Response of growth and wax production of Jojoba (Simmondsia Chinensis (LINK) Schneider) to the site of cultivation at Egypt.

Salah M. Mahmoud[1], Saber F. Hendawy[2], Ibrahium M. F.[1], Mahmoud A. El Serafy[1], and Hussan A. Youssf[1]

[1]El-Azhar Univ. Faculty of Agric, Dept of Horticulture, Nasr City Cairo, Egypt.
[2]Medicinal and Aromatic Plants Researches Dept., Pharmaceutical and Drug Industries Researches Division, National Research Center, Egypt

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Jojoba plant (Simmondsia Chinensis (link) Schneider), or Ho-Ho-ba or goat nut is a shrub belonging to the Simmondsiaceae family. It is well known as a useful medicinal plant and as a new crop of interest for many industrial purposes. The present study was carried out duringhe two successive seasons of 2012/ 2013 and 2013/ 2014 in private jojoba farms located as following: El-Kassasin city, El-Ismailia, Marsa Matroh, El-Sharkia, Asuite and El-Khanka governorates(Egypt). The study focused on studying the effect of the different local growing site of Egypt on the growth and wax production, and aiming to detect the best location for the suitable growing site to produce the best growth and wax yield. Nine jojoba female shrubs were selected in each farm from the growing shrubs depending on its obvious morphological growth characters and the different seeds shape and then they were marked by labels for data measurements. The monthly temperature and relative humidity average during the study seasons of culture were taken and recorded. The physical and chemical properties of the experimental soil were also determined and presented. Growth and flowering characters of jojoba shrubs e.g. plant height and volume as well as flowering period and fruiting set were greatly altered in relation with the growing location. Indeed, plants grown in upper Egypt Asiut site tended to produce the best growth rate and the extended flowering. Moreover, plants cultivated in El Sharkia and Assiut sites gave the biggest yield of wax, compared to the other cultivation sites, while the lowest yield of wax was from plants cultivated in Marsa Matroh area. The best level of most of the fatty acid content (Palmitic, Oleic, Nervonic, Gadoleic and Erucic acids) was found in the wax extracted from seeds of shrubs grown in Ismailia growing site.

Key words: jojoba, growing site, wax, fatty acid, Hohoba, growth, flowering

Corresponding author: Prof. Dr Salah El Deen M. Mahmoud, E-mail: *salaheldeenm2005@yahoo.com*

1. Introduction

Jojoba plant (*Simmondsia chinensis (link) Schneider*) is a shrub belongs to *Simmondsiaceae* family. Jojoba is a woody, much branched, ever green, dioecious, long-lived shrub. It grows widely in the semi-arid region (Benzioni, 1997). The seed contains about 50% of liquid wax and matures by July and August (Ahmed, 1989 ; Tandy, 1988).

El-Hadeedy (1984) mentioned several uses for Jojoba liquid wax such as: component in hair oil, shampoo, soap, in-face creams and sunscreen compounds. It is used also as a suitable carrier or coating for some medicinal preparations, stabilizer for penicillin products, as cooking oil, low calorie additive for salad oil. It is recommended to be used as a polishing wax for floors, furniture and automobiles, in the protective coating of fruits, food preparations and paper containers. It is also used in cosmetics such as lipsticks. Furthermore Ranhotra et al. (1986) reported that Jojoba oil could be possibly used in low-calorie backed food at levels up to 9% in the diet as it didn't cause an increase in the body weights when used instead of soybean oil. Moreover, the liquid wax of Jojoba is used in lubrication of high speed machines (Salunkhe et al., 1992). Weiss (2000) reported that Jojoba oil is a valuable carrier for medicines that must pass through the stomach to the small intestine. Jojoba oil was used as a medicine for cancer, kidney disorders, headache, wounds and sore throat and they used jojoba seed and oil for cooking. In addition, El-Shamy et al. (2001) reported that the oil has anti-microbial, anti-parasitic, anti-pyretic, anti-inflammatory and hypo cholesterolemia effects. Moreover, the oil was found to have a curative effect on mouth ulcers (Roth, 2001). After oil expression the metal contains more than 30% protein and used as animal feed after detoxification (Benzioni 1997).

