J. Agric. Sci. Mansoura Univ., 29 (12): 7201 - 7215, 2004

STUDIES ON JOJOBA [*Simmondsia chinensis* (LINK) SCHNEIDER]:

I- STUDIES ON SOME VEGETATIVE AND FLOWERING CHARACTERISTICS.

El-Torky, M.G.[1-]; A.H. Shahein[2]; Ola A. El-Shennawy[1]; Eman M. El-Fadly[1].

1- **Department of Floriculture, Ornamental Horticulture and Garden Design, Faculty of Agriculture, Alexandria University, Egypt.**
2- **Department of Pomology, Faculty of Agriculture, Alexandria University, Egypt.**

ABSTRACT

Plant height, the number of main branches per plant, time of sex differentiation, habit of flowering as well as fruiting pattern and yield were studied using different jojoba clones of about 20 years old. Data showed that :

1- Plant height of the progeny of SF1 attained the highest values after 36-months, followed by SF3 then TF7. The differences between the three progenies seemed to be a genetically trait. However, the environmental conditions might also have a slight effect on plant height. Consequently, the progeny population of SF1 proved to be highly stable against the seasonal variations, whereas both SF3 and TF7 have slightly reacted with the seasonal variations.
2- With respect to the number of main branches per plant, it was found that the progeny population of SF3 obviously attained the highest values of main branches at 36 months. The extensive branching of SF3 appeared clearly in the three seasons as compared with that of both SF1 and TF7 regardless the seasonal effect.
3- As for the time of sex differentiation, the data showed that, among a population of 2650 young plants of jojoba grown under greenhouse conditions (13 months-old), only 3.7% of the plants commenced flowering and this percentage increased gradually during the second year to be 25.32% (24 months old plants). Moreover, the time of flowering varied widely among plants. On the other hand, the number of male jojoba plants which commenced flowering was always greater than the number of females.
4- In male and female shrubs of the studied jojoba clones, flowers usually develop at every other node which was found to be the common habit of flowering of all the studied males; SM1, SM2 and SM3, and only one of the three studied females; SF4. Flowers develop at every node in two females; SF1 and SF3. All the studied shrubs tended to produce both types of flowering habit on the same shrub, but only one type was always clearly dominant. The habit of flowering appears to be primarily under genetic control which may be modified by environmental conditions.
5- The common fruiting pattern in the studied jojoba females was that of a single fruit. In addition, the percentage of fruits with single, double and triple seeds varied from 90.37 to 96.00% , 3.94 to 9.12% and 0.00 to 0.51%; respectively. Clear differences were found between clones. As an average for the three years, the clone SF3 proved to give the highest yield of fruits. Moreover, the yield of the selected clones varied greatly between shrubs as well as between years. Clone SF3 attained the same attitude of fruits and produced the highest yield in the three years of study, with an average of 2258.33 gram per plant as compared with that

of SF1 (433.33 g \ plant.) and SF2 (178.33 g \ plant.) The seasonal performance of clones differed greatly as well.

INTRODUCTION

Jojoba [*Simmondsia chinensis* (Link) Schneider. Family Simmondsiaceae] is a multi-stemmed evergreen oil producing shrub with an extremely long life (Bailey, 1961). It rarely exceeds one meter in its native habitat and in more favorable sites, bushes as high as five meters have been recorded (Hogan, 1979). With respect to volume parameters; height and shrub width, Benzioni *et al.*, (1996) found some differences between clones and shrubs within the clone which were attributed to both genetic and environmental factors (salinity levels) and / or interaction. They also studied the rate of growth of the different clones and found that the growth rate curves of all clones were found similar. The shrubs of all clones grew slowly until the age of about 18-20 months, then they started growing rapidly through the next year. During this year, the shrub height and width increased rapidly to gain a final growth of about three times as what was gained through the first 18-20 months.

Palzkill (1987) reported that the fact that jojoba is a dioecious plant (male and female flowers occur on different plants) and that it has been continuously propagated by seeds has generated an extremely heterogeneous population. Native jojoba and seeded plantations throughout the world show great variability among plants including several characteristics such as plant height and number of side shoots. Botti *et al.*, (1996) found that the number of side shoots of some selected jojoba genotypes varied from 5.8 to 89.7 which was attributed to the genetic variability among shrubs. The authors also found some variability between the three field locations which was considered as a result of some environmental factors including soil and water salinity.

The sex of a young jojoba plant can not be identified until the first flower buds appear. This may be in the first summer of the first year, whereas in slow plants, which is the normal situation, it may take until the fourth year (National Research Council, 1985) or more (Campbell, 1985). Variability is mainly due to genetic heterogeneity (Hawson, 1985 and Ramonet-Razcon, 1988). There may be a relationship between the plant development and the time of sexual differentiation and production (Aragao and Oliveira, 1985).

Flowering in jojoba may occur at every node or every other node on newly matured growth. Relationships were found between the genetic background and flowering pattern (Gentry, 1958 and Forti *et al.*, 1985).

The most common fruiting pattern in jojoba is that of a single fruit developing on every other node (Yermanos, 1974). Some plants produce two- and three-seeded capsules since each ovary contains three ovules, each of them has the potential of becoming a seed (Hogan, 1979 and Ramonet-Razcon, 1988).

