	32.44b	2.50fg	2.66c	0.283a	0.283a-c	12.00b	12.00b
7	37.22fg	30.11bc	3.33d-f	2.66c	0.217b	0.283a-c	2.83ab	12.67ab
8	42.42cd	26.11de	2.66e-g	2.89bc	0.300a	0.283a-c	9.17d	9.22c-f
9	42.39cd	27.34c-e	4.33cd	3.89ab	0.300a	0.300ab	9.00d	9.83cd
10	42.12cd	21.78f	5.33bc	5.00a	0.333a	0.283a-c	8.50d	7.78fg
11	43.75b-d	40.83a	7.08a	4.66a	0.283a	0.267a-c	9.17d	9.44c-e
12	41.71c-e	17.00g	3.55d-f	4.22a	0.217b	0.283a-c	8.17d	8.00e-g
13	41.66c-e	24.11ef	5.44bc	4.55a	0.217b	0.267a-c	8.00d	7.77fg
14	49.50a	17.78g	3.78de	4.11a	0.333a	0.267a-c	8.83d	8.00e-g
15	35.68g	25.22ef	2.83e-g	3.00bc	0.300a	0.267a-c	10.50c	10.00c

Values in the same column having different letters showed statistically significant differences (P < 0.05).

D-Chlorophyll A, B and Carotenoids.

The results for chlorophyll A, B and carotenoids in Table 6 revealed that female shrub No. 3 recorded the highest values for Chlorophyll A during both seasons while the highest values of Chlorophyll B recorded for female No. 2 in the first seasons and second seasons. Regarding the Carotenoids, the highest values recorded for No.5 in the first and second seasons. These results are in line with this reported by Al-Ani *et al*. (1972), who found differences in photosynthetic capacities among jojoba from different populations.

Table 6. Chlorophyll (a & b) and carotenoids in the 15 trees females Jojoba shrubs during seasons 2014&2015

No. of shrubs	Chlorophyll a		Chlorophyll b		Carotenoids	
	2014	2015	2014	2015	2014	2015
1	0.330c	0.350c	0.270d	0.280b	0.013cd	0.007c
2	0.380ab	0.410a	0.327a	0.333a	0.013cd	0.010bc
3	0.390a	0.400a	0.317ab	0.320a	0.037ab	0.040a
4	0.330c	0.360bc	0.280cd	0.280b	0.017cd	0.020bc
5	0.260e	0.280d	0.207e	0.213c	0.040a	0.040a
6	0.240f	0.270de	0.200ef	0.207c	0.020b-d	0.020bc
7	0.240f	0.250f	0.180fg	0.200c	0.020b-d	0.020bc
8	0.370b	0.370b	0.300bc	0.323a	0.027a-d	0.013bc
9	0.210g	0.220g	0.100j	0.107f	0.010d	0.007c
10	0.200g	0.207g	0.160gh	0.170d	0.030a-c	0.027ab
11	0.230f	0.240f	0.150h	0.150de	0.017cd	0.020bc
12	0.310d	0.273d	0.290cd	0.290b	0.020b-d	0.017bc
13	0.260e	0.270de	0.210e	0.213c	0.017cd	0.020bc
14	0.260e	0.270de	0.127i	0.130ef	0.010d	0.010bc
15	0.210g	0.253ef	0.170gh	0.170d	0.023a-d	0.020bc

Values in the same column having different letters showed statistically significant differences (P < 0.05).

E- Flowering and fruiting characteristics:

1- Flowering date of jojoba shrubs:

Data tabulated in Table 7 showed the variation among in their fruit ripening dates. Flowering date of jojoba shrubs started between 1/2 to 17/2 in season 2014 and between 4/2 to 22/2 in season 2015, it was cleared that shrub No. 4 was the earliest one in start of flowering during both seasons, and No.11 was the lasted one in the first and second seasons. These results are supported by the previous findings of Ahmed, (1989), who reported that the seed maturation in Egypt take period extend about five months after pollination.

2- Number of flowers:

Data as shown in Table 7 represent the number of flowers of female studied jojoba shrubs in 2014 and 2015 seasons. From this table it was cleared that the shrubs No.5, 9 and 15 had the highest values of flowers in the first season. Whereas in the second season, the highest values recorded with shrub No.7. These results are in line with Botti *et al*. (1996); Howson, (1985) and El-Said, (2010), who found that, number of flowers was dependent on genotypes.