On the other hand, Yermanous (1979) stated that the quality of oil content of jojoba seeds has exhibited variation regardless to the geographic origin of the seeds. El-Mardi and Beg (1983) in Sudan, indicated that the times of fruit set were observed in all sites; at Erkowit, it was from October untill April and at Bara, it was from August untill October. While the time of maturity of fruits was in Erkowit location from March to October, and at Bara, from November to January.

Under other climates, Botti et al. (1998) reported that significant differences were presented among the clones in the majority of the measured parameters. These variables were affected somewhat by

location and environment. Benzioni et al. (1999) reported that in Israel, the fruit set was affected to a great extent by environmental conditions at the time of pollination**.**

2. Materials and methods

The present study was carried out at the two successive seasons of 2012/ 2013 and 2013/ 2014 at private jojoba farms located at the following growing sites: El-Kassasin city in El-Ismailia governorate, Marsa Matroh, El-Sharkia, Asiut and Qalubia, Egypt. The jojoba shrubs were planted at all the chosen farms at the year of 2007 at the rate of 700 female shrubs/ feddan, growing under the open field conditions and were irrigated by drip irrigation system.

This study focused on studying the effect of the different growing site on the growth, flowering, seed yield and wax production of Jojoba and determining the best location for jojoba cultivation in terms of optimal growth and best seed and wax production. The monthly temperature and relative humidity average during the study seasons of 2012 to 2013 were taken and recorded in Tables (). The physical and chemical properties of the experimental soil were also determined and presented in tables 1 and 2.

Table 1. Chemical characteristics of soil analysis for samples collected from the different growing sites

City	pH	EC dS/m	Soluble Cations (meq/l)				Soluble Anions (meq/l)		
			Na^{+}	K^{+}	Ca^{++}	Mg^{++}	HCO_3^{-}	CL^{-}	SO_4^{--}
Ismailia	8.3	0.12	11.35	0.2	3.05	5.375	0.7	13.375	5.175
Marsa Matrouh	7.77	0.67	3.55	0.7	1.65	0.8	0.3	3.45	2.95
Qalubia	7.67	0.75	3.9	0.65	2	0.95	0.3	3.85	3.35
Sharkia	7.9	1.9	14.2	0.5	2.5	1.8	0.9	17	1.1
Assuit	7.88	6.2	52.9	1.2	4.9	3	1.5	59	1.5

Table 2. Physical characteristics of soil analysis for samples collected from the different growing sites

CITY	SANDY	SILT+ CLAY	TEXTURE
Ismailia	95.9975	4.0025	Sandy
Marsa Matrouh	97.53	2.47	Sandy
Qalubia	99.17	0.83	Sandy
Sharkia	96.12	3.88	Sandy
Assuit	98.31	1.69	Sandy

The general plant morphological characteristics were measured as follows:

2.1. Growth characters: height and volume of shrubs (m) were measured at the end of growing seasons on October 2012 and 2013. The plant canopy volume (cv) was calculated using the

equation CV=0.528 x H x D^2, whereas H: is the plant height and D: is the plant diameter (Turrell 1946).

2.2. Flowering and fruiting characteristics

Five shoots were randomly selected at different sides on each female shrub at height of 50 cm from ground surface and the following data were recorded: Onset of flower-set: flowering start was assessed during flowering period per shrub in both seasons. Percentage of fruit set: Fruit set percentage was calculated as the following formula: Fruit set %= (No. of fruits divided on total No. of flowers at full bloom) x 100. Flowering end: time of the last flower open.

2.3. Seed yield characteristics: Seeds were manually harvested from each selected shrub, they were subjected to the following yield characteristics determination: Seeds yield/shrub (g): by collecting and weighting seeds from each shrub. Seeds yield per feddan in Kg.

2.4. Wax characteristics

2.4.1.Wax yield

Wax in jojoba seeds was extracted according to the two methods described by AOAC (2005) using soxhlet instrument as well as hydraulic extraction. The hydraulic extraction was done as follows: The seeds were oven dried at 60 ^{o}C for 6hours, then expressed under pressure using Carver model C, 2759 S/N, Fred. S. Carver Inc. The oil obtained by expression was filtered using filter paper No. 52, and then dried over with anhydrous sodium sulfate. The dried extracted oils were stored in glass bottles in the refrigerator at 5 ^{o}C till the analysis and / or the determination of their physical and chemical characters.