MATERIALS AND METHODS

This experiment was carried out throughout the period of 1997 -2002 at the Research Stations of the Desert Development Center, belonging to the American University in Cairo. Plant height and the number of main branches of two female progeny populations grown at Sadat Research Station (SF1, SF3) and one female grown at Tahrir Research Station (TF7) were studied throughout three successive seasons of 1997, 1998 and 1999. About 500 seeds of each clone were sown on October each year, the seeds were sown in plastic bags of 30 cm length and 16 cm diameter. After four weeks, only 225 seedlings were taken at random from each clone and were divided into three replications, each of 75 seedlings. The experiment was arranged in the form of Randomized Complete Block Design. The first data were taken four weeks after planting and then repeated after 5,6,7,8,18,26,33 and 36 months. Data included the plant height (measured in cm from the soil surface to the top of the plant) and the number of main branches per plant. In order to study the time of sex differentiation of jojoba seedlings, a population of 2650 seedlings were raised by seeds sown on October 19,1998 in big plastic bags (30 cms length and 16 cm diameter). Seedlings were kept in the greenhouse for two years. The plants were checked for flowering every week and data were collected at monthly intervals until the plants were 18 months old, then finally were taken after 24 months from seed sowing. Data included the number of male and female plants as well as their flowering time.

The flowering habit of six selected jojoba clones was studied using three pollen (male) parents; SM1, SM2 and SM3 and three seed (female) parents; SF1, SF3 and SF4. The type of flowering for 200 branches taken at random for each selected shrub was recorded. Every branch was checked well to see the habit of flowering : either every node or every other node. Data were taken through the flowering season of April / May, 2000.

For the study of fruiting pattern and yield, data were recorded for only three seed parents; SF1, SF2 and SF3. The whole yield of fruits for each shrub was collected for three successive years; 2000, 2001 and 2002. The total number of fruits per shrub was counted as well as the number of one-, two-, and three-seeded fruits for each of the three selected seed parents. Data included also the seed yield expressed as the number of seeds per plant and the yield in grams per shrub. The mean weight of 1000 seeds was also recorded for each shrub.

RESULTS AND DISCUSSION

1- Plant Height

Plant height of three jojoba progeny populations throughout the three successive seasons of 1997, 1998 and 1999 are presented in Table 1 a, b and c. It was found that the progeny populations of SF1 and SF3 attained significant higher values of plant height when being 36 months old, as compared with that of TF7. The growth rate curves illustrated in Figure 1. showed that all progeny populations grew similarly within the first period of

vegetative growth which was about eight months. When the plants were about 18 months old, the genetic differences between the three progenies started to appear, regardless the seasonal effect. The differences between the three progenies as well as the performance of plant height seemed to be a genetic trait, the same type of growth curves were obtained throughout the three seasons of the study designating a kind of interclonal variability (Fig. 1).

The environmental conditions (differences in rainfall, temperature, quality of water at Sadat and Tahrir), however, had also a slight effect on plant height as shown in Fig. 2 A, B and C.

Table 1 : Plant height (cm) of three jojoba progeny populations derived from three seed parental clones grown at Sadat Station (SF1, SF3) and South Tahrir (TF7).

a- First season populations sown in October, 1997.

Clone	Plant age (months)								
	4	5	6	7	8	18	26	33	36
SF1	11.23	14.52	16.28	19.09	20.09	43.41a	45.63a	56.89a	65.03a
SF3	11.69	14.75	16.14	18.05	18.46	38.80b	43.65a	50.81a	57.51a
TF7	11.36	14.30	15.19	16.39	16.99	30.60c	39.09b	45.50b	49.77b
$L.S.D_{0.05}$	N.S.	N.S.	N.S.	N.S.	N.S.	3.14	2.62	6.80	7.62

b- Second season populations sown in October, 1998

Clone	Plant age (months)								
	4	5	6	7	8	18	26	33	36
SF1	11.23	11.36	14.73	18.63	20.46	38.43	45.59	57.89a	72.11a
SF3	11.69	13.17	15.81	19.77	21.63	39.07	49.41	57.40a	66.74a
TF7	11.36	13.28	15.23	18.19	20.31	32.66	41.41	45.34b	50.48b
$L.S.D_{0.05}$	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	10.19	7.15

c- Third season populations sown in October, 1999.

Clone	Plant age (months)								
	4	5	6	7	8	18	26	33	36
SF1	11.28	15.82	18.04	19.32	20.53	36.06	52.10a	54.18a	65.29a
SF3	12.16	16.78	19.34	20.32	21.15	31.22	37.02b	41.51ab	57.17ab
TF7	12.09	15.18	17.65	19.11	20.52	27.83	34.12b	36.55b	48.41b
$L.S.D_{0.05}$	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	12.72	12.74	9.43

- **Values followed by the same letters are not significantly different at 0.05 level of probability.**

Ayerza (1996) also detected high significant differences between jojoba clones and shrubs with respect to plant volume parameters (height and width); which he attributed to the genetic variability among and within clones.

On the other hand, the limited seasonal variations which were detected in the current investigation (Figure 2), especially for SF3 and TF7, might be due to the differences of rainfall and/or the quantity and quality (salinity) of irrigation water. Benzioni and Nerd (1985), Benzioni *et al.*, (1996), Botti *et al.* (1996) and Nelson (1996) found that the seasonal differences in plant height exist as a result of some environmental factors as irrigation water and soil salinity. In spite of the importance of fertilization as another factor which might be responsible for the differences in plant height between shrubs as reported by Benzioni and Nerd (1985) and Nelson and Watson (2001), but it is not confirmed in the current study, since no fertilization regime was used at all.