3-Number of fruits:

As shown in Table 7, the shrub No. 5 and 15 gave the highest number of fruits in the first season. While, the shrub No. 7 was the highest number of fruits in the second season. In this concern, Benzioni *et al*. (1999) indicated that the number of fruits is affected to a great extent by environmental conditions and pollination.

Table 7. Measurements of start of flowering, No. of flowers and No. of fruits in the 15 trees females Jojoba shrubs in seasons 2014 & 2015.

No. of shrubs	Start of flowering		No. of flowers		No. of fruits	
	2014	2015	2014	2015	2014	2015
1	4/2	6/2	10.37ab	9.44ef	9.11bc	8.17d
2	4/2	8/2	8.22cd	9.61ef	6.72ef	8.33d
3	4/2	7/2	8.61cd	10.94c-e	7.10d-f	9.50cd
4	1/2	4/2	9.28bc	12.44ab	8.04c-e	11.67ab
5	2/2	5/2	11.28a	10.22de	11.05a	8.33d
6	10/2	13/2	8.79b-d	12.00bc	7.77c-f	11.33ab
7	11/2	14/2	8.44cd	13.56a	6.18f	12.67a
8	9/2	13/2	7.94cd	10.53c-e	6.03f	9.22cd
9	13/2	17/2	11.28a	10.33de	10.44ab	11.43ab
10	13/2	14/2	9.28bc	7.39gh	8.64cd	8.17d
11	14/2	22/2	7.28d	5.78i	6.05f	3.33ef
12	16/2	20/2	9.28bc	11.61b-d	8.69cd	10.44bc
13	16/2	18/2	7.42d	6.06hi	3.70g	2.61f
14	15/2	17/2	8.28cd	5.56i	6.42ef	4.59e
15	17/2	20/2	11.28a	8.17fg	11.19a	8.50d

Values in the same column having different letters showed statistically significant differences (P < 0.05).

F- Yield/ shrub (kg) Seed length, Seed width (cm) and Seed weight (g):

Data presented in Table 8 showed significant variation among female tested shrubs under the present study. Average yield varied from 1kg per shrub to 3.5 kg per shrub. The highest average yield was recorded in Shrub No. 12 during first and second seasons. Similarly, Benzioni et al., (1999), Abu El-Khashab et al., (2007)

and El-Said (2010) detected variation in yield of jojoba shrubs at different season Brown and Hall (1982) mentioned that structure and fertility of several jojoba shrubs recorded a wide variation from year to year due to climatic effect.

Data in Table 8 show that among the studied female tested shrubs, shrubs No. 6 was the highest seed length during the first season. While, the shrub No. 11 gave the highest seed length in the second season. Concerning the seed width, the shrub No. 13 gave the highest seed width in the first season. Whereas, the shrub No. 12 gave the highest seed width in the second season. As for seed weight (gm), the highest values were obtained shrub No. 12 in the second season. These results are nearly in the same line with these obtained by Benzioni et al. (1999); Abu El-Khashab et al. (2007) and El-Said (2010). Also, El-Torky et al. (2004) found that clear differences between clones. Furthermore, Yermanos (1982) indicate that variation in yield and seed characteristics from one year to the next due to genotype and environmental factors such as temperature.

Table 8. Yield, seed length (cm) estimation, seed width (cm) and seed weight (gm in the 15 trees females Jojoba shrubs during seasons 2014 & 2015.