The following data were recorded:-

4-1-1 Wax percentage weight/ 100// by using soxhlet instrument.

4-1-2 Wax yield per shrub (g): was measured as wax amount in gram per shrub seeds weight, using the hydraulic extraction.

4-1-3 Liquid Wax yield per feddan (Kg): was calculated by multiplying wax weight per shrub by number of the female shrubs per feddan.

4.1.The chemical properties of waxes:

Fatty acids chemical content of jojoba wax as methyl ester was estimated using high performance liquid chromatography (HPLC) (Gimeno et al. 2000) at the Agricultural Research Center; Food Technology Research Institute.

STATISICAL DESIGN AND ANALYSIS

The growing site experiment was designed as a split plot design and statistically analyzed using two ways of analysis of variance (ANOVA) and Duncan-test for threshold of significance of 5% was presented (Duncan, 1955). The statistical analysis were performed using "spss software ver. 18" for windows 7.

3. Results and discussions

3.1. Growth characters

There were great variations among the growth character of jojoba shrubs due to the site of cultivation. From the calculating data in the first season, it is clear that plants which were grown in Assiut area gave the best value of 130.14, while the lowest value was belonging to those grown in Marsa Matrouh with small value of 75.77. This trend was confirmed in the second season but with slightly difference. Botti et al., (1998) found that all leaf parameters which were measured in jojoba plant showed differences among clones; leaf length, leaf width, length/width ratio and leaf area.

3.2. Flowering and fruiting characters

The flowering start and the flowering end as well as the flowering period differed greatly according to the site of jojoba planting. Growing jojoba shrubs in Kalubia site induced plants to flower earlier and to delay their flowering end and extended their flowering period when compared to the other growing sites.

However in the first season, jojoba plants cultivated on Qalubia started flowering on December 15 and ended their flowering on June 30 and accordingly, their flowering period was extended to 197 days. On contrast, plants grown in Ismailia site started flowering very late on January 8 and ended their flowering on January 12 with the smallest flowering period of 155 days Figure 6. In the second season jojoba plants cultivated on Kalubia started flowering on December 19 and ended their flowering on July 2 and accordingly their flowering period was extended to 195 days. On the contrast, plants grown in Ismailia site started flowering very lately on January 8 and ended their flowering on January 12 with the smallest flowering period of 155 days Figure 7. This trend hold true during the second season with insignificant differences values. Plants grown in Assiut growing site gave the biggest values of flowers density and fruiting set since in the first season, they were 19.87 and 82.53 %, respectively, while in the second season these values were 20.51 and 92.07 %, respectively. Benzioni et al. (1999) reported that the fruit set of jojoba plants were affected to a great extent by environmental conditions at the time of pollination. Ahmed (1989)

mentioned that seed maturation of jojoba in Egypt take place in July and August with about five months after pollination.

3.3. Seeds yield characters

The environmental condition of Sharkia as well as Assiut cultivation areas was greatly suitable for producing the highest seed yield compared to the other growing site. The best seed characters e.g. Seed weight (g), Seed yield (g/ shrub) and Seed yield (kg/feddan) were obtained from shrubs planted on Sharkia or Assiut location since both gave the highest values with insignificant differences between them. The lowest values from these characters were found in jojoba shrubs planted in Marsa Matrouh growing site. The same trend was also occurred in the second season of this study with slightly insignificant modification. However, the most suitable growing site for the favorable seed yield was that of Sharkia or Assiut location, while the lowest values were from plants grown in Marsa Matrouh growing site. This trend was confirmed in the second season but with different values.

Cappillino et al. (2003) stated that the large variability of seed size among the different locations was not possible. Seeds from different clones collected from the same plantations varied in the weight per 1000 seeds by more than 50%, and thus, it appeared that factors other than geographic location were responsible for the diversity in seed size.

3.4. Wax production

The plants cultivated in Sharkia and Assiut sites gave the greatest yield of wax, compared to the other cultivation sites. Furthermore, growing jojoba plants in Ismailia region resulted in less yield of wax but better than that of Qalubia site, while the lowest yield of wax was from plants cultivated in Marsa Matroh area Figure 11. The yield of Jojoba wax percentage in the second season can be arranged in decrease as fellow: 47.44, 47.20, 46.04, 41.98, and 32.77% for Assiut, Sharkia, Ismailia, Qalubia and Marsa Matroh growing site, respectively. This trend was observed in the first seaon of this study but with a slight decrease may be due to the environmental condition and the plant ages. The effect of growing site on the yield of Jojoba wax was also studied by Verbiscar and Banigan (1980) and Naqvi et al. (1990). They postulated the same finding that there were significant positive correlation has been observed between Jojoba seed wax yield and the geographic region of its cultivation.