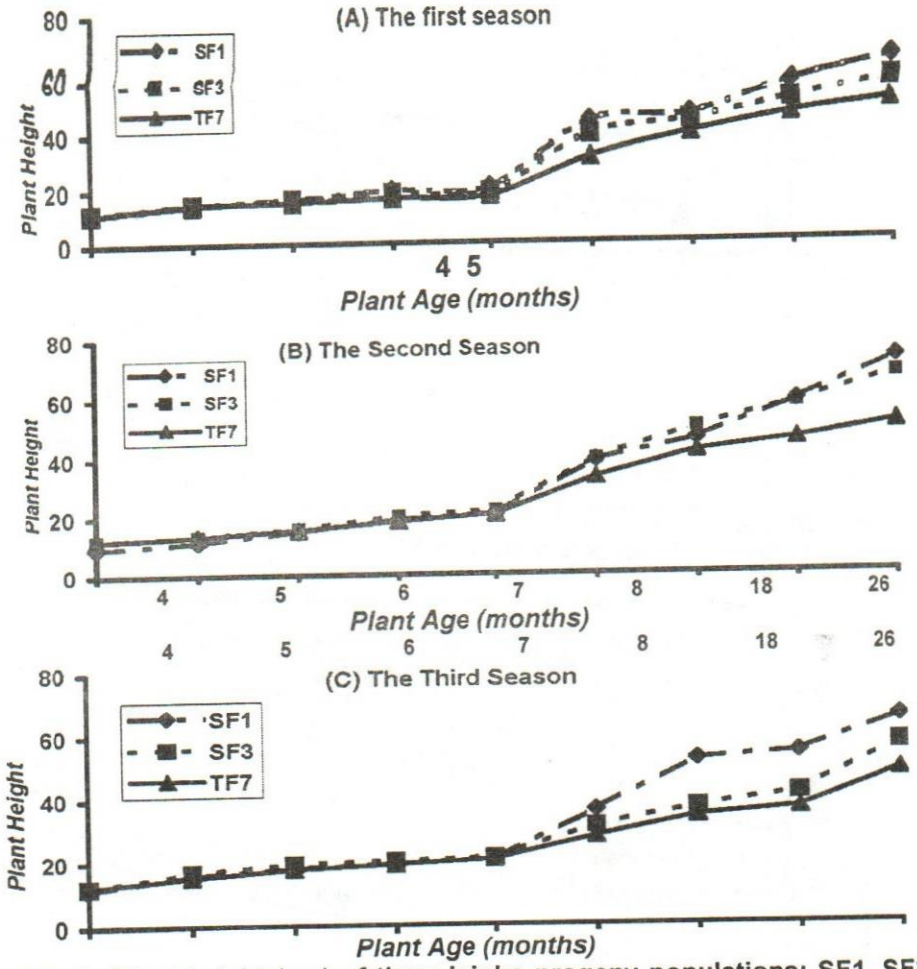

Fig. 1 Plant height (cm) of three jojoba progeny populations; SF1, SF3 and TF7. Graphs show the interclonal variability throughout three successive seasons: the first season (A) sown on October, 1997; the second season (B) sown on October, 1998; and the third season(C)sown on October, 1999.

2- Number Of Main Branches Per Plant

Data on the number of main branches of three jojoba progeny populations throughout the three successive seasons of 1997, 1998 and 1999 are presented in Table 2 a, b and c. It was found that the progeny population of SF3 obviously attained the highest values of main branches when being 36 months old. The growth rate curves illustrated in Figure 3 showed that all progeny populations grew similarly within the first period of vegetative growth along approximately one year. The differences between progeny populations did not appear clearly until the plants were about two years old. The extensive branching of SF3 appeared clearly in the three seasons compared to both SF1 and TF7 regardless of the seasonal effect.