No. of	Yield/ shrub (kg)		Seed length (cm)		Seed width (cm)		Seed weight (gm)	
shrubs	2014	2015	2014	2015	2014	2015	2014	2015
1	1.50	2.00	1.47ef	1.49f	1.18a-c	1.17ab	0.96cd	1.12de
2	2.00	1.50	1.74bc	1.71bc	1.16bc	1.18ab	1.05c	1.39ab
3	1.50	1.00	1.79b	1.53ef	0.97de	1.20ab	0.83d	1.20cd
4	1.50	1.50	1.77bc	1.55ef	1.19ab	1.20ab	1.31b	1.21cd
5	2.50	1.50	1.78bc	1.57de	1.15bc	1.15ab	1.31b	1.11de
6	1.50	1. 50	2.10a	1.60de	1.15bc	1.03c	1.25b	0.87f
7	1.00	1.00	1.65b-e	1.76ab	1.10b-d	1.13b	0.98cd	1.20cd
8	1.50	0.50	1.53ef	1.78ab	1.15bc	1.19ab	1.04c	1.35ab
9	2.00	3.00	1.44f	1.71bc	1.10b-d	1.16ab	0.96cd	1.35ab
10	2.50	1.50	1.60c-f	1.76ab	1.00de	1.16ab	0.95cd	1.32bc
11	1.00	2.00	1.60c-f	1.81a	1.05cd	0.99c	0.98cd	1.01e
12	3.00	3.50	1.42f	1.73ab	1.30a	1.22a	1.52a	1.46a
13	1.00	2.00	1.73b-d	1.64cd	1.07b-d	1.20ab	0.84d	1.44ab
14	1.50	2.00	1.55d-f	1.54ef	1.05cd	0.97c	1.02c	0.83f
15	2.50	1.50	1.80b	1.58de	0.90e	1.17ab	0.84d	1.21cd

Values in the same column having different letters showed statistically significant differences (P < 0.05).

G- Number of ridges, Number of grooves, seed oil content and moisture content:

The results presented in Table 9 show that the female tested shrub No. 5 had the highest number of ridges during both seasons. As regard to the No. of grooves, It was obviously cleared in Table 9 that No. of grooves ranged between 3 – 4 grooves in both studied seasons. Concerning seed oil, the shrub No.13 was the highest shrub of oil content (56.00%) followed by shrub No. 2 (54.33) in the first season. While the season 2015 had the highest percentage of oil in shrub No. 11 (61.17%) and the lowest percentage of oil content in shrub No. 14 (39.11%) during the first season. While, the shrub No. 3 (49.50) gave the lowest in the second season. As for moisture content, The moisture content in Table (9), moisture content ranging from 7.59% to 15.59 % in the first season . Whereas, in the second one, moisture content ranging from 7.87% to 10.89% The Shrub No. 7 was the lowest value in moisture content compared with the other shrubs under this investigation at season 2014. On the other hand, the shrub No. 5 was the lowest value in moisture content (7.87%) and shrub No. 14 and15 were the highest value in moisture content in season 2014. While, the shrub No. 4 was the highest value in moisture content in season 2015 These results are in line with those reported by Benzioni et al. (1999); Uilger *et al.* (2002); Abu El-Khashab *et al.* (2007) and Shereen *et al.* (2010). Also, Botti *et al.* (1998) found that the differences were present among the shrubs in the oil content.

Table 9. Number of ridges, number of grooves along with seed, seed oil content and Moisture content % in the 15 trees females Jojoba shrubs during seasons 2014 & 2015.

No. of	No. of ridges		No. of grooves		Seed oil %		Moisture content%	
shrubs	2014	2015	2014	2015	2014	2015	2014	2015
1	15.44e	14.44ef	3.00b	3.00b	50.74c	51.12c-e	12.43bc	10.32ab
2	18.33bc	17.33bc	4.00a	4.00a	54.33ab	53.35b-d	10.85de	8.53d-g
3	16.44d	17.33bc	3.00b	3.00b	44.42de	49.50e	11.93b-d	9.25b-e
4	17.44cd	16.44cd	3.00b	3.00b	50.16c	51.16c-e	12.63bc	10.89a
5	20.22a	18.44a	3.00b	3.00b	53.18a-c	54.10bc	10.09ef	7.87g
6	18.56b	18.33ab	3.00b	3.00b	50.81c	50.56c-e	13.05b	9.43b-d
7	12.33g	11.11h	3.00b	3.00b	54.11ab	52.17b-e	7.59h	8.32d-g
8	15.44e	15.44de	3.00b	3.00b	52.65bc	53.10b-d	8.73gh	7.91g
9	14.44ef	13.44f	4.00a	4.00a	52.87a-c	52.40b-e	8.31gh	8.13e-g
10	15.22ef	14.44ef	3.00b	3.00b	50.11c	51.32c-e	10.82de	8.92c-g
11	11.22h	10.11h	3.00b	3.00b	46.36d	61.17a	11.76cd	9.15c-f
12	15.33ef	15.33de	4.00a	4.00a	52.42bc	53.78bc	9.37fg	8.01fg
13	17.33cd	16.44cd	4.00a	4.00a	56.00a	55.25b	7.72h	7.93g
14	14.33f	13.33fg	3.00b	3.00b	39.11f	49.80de	15.59a	9.82bc
15	12.55g	12.33g	4.00a	4.00a	41.71ef	51.15c-e	14.50a	8.10e-g

Values in the same column having different letters showed statistically significant differences (P < 0.05).