3.5. Wax chemical properties

The fatty acid composition of jojoba oil was influenced remarkably by the growing sites of jojoba shrubs. From the presented data (table 3) the best level of the fatty acid content was found in the wax extracted from seeds of shrubs grown in Ismailia growing site. The lowest values of fatty acids content were found in seeds wax of shrubs grown in Marsa Matroh (Palmitic, Oleic, and Nervonic acids) and Qalubia (Gadoleic and Erucic acid). These results agreed those obtained by Wisniak (1994), Breyss et al. (1994), Gaafar (2002), El-Halawany (2002) and El-Shamy et al. (2001).

Table 3. Measurements of the fatty acids composition percentages of jojoba oil extracted from shrubs grown in the different growing sites during the growing season of 2012/ 2013.

Fatty acids	Ismailia	Marsa Matroh	Sharkia	Asuit	Qalubia	LSD
Palmitic	2.17	1.54	2.15	1.55	2.13	N.S
Oleic	17.30	13.05	17.21	13.12	16.95	1.80
Gadoleic	59.06	68.44	58.76	68.78	57.87	1.78
Erucic	17.56	17.23	17.47	17.32	17.20	N.S
Nervonic	2.13	1.55	2.12	1.56	2.09	N.S

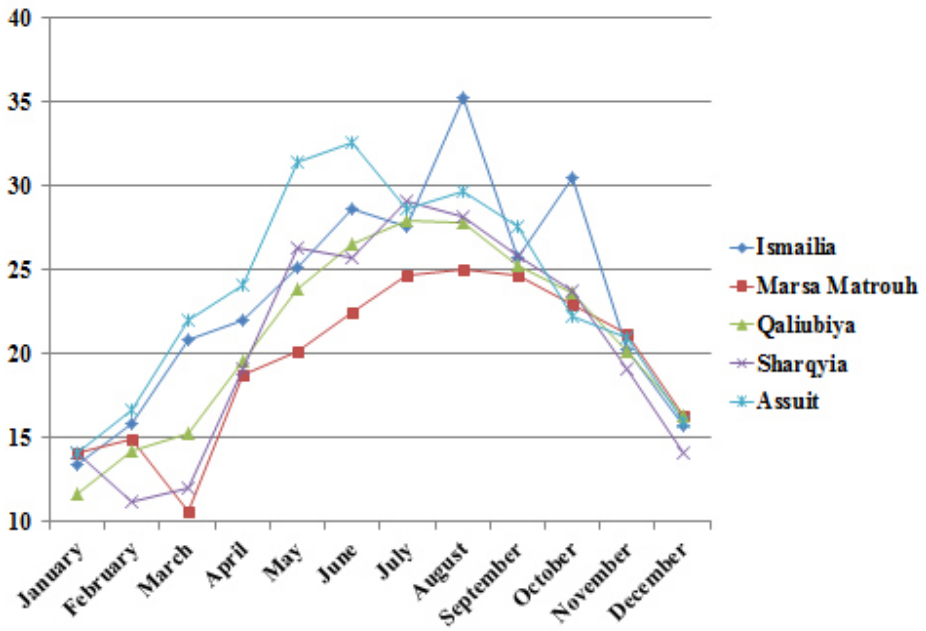

Figure 3. Monthly averages of the recorded temperature (Min.& Max) at the different growing sites during the season 2013 of the experiment.