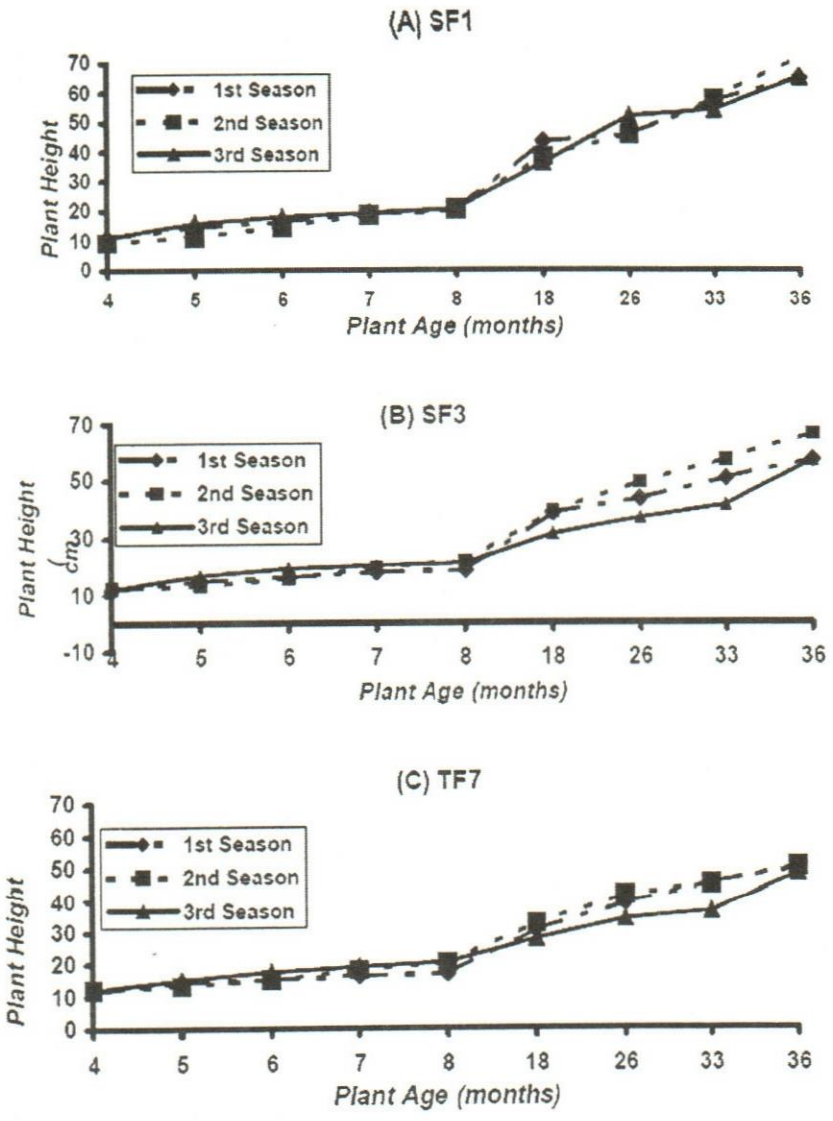

Fig. 2 Plant height (cm) of three jojoba progeny populations; SF1 (A), SF3 (B) and TF7 (C). Graphs show the seasonal variability throughout three successive seasons: the first season sown on October, 1997; the second season sown on October, 1998; and the third season sown on October, 1999.

The effect of environmental conditions on the number of main branches could be seen from the combined curves of Figure 4. There were some limited differences between the three seasons which started to appear almost when the plants were only few months old. These results agreed with the findings of Botti *et al.*, (1996) who recorded significant differences among

some selected progeny populations with respect to the number of side shoots which were attributed to the genetic variability among shrubs. They also found that this variability was considered as a result of some environmental factors including soil and water salinity. Shrubs planted under higher salinity levels produced greater number of shoots. The seasonal variations in the number of main shoots might also due to the temperature prevailing during the growing season. The development of new branches might be associated with temperature as found by Ching (1996).

The point again is the interclonal genetic variability among jojoba progeny populations which was found as a direct result of the fact that pollination system in jojoba depends on the wind and the mechanism of sexual reproduction. These genetic differences are clearly noted in the plant structure and the number of side shoots (Ayerza, 1996). This condition, though beneficial for the species in natural forms, is a serious disadvantage for commercial purposes (Palzkill, 1987). Obtaining a clone like SF3 might be useful in the breeding programme since extensive branching is one of the important vegetative traits related to yield potential.

Table 2 : Number of main branches per plant of three jojoba progeny populations derived from the seed parental clones grown at Sadat Station (SF1, SF3) and South Tahrir (TF7).

a- The first season populations sown in October, 1997.

Clone / Clon	Plant age (months)								
	4	5	6	7	8	18	26	33	36
SF1	1.58	1.79	2.04	2.22a	2.30a	3.28	4.48	6.32b	7.14b
SF3	1.15	1.32	1.47	1.72b	1.90ab	4.11	5.84	10.06a	10.51a
TF7	1.11	1.34	1.34	1.59b	1.68b	3.53	5.38	6.39b	7.78b
$L.S.D_{0.05}$	N.S.	N.S.	N.S.	0.40	0.46	N.S.	N.S.	1.22	1.78

b-The second season populations sown in October,1998.

Clone	Plant age (months)								
	4	5	6	7	8	18	26	33	36
SF1	1.32	1.50	1.62	1.97	2.06	3.69b	5.34b	7.56b	9.70b
SF3	1.29	1.47	1.86	2.42	2.49	5.98a	8.47a	10.12a	12.81a
TF7	1.21	1.49	1.69	2.25	2.42	4.67b	6.54b	8.32b	9.66b
$L.S.D_{0.05}$	N.S.	N.S.	N.S.	N.S.	N.S.	1.13	1.83	1.52	2.32

c-the third season populations sown in October, 1999.

Clone	Plant age (months)								
	4	5	6	7	8	18	26	33	36
SF1	1.37	1.43	1.57	1.67	1.74	3.73	6.12	8.64b	10.30b
SF3	1.29	1.38	1.45	1.90	1.99	4.34	7.38	11.96a	14.38ab
TF7	1.26	1.28	1.30	1.56	1.67	4.21	5.85	8.44b	11.54b
$L.S.D_{0.05}$	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.49	3.11

- **Values followed by the same letters are not significantly different at 0.05 level of probability.**

3. Time of sex differentiation

Data revealed that flowering did not occur during the first year (Table 3). After 13 months, only 3.7% of the plants commenced flowering. Flowering increased gradually and slowly during the second year to be 25.32% when the plants are 24 months old. These results agreed completely with Khairi (1978), Campbell (1985), as well as the report of the National Research

Council (1985). On the other hand, the time of flowering varied widely among plants. This variability is mainly due to the genetic heterogeneity of jojoba as a seed-propagated shrub (Hawson, 1985).

It was also noticed that the number of male jojoba plants which commenced flowering was always greater than the number of females. The high percentage of males which commenced flowers compared to the low percentage of females may be due to the fact that male jojoba plants are more tolerant for high temperature than females as found by Cole (1979) and Yermanos (1980). The high temperature optimum for the production of flowering buds is 30/25°C (day / night) for females but is 33/28 to 36/31°C for males (Dunstone, 1982) which may be similar to the temperatures in the greenhouse under which the population of jojoba of the current study was grown.

Table 3 : Time of sex differentiation of a seed jojoba population expressed as a relationship between the number and percentage of flowering plants and plant age throughout two years after seed sowing.