H- DNA fingerprint:

Random amplified polymorphic DNA (RAPD-PCR) procedure

A set of five random 10-mer primers (Table, 10) were used in the detection of polymorphism among evaluated jojoba strains.

Polymorphism detected by RAPD marker:

Five RAPD primers were tested with the DNA of 15 jojoba strains. These primers produced multiple band profile which ranged from 8 to 23amplicon (Table 10). Total number of amplicons amplified by the five primers was 75 with an average 15 amplicon/primer (Fig 3). The number of polymorphic bands ranged from 5 (OP-Z03) to 20 (OP-A07), representing percentage of polymorphism ranged from 41.6% (OP-Z03) to 86.9% (OP-A07). The size of the amplified bands varied according to the used primers, it was ranged from 55bp to 2269bp.

Table 10. Polymorphic, monomorphic, total amplicon and percentage of polymorphism as detected by Five RAPD primers.

Primer	Total no. of implications	Monomorphic implications	Polymorphic implications	Percentage of polymorphism
OP- A-07	23	3	20	86.90%
OP- A-18	19	4	15	78.90%
OP- C-04	13	3	10	76.90%
OP- C-19	8	1	7	87.50%
OP- Z-03	12	7	5	41.60%
Total	75	18	57	
Average	15	3.5	11.4	

Table 11. Genetic similarity among fifteen jojoba strains detected by RAPD marker.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.000													
2	0.083													
3	0.333	0.458												
4	0.333	0.375	0.625											
5	0.208	0.583	0.583	0.417										
6	0.125	0.417	0.333	0.500	0.625									
7	0.333	0.625	0.542	0.458	0.667	0.583								
8	0.208	0.583	0.500	0.583	0.625	0.875	0.750							
9	0.083	0.458	0.458	0.542	0.667	0.667	0.792	0.750						
10	0.042	0.500	0.417	0.250	0.708	0.625	0.750	0.708	0.583					
11	0.125	0.500	0.583	0.333	0.708	0.375	0.750	0.625	0.750	0.708				
12	0.00	0.625	0.375	0.375	0.583	0.667	0.625	0.833	0.542	0.667	0.500			
13	0.042	0.583	0.417	0.333	0.625	0.625	0.667	0.792	0.583	0.625	0.625	1.000		
14	0.042	0.500	0.583	0.333	0.792	0.458	0.667	0.625	0.750	0.542	0.792	0.500	0.625	
15	0.083	0.292	0.625	0.375	0.500	0.333	0.542	0.500	0.458	0.333	0.667	0.375	0.500	0.583

Genetic similarity:

The genetic similarity ranged from zero (T1 and T12) to 1 (T12 and T13). A high value of genetic similarity (0.875) was also observed between the strains (T8 and T6) followed by 0.792 between (T5 & T15, T8 & T13 and T11&T14), respectively (Table 11) reflecting a common genetic background. Gupta et al. (1994) and Attia et al., (2012), they get good amplification patterns with other genomes derived from different plant species using (GACA) 4 which correspond to Mic3, On the other hand, the 3-pinned ignition (Mick 4, Mick 5 and Mick 6) was less repeatable. Only one primer (Mic4) showed nine polymers amlicons out of twenty-two (40.9%) (Abu El-Khashab et al. 2007 and Gaber et al., 2007).

Genetic marker has been demonstrated to be associated a phenotypic trait of interest, it can be used as a selection target to obtain an indirect response in the trait Breseghello and Sorrells, (2006). Market – trait are reported in various agronomical and horticultural crops (Tayebe et al. 2013). On the other hand, strains (T9, T10, T13, T14 and T15) showed a lower value of genetic similarity withT1 (0.08, 0.04, 0.04, 0.04 and 0.08, respectively); another strains also recorded low value of genetic similarity (0.25, 0.33, 0.37, 0.33, 0.33 and 0.37) with T4 (T10, T11, T12, T13, T14 and T15), respectively.