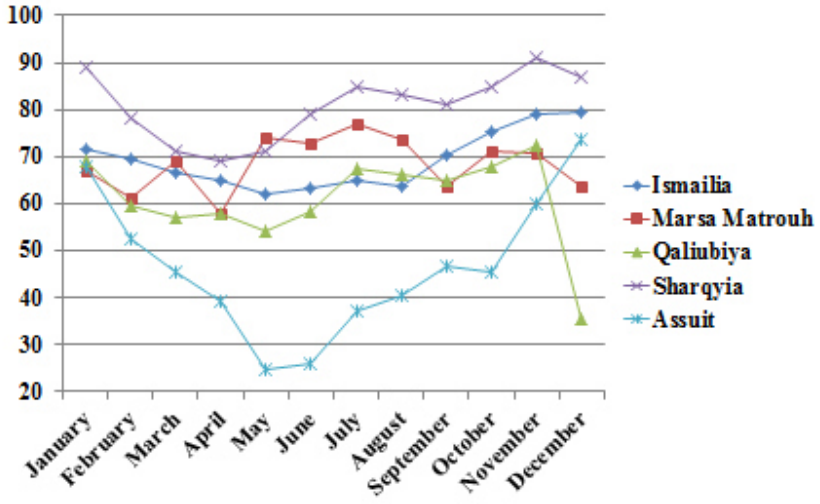

Figure 4. Monthly averages of the relative humidity percentage at the different growing sites during the tow seasons of the experiment.

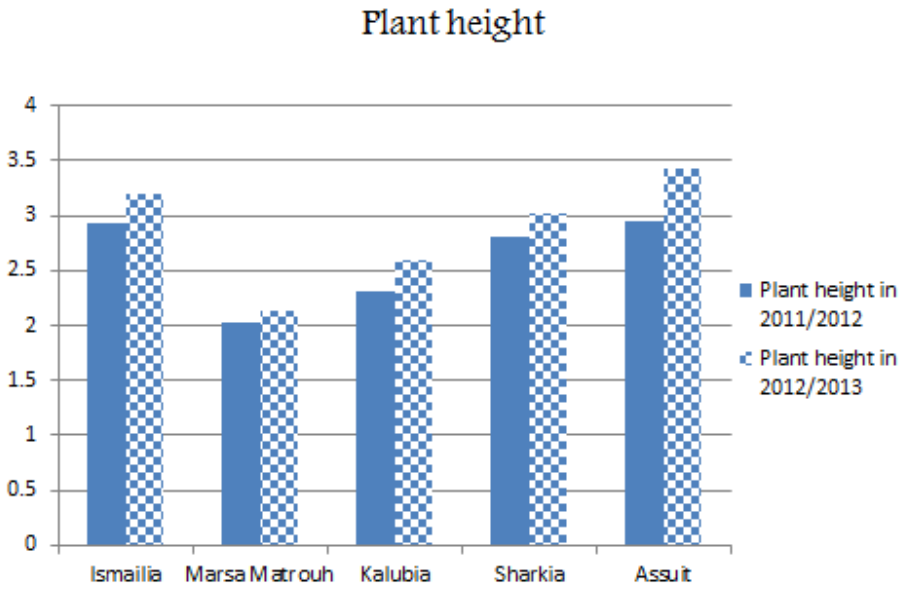

Figure 5. Diagram showing plant height (m) of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013.

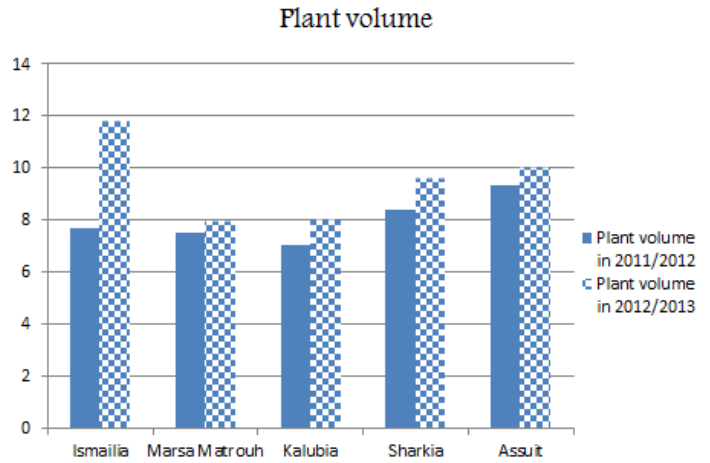

Fig (102): Diagram showing plant volume (m^3) of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013.

Figure 6. Diagramm showing plant volume (m^3) of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013.