Plant age (months)	Number and percentage of flowering plants*					
	Total		Male		Female	
	No.	%	No.	%	No.	%
12	Zero	00.00	Zero	00.00	Zero	00.00
13	98	03.70	94	03.55	4	00.15
14	255	09.62	222	08.38	33	01.24
15	262	09.89	229	08.64	33	01.24
16	264	09.96	229	08.64	35	01.32
17	285	10.75	243	09.17	42	01.58
18	298	11.25	246	09.28	52	01.96
24	671	25.32	523	19.74	148	05.58

*** Data were recorded for a population of 2650 jojoba plants planted by seeds on October 19th, 1998 and grown under greenhouse conditions.**

4. Habit of flowering

As described by Gentry (1958), Hogan (1979) ,the National Research Council (1985) and Ayanoglu (2000), it was found that the female or pistillate flowers of the studied shrubs of jojoba were solitary, small, pale green coloured having no petals, only five pale green sepals could be seen as well as three stigmas attached to the ovary. No multiple flowering system was observed in the studied females. In staminate plants, clusters of flowers were usually formed producing huge amounts of yellow pollen, they also produce no petals as the pistillate flowers.

On the other hand, the flowering habit of six selected jojoba clones was studied (Table 4). It was found that in male and female jojoba shrubs, axillary flowers usually develop at alternate nodes on newly matured growth. Flowers usually develop at every other node which was found to be the common habit of flowering of all the studied males; SM1, SM2 and SM3, and only one of the three studied females; SF4. Flowers develop at every node in two females; SF1 and SF3. All the studied clones tended to produce both the two types of flowering habit on the same shrub, but only one type was always clearly dominant (Table 4).

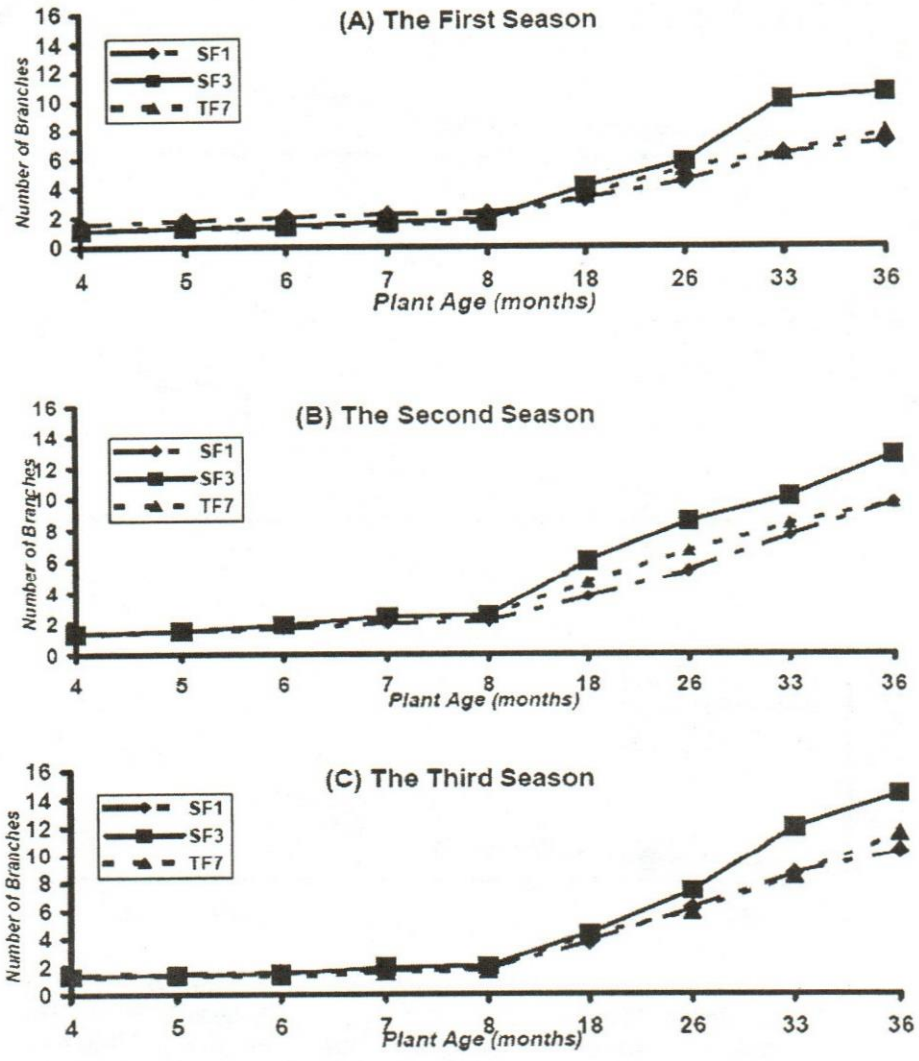

Fig. 3. Main branches growth curves of three jojoba progeny populations; SF1, SF3 and TF7. Graphs show the interclonal variability throughout three successive seasons: the first season (A) sown on October, 1997; the second season (B) sown on October, 1998; and the third season (C) sown on October, 1999.