Generally, genetic similarity value was low among the investigated strains. These variations observed in genetic similarity could be attributed to the effectiveness of origin of these strains as a seedy plant.

Cluster analysis:

Dendrogram obtained from UPGMA cluster analysis of genetic distances Fig (4) revealed that, the strains were divided into five clusters. The first cluster was divided into two groups each. The first group included (T13 and T12); while the second one collected (T6 and T8). The second cluster was divided into three groups, one of them involved (T7 and T9). The second group contained T11 and T4; while the third group involved only strain T5. Strain T2 was found alone in the third cluster; the same was true for strain T1 which located alone the fifth cluster. Meanwhile, the fourth cluster grouped strains T3, T4 and T15.

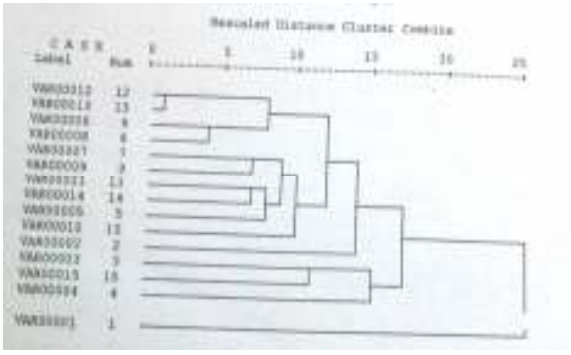

Fig. 3. Dendrogram using Average Linkage (Between Groups).