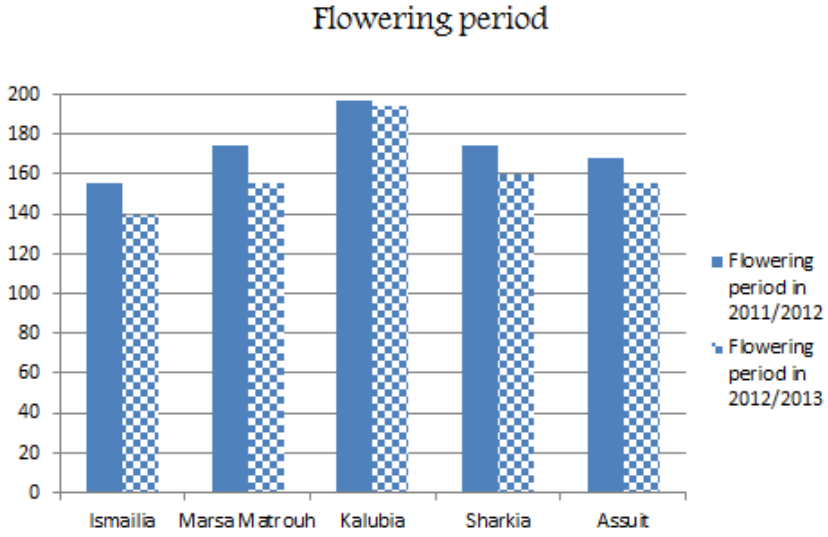

Figure 7. Diagramm showing flower period of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013.

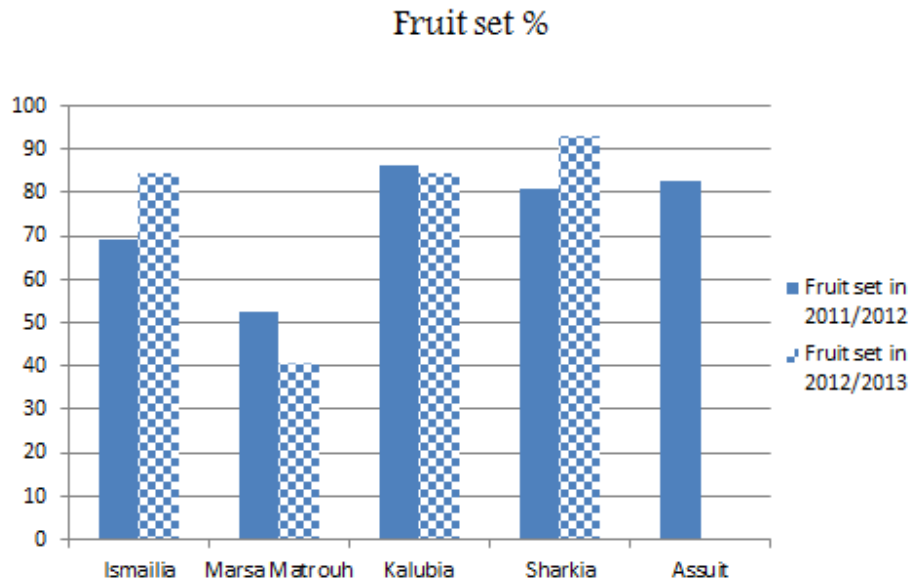

Figure 8. Diagram showing fruit set of different governorates in both seasons 2011/2012 & 2012/2013.