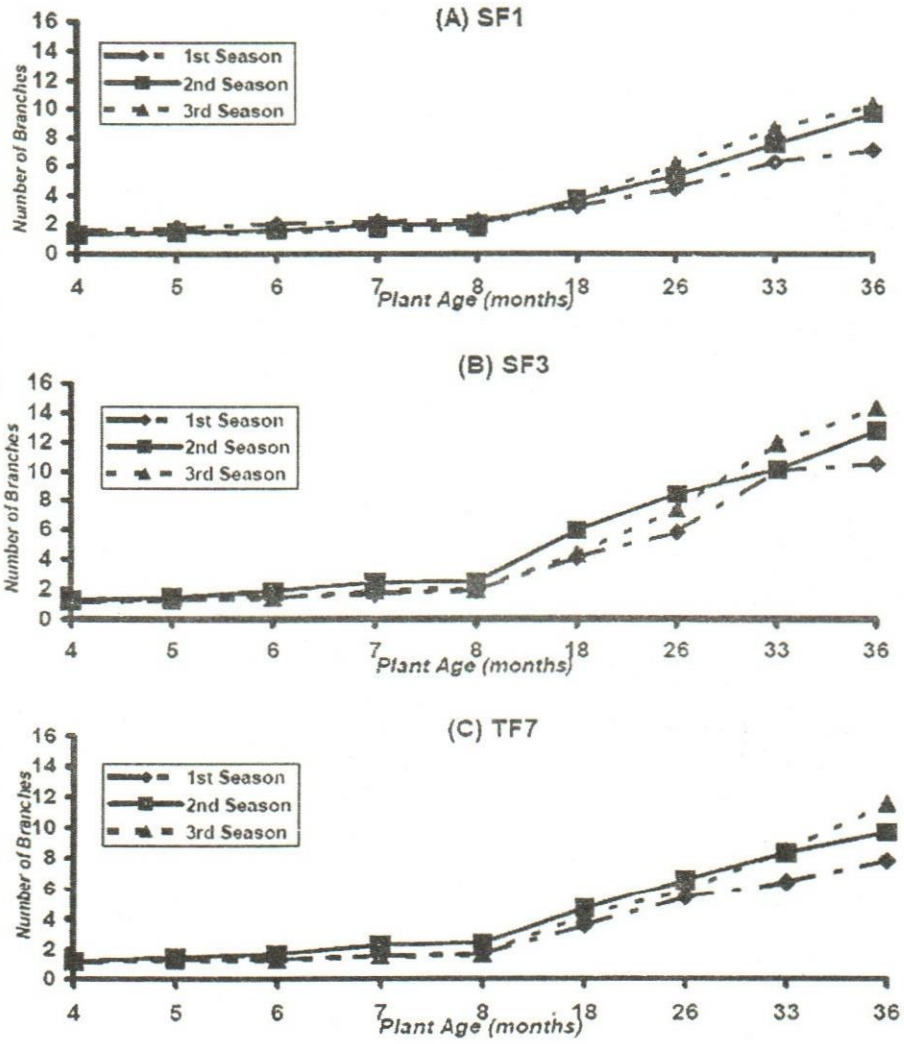

Fig. 4. Main branches growth curves of three jojoba progeny populations; SF1 (A), SF3 (B) and TF7 (C). Graphs show the interclonal variability throughout three successive seasons: the first season sown on October, 1997; the second season sown on October, 1998; and the third season sown on October,

hese results are in full agreement with the findings published by Gentry (1958), Yermanos (1974), Hogan *et al.*, (1980) as well as the National Research Council (1985). The habit of flowering appears to be primarily under genetic control which may be modified by environmental conditions (Gentry, 1958 and Yermanos, 1974) which may explain the tendency of shrubs to produce both the two types of flowering habit in different ratios

together on the same shrub. Relationships were also found between genetic background and flowering pattern in jojoba (Forti *et al.*, 1985).

Table 4: The flowering habit of six selected jojoba clones (three males and three females).

Selected clones	Percentage of branches * flowering at	
	Every node	Every other node
SM1	14%	86%
SM2	08%	92%
SM3	03%	97%
SF1	84%	16%
SF3	88%	12%
SF4	04%	96%

* Data were recorded for 200 branches taken at random for each selected shrub during the flowering season of April / May, 2000.

5. Fruiting pattern and yield

The common fruiting pattern in the studied jojoba females was that of a single fruit. No double or triple fruit clusters (as reviewed by Yermanos, 1974) were observed. The numbers and percentages of fruits with one-, two- and three- seeds are shown in Table 5. It was found that the percentage of fruits with single, double and triple seeds varied from 90.37 to 96.00% , 3.94 to 9.12% and 0.00 to 0.51% ; with an overall average of 93.92 ±3.65 , 6.52 ±3.30 and 0.18 ±0.03% respectively. The range and averages found in the current study were similar or in the same range obtained by Ramonet-Razcon (1988) and Estilai and Hashemi (1993).

Table 5: Mean percentages of one- , two- , and three-seeded fruits of three selected jojoba clones taken throughout 2000, 2001 and 2002.

Selected clones	Year	Total no. of fruits/shrub	% of fruits with		
			One seed	Two seeds	Three seeds
SF1	2000	631	91.92	07.92	00.16
	2001	592	90.37	09.12	00.51
	2002	307	94.46	05.21	00.33
	Mean SF1	510.00	92.25	7.42	0.33
SF2	2000	122	92.62	07.38	00.00
	2001	206	93.20	06.80	00.00
	2002	552	91.30	08.33	00.37
	Mean SF2	293.33	92.37	7.50	0.12
SF3	2000	3673	94.36	05.53	00.11
	2001	1767	95.42	04.47	00.11
	2002	4595	96.00	03.94	00.06
	Mean SF3	3345	95.26	4.65	0.09
mean			93.29±3.65	06.52±3.30	00.18±00.03

It was found that the majority of capsules usually produce one seed per capsule. Few plants were found with two- and rarely with three-seeded

capsules which is in complete agreement with Hogan (1979), the National Research Council (1985), Ramonet-Razcon (1988) and Estilai and Hashemi (1993).

Clear differences were found between clones. As an average for the three years, the clone SF3 proved to give the highest yield of fruits (3345) compared to either SF1 (510) or SF2 (293.33 fruits/shrub). The variability between clones as well as within each shrub throughout the three years (2000-2002) might be attributed to the great genetic variability among shrubs as a result of the obligatory cross pollination system which ensures a multiple recombination of the gene pool in the population as mentioned by Ramonet-Razcon (1988) who also found that the occurrence of single, double and triple seeded capsules, was influenced by the female plant irrespective of the male plants.