Dendrogram using Average Linkage (Between Groups

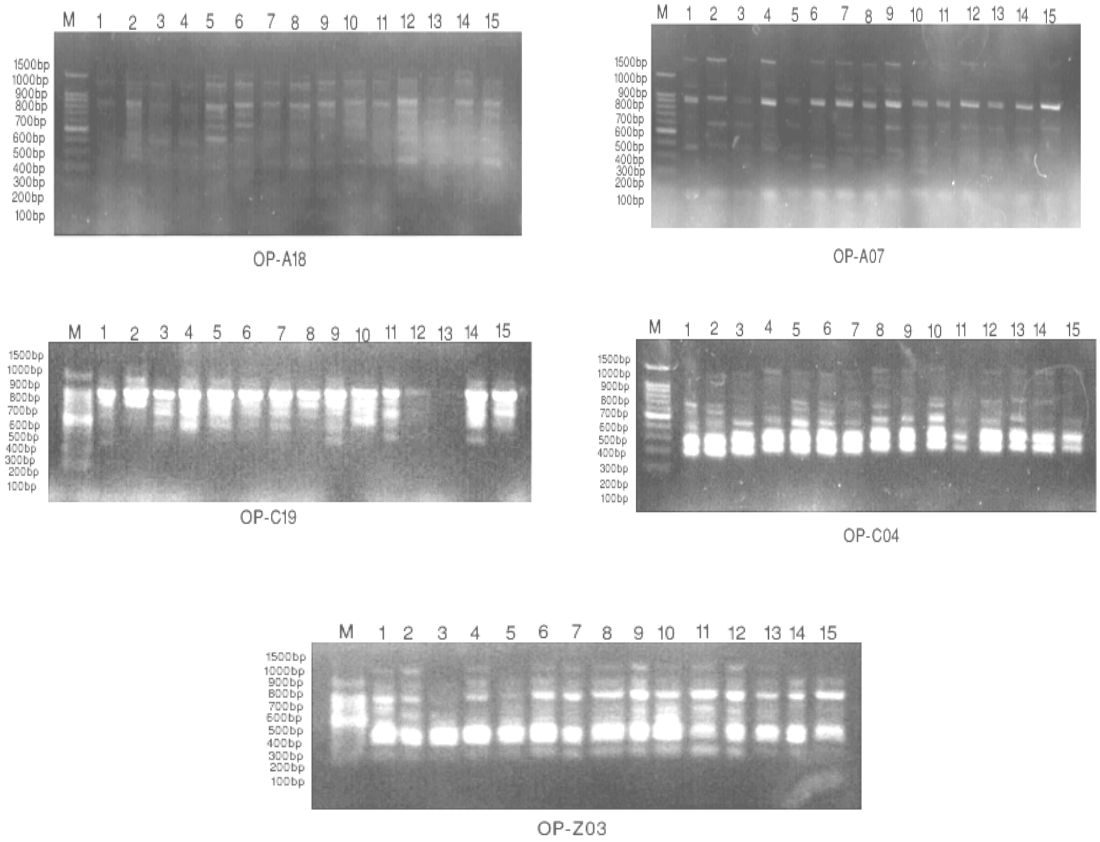

Fig. 4. RAPD-PCR analysis of different 15 trees females cultivated.
1- T1, 2- T2, 3-T3, 4-T4, 5-T5, 6- T6, 7-T7, 8- T8, 9-T9, 10 -T10, 11-T11, 12- T12, 13- T13, 14- T14 and 15-T15.

CONCLUSION

It could be concluded from the aforementioned results, that the five Jojoba genotypes were significantly different in morphological characteristics, physiological aspects genetic markets and chemical constituents.

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تقييم بعض الطرز الوراثية للجوجوبا المؤنثة تحت ظروف التربة الرملية

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تم إجراء هذا البحث على شجيرات جوجوبا بمزرعة الهايكستب بمحافظة القاهرة لعدد ١٥ شجيرة جوجوبا بذرية مؤنثة عمر ٨ سنوات خلال موسمي عام ٢٠١٤ و ٢٠١٥. الشجيرات تنمو فى تربة رملية فى أربعة خطوط على مسافة ٣ × ٣ متر وتروى بنظام الري بالتنقيط وذلك لتقييم الشجيرات التى يمكن أن تعطى أفضل إنتاجية ونسبة زيت، وعلاوة على ذلك تم تحليل الـ د ن ا باستخدام تكنيك الـ RAPD فى عينات أوراق جديدة ، وكان الهدف من هذا الجزء هو تحديد درجة علاقة القرابة والاختلافات الوراثية فيما بينها. اتضح من نتائج الدراسة الأتي: أولا: اقوي الشجيرات رقم (١ ، ٢ ، ٥ ، ٩ ، ١٠ ، ١٢) و (١٥). ثانيا: رقم الشجيرة رقم (٤) هي الأكثر تبكيرا في التزهير في كلا موسمي النمو. ثالثا: اعلي إنتاج للشجيرات المؤنثة كانت الشجيرات رقم (٥ ، ١٠ ، ١٢) و (١٥) في الموسم الأول ، بينما كانت في الفصل الثاني رقم (٩) و (١٢) في الفرع. رابعا: أنْ الشجيرات المؤنثة رقم (٢ ، ٥ ، ٧) و (١٣) أعطت اعلي نسبة المئوية للزيت في البذرة في الموسم الأول ، في حين انه في الموسم الثاني ، كانت الشجيرة المؤنثة رقم (١١) هي الأفضل. خامسا: البصمات الوراثية للأنواع المختلفة تمت باستخدام ١٥بادىء وقد نتج عنه عن ٥ بادئ ايجابي ISSR marker ، ولم يتأثر ١٠ بادئ وأظهرت النتائج أنْ هناك اختلافات بين السلالات ، ويتضح مما سبق أنْ الشجيرات رقم ٥ و ٤و ١١و ١٢ و١٣ وكانت الأفضل في قوه النمو والحصاد المبكر والإنتاج والنسبة المئوية لمحتوى الزيت. ويمكن إكثارهم خضريا والتوسع في زراعتها . وفيما يتعلق بالقيمة العالية لتشابه الجينات ، كان الرقمان ٨ و٦. وأيضا كانت أعلى قيمة لمعامل التماثل (٠.٨٧٥) بين الشجيرة (٦ و ٨) يليها معامل التماثل رقم (٠.٧٩٢) بين الشجيرات (٥، ١٥، ٨، ١٣، ١١ و ١٤) على التوالي، وبناء على تحديد مستوى هذه الاختلافات باستخدام خمسة من بادئات ISSR-PCR يمكن إقرار أنها فعالة في تحقيق الهدف من الدراسة.