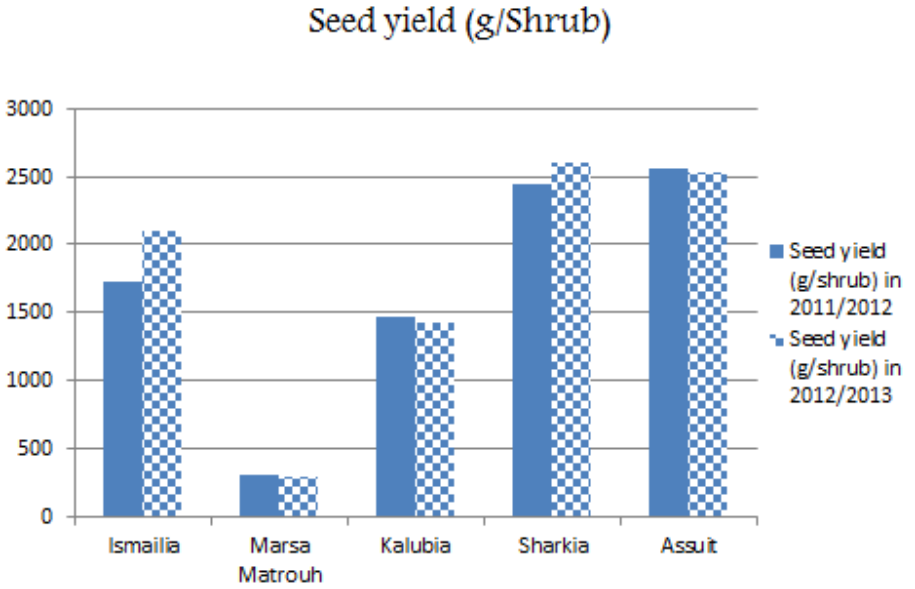

Figure 9. Diagram showing seed yield (g/Shrub) of jojoba plants growing in different governorates in both seasons of 2011/2012 & 2012/2013

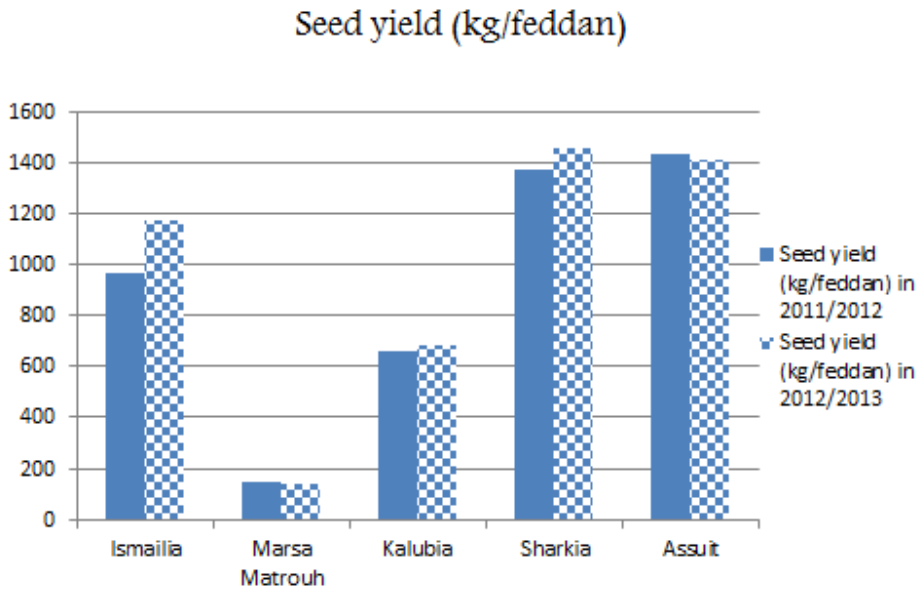

Figure 10. Diagram showing yield (kg/feddan) of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013.

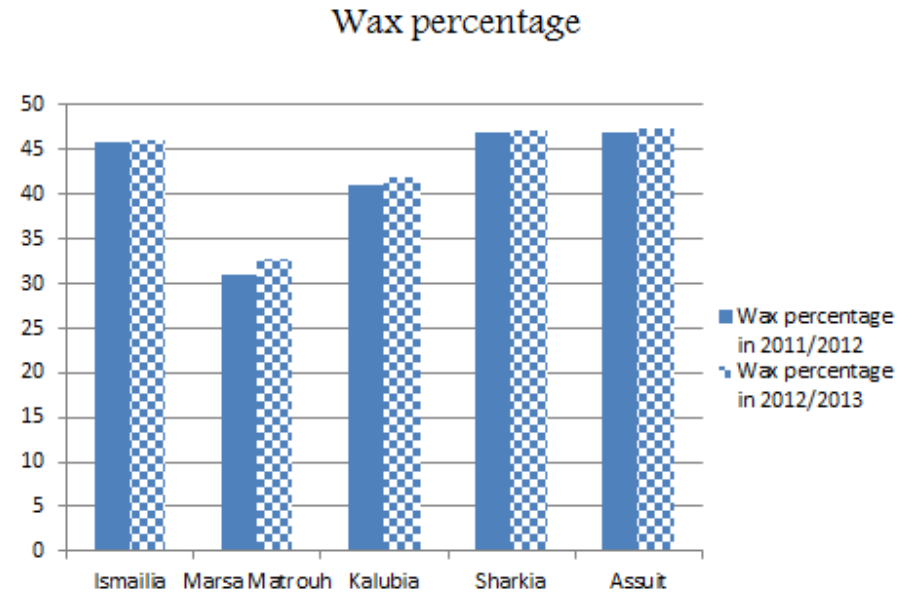

Figure 11. Diagram showing wax percentage of different governorates in both seasons 2011/2012 & 2012/2013