Regarding yield, three selected female jojoba clones were individually harvested throughout three consecutive years; 2000, 2001, and 2002 (Table 6). The number of seeds harvested for each shrub, the corresponding weight of seeds / shrub as well as seed size expressed as the weight of 1000 seeds were carefully recorded for the individual selected jojoba clones.

Table 6: Total yield/shrub and the weight of 1000 seeds of three selected jojoba clones in the seasons 2000, 2001 and 2002.

Selected clone	Year	Yield		Weight of 1000 seeds
		No of seeds/plant	g./plant	
SF1	2000	0683	0550	948.28
	2001	0652	0480	897.20
	2002	0325	0270	931.03
	Mean SF1	553.33	433.33	925.50
SF2	2000	0131	0090	796.46
	2001	0220	0130	677.08
	2002	0595	0315	625.00
	Mean SF2	315.33	178.33	699.51
SF3	2000	3884	2265	653.49
	2001	1798	1300	771.06
	2002	4665	2910	659.71
	Mean SF3	3449.00	2158.33	694.75

It was found that the yield of the selected clones (expressed either as the number of seeds/shrub or their corresponding weight in grams) varied greatly between clones as well as between years. Clone SF3 attained the same attitude of the number of fruits and produced the highest yield in the three years of study, with an average of 2258.33 grams compared to SF1 (433.33 g.) and SF2 (178.33 g.). The seasonal performance of clones differed greatly as well. SF1 yielded more in the year 2000 (550 g.), while SF2 and SF3 produced much higher yield of seeds in the year 2002 (315 and 2910 g. respectively). Relationship between genetic background of individual shrubs and yield is then considered strong (Forti *et al.*, 1985). The seasonal variations in yield (the year-to-year variability), however, were mainly due to the environmental conditions surrounding the shrubs during flowering and

seed setting. Yermanos (1982) also concluded that the variation in yield from one year to the next did not represent a biennial bearing pattern, but was an interaction between genotype and environmental factors such as temperature.

The seed size (expressed as the weight of 1000 seeds) showed also clear noticeable differences between shrubs, but the seasonal differences looked very limited (Table 6). The mean weight of 1000 seeds calculated for the clone SF1 was much higher (925.50 g./1000 seeds) which means that the clone SF1 had the biggest seed size. Seed size of SF2 and SF3 were similar to each other and much smaller (699.51 and 694.75 g/1000 seeds for SF2 and SF3 respectively). The range of seed size in the current study is in full agreement with the ranges mentioned by Hogan *et al.,* (1980),Thompson (1990), Ayanoglu (2000) and Chikara *et al.,* (2001). The size of seeds seemed to be genetically controlled as many other quantitative characters in jojoba (Forti *et al.,* 1985 and Purcell and Purcell, 1988). The variability between plants, with respect to the seed size, is also attributed to the genetic variability among shrubs. Since the seasonal variations were too limited, then the role of environment is also limited in controlling this trait (Gentry, 1958 and Thompson, 1990). Selection for big seed size, as the progeny of SF2 and SF3, would be, then, of great advantage in the breeding programmes since selection for larger seed size would be also a selection for higher oil content according to seed unit (Gentry, 1958).

REFERENCES

Aragao, G.M. and J. de Oliveira (1985). Jojoba in Brazil. Proceedings of the Sixth International Conference on Jojoba and its Uses, Beer – Sheva, Israel : 59-70.

Ayanoglu, F. (2000). Jojoba [*Simmondsia chinensis* (Link) Schneider] and its cultivation in Turkey. I. Morphology, production and cultivation of jojoba. Anadolu 10 (1) : 18-30.

Ayerza, R. (1996). Evaluation of eight jojoba clones for rooting capacity, plant volume, seed yield and wax quality and quantity. Proceedings of the Ninth International Conference on Jojoba and its Uses, Catamarca, Argentina : 1-3.

Bailey, L.H. (1961).The standard cyclopedia of horticulture. Vol. 3, P-Z. Nineteenth printing. The Macmillan Company.

Benzioni, A. and A. Nerd (1985). Effect of irrigation and fertilization on vegetative growth and yield of jojoba in relation to water status of the plants. Proceedings of the Sixth International Conference on Jojoba and its Uses, Beer-Sheva, Israel : 201-212.

Benzioni, A.; M. Ventura and Y. de Malach (1996). Long-term effect of irrigation with saline water on the development and productivity of jojoba clones. Journal of Horticultural Science 71 (6): 835-846.

Botti, C.; E. Doussoulin; X. Lopez; P. Cruz and L. Canves (1996). Selection and evaluation of clonal jojoba germplasm: I. Young plants. Proceedings of the Ninth International Conference on Jojoba and its Uses, Catamarca, Argentina : 65-70.

Campbell, A.M. (1985). Management methods for increasing yield potential of direct seeded jojoba plantations. Proceedings of the Sixth International Conference on Jojoba and its Uses, Beer – Sheva, Israel : 111-117.

Chikara, J.; A.R. Prakash and J.B. Pandya (2001). Dwarf mutant in jojoba (Simmondsia chinensis). Indian J. Genet., 61 (1) : 84-85.

Ching, A. (1996). Photosynthetic response of jojoba to low temperature. Proceedings of the Ninth International Conference on Jojoba and its Uses, Catamarca, Argentina : 37-39.

Cole, S.L. (1979). Aberrant sex ratios in jojoba associated with environmental factors. Desert Plants 1(11): 8-11.

Dunstone, R.L. (1982). Jojoba flower buds : Effects of preconditioning temperature. Aust. J. Agric. Res. 33 : 649-656.

Estilai, A. and A. Hashemi (1993). A four-carpeled fruit mutant in jojoba. HortiScience, 28 (7) : 739-739.