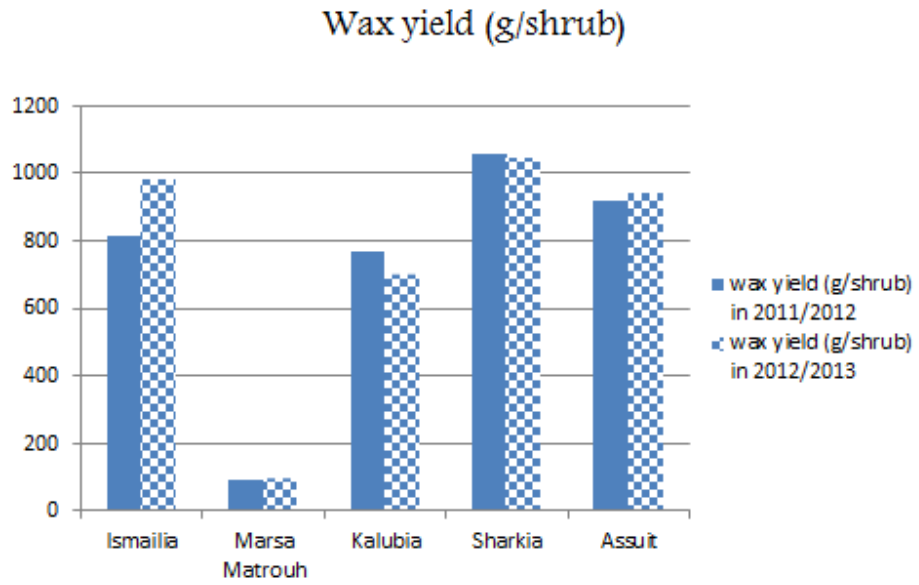

Figure 12. Diargram showing wax yield (g/shrub) of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013

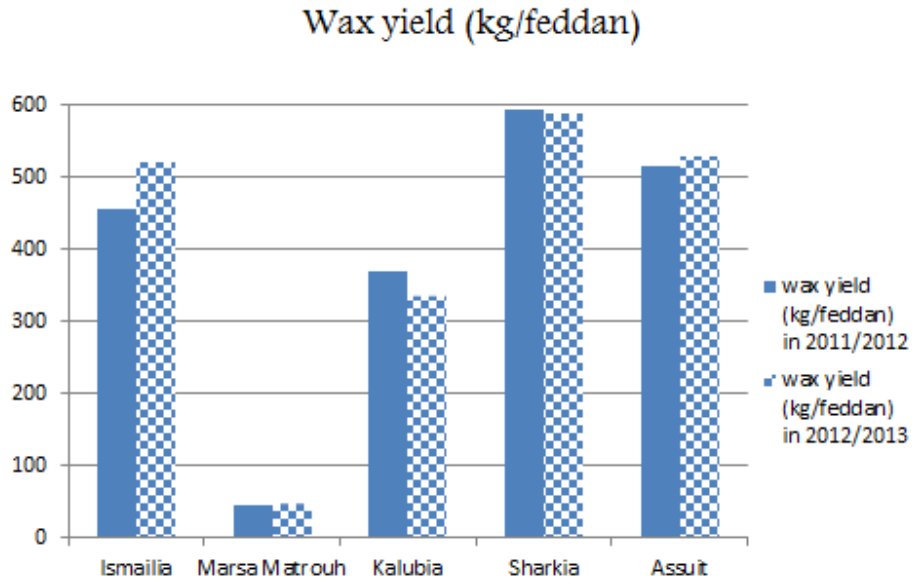

Figure 13. Diagram showing yield (kg/feddan of jojoba plants grown in different governorates in both seasons of 2011/2012 & 2012/2013.

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