Forti, M.; A. Nerd and A. Benzioni (1985). Effect of genetic background on flowering pattern, growth and yield of jojoba. Proceedings of the Sixth International Conference on Jojoba and its Uses, Beer-Sheva, Israel 293-298.

Gentry, H.C. (1958). The natural history of jojoba (*Simmondsia chinensis*) and its cultural aspects. Economic Botany 12 (3) : 261-295.

Hawson, M.G. (1985). Jojoba in western Australia. Proceedings of the Sixth International Conference on Jojoba and its Uses, Beer – Sheva, Israel: 51-58.

Hogan, L.M. (1979). Jojoba. A new crop for arid regions. In Ritchi, G.A. (ed). New Agricultural Crops. Pp. 177-205. Westview Press, Inc. U.S.A.

Hogan, L.M.; C.W. Lee; D.A. Palzkill and W.R. Feldman (1980). Jojoba : A new horticultural crop for arid regions. HortScience, 15(2) : 114-115.

Khairi, M.M.A., (1978). Intiation and present status of jojoba development in the Sudan. Proceedings of the Third International Conference on Jojoba, Riverside, California : 137-140.

National Research Council (1985). Jojoba : New crop for arid lands, new material for industry. National Academy Press, Washington, D.C. pp. 17-20.

Nelson, J.M. (1996). Long-term effects of managing irrigation to reduce frost damage in jojoba. Proceedings of the Ninth International Conference on Jojoba and its Uses, Catamarca, Argentina : 44-46.

Nelson, J.M. and J.E. Watson (2001). Nitrogen fertilization effects on jojoba seed production. Industrial Crops and Products, 13 (2): 145-154.

Palzkill, D.A. (1987). Review of some naturally occurring variability in jojoba and its uses in cultivar development. Proceeding Reunion Internacional de jojoba. Asuncion, Paraguay (ALAJO) 6: 1-8.

Purcell, H.C. and H.C. Purcell II (1988). Jojoba crop improvement through genetics. Proceedings of The Seventh International Conference on Jojoba and Its Uses. Phoenix, Arizona 1: 69-85.

Ramonet-Razcon, R. (1988). Selection criteria and evaluation procedures for jojoba plant improvement. Proceedings of The Seventh International Conference on Jojoba and Its Uses. Phoenix, Arizona 1: 60-68.

Thompson, A.E. (1990). Arid-land industrial crops. J.Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR. 232-241.

Yermanos, D.M. (1974). Agronomic survey of jojoba in California. Economic Botany 28 : 160-174.

Yermanos, D.M. (1980). Self –pollinating jojoba. Proceedings of the Fourth International Conference on Jojoba, (Consejo Nacional de Ciencia y Technologia, Mexico) : 345-346.

Yermanos, D.M. (1982). Review of seven years of performance data on jojoba under cultivation. In Proceedings of the Fourth International Conference on jojoba. pp. 22-26. (International Council on Jojoba : Hermosillo, Mexico).

دراسات على نبات الجوجوبا:
٢ – دراسات على بعض الصفات الخضرية والزهرية

محمد جمال التركي[١] وعبد الفتاح حامد شاهين[٢] وعلا عبد العزيز الشناوي[١] وإيمان محمدين الفاضلي[١]

١ – قسم الزهور ونباتات الزينة – كلية الزراعة – جامعة الأسكندرية.

٢ – قسم الفاكهة – كلية الزراعة – جامعة الأسكندرية.

تم إجراء هذه التجارب خلال الفترة من ١٩٩٧ إلى ٢٠٠٢ بمحطات بحوث مركز تنمية الصحراء التابع للجامعة الأمريكية بالقاهرة.

أعطى النسل الناتج من السلالة SF1 أعلى قيم لارتفاع النبات عند بلوغها ٣٦ شهر وأعقبه السلالة SF3 ثم TF7. وقد اتضح أن الفروق بين السلالات الثلاثة المدروسة تبدو كصفة وراثية. وعلى كل حال فقد وجد أن الظروف البيئية قد يكون لها تأثيرا بسيطا على ارتفاع النباتات، وكنتيجة لذلك فإن نسل السلالة SF1 يعتبر على درجة عالية من الثبات ضد الاختلافات الموسمية في حين أن السلالتين SF3 و TF7 قد تأثرت بدرجة ما بالاختلافات الموسمية. وكان عدد الفروع الرئيسية لكل نبات في النسل الناتج من السلالة SF3 أعلى ما يمكن عند بلوغ النباتات ٣٦ شهرا. وبدا واضحا ثبات صفة التفريع الغزير لتلك السلالة مقارنة بكلا من السلالتين الأخريين (SF1 و TF7) عبر ثلاث سنوات متتالية (موسم ١٩٩٧ ، ١٩٩٨ و١٩٩٩) بغض النظر عن التأثيرات الموسمية.

بالنسبة لميعاد تمييز الجنس ،فإن بيانات هذه الدراسة على ٢٦٥٠ شتلة هوهوبا منزرعة بالصوب (عمرها ١٣ شهرا) توضح أن ٣,٧٪ فقط من العشيرة هي التي أزهرت، وقد ازداد التزهير بالتدريج وببطء خلال العام الثاني ليصل إلى ٢٥,٣٢٪ من حجم العشيرة (عند بلوغ النباتات ٢٤ شهرا). كما وجد أن زمن التزهير اختلف بشدة بين النباتات وهذه الإختلافات ترجع أساسا إلى الخلط الوراثي للهوهوبا. ولقد لوحظ أن عدد ذكور الهوهوبا التي بدأت التزهير دائما ما يكون أكبر من عدد الإناث.

كما أظهرت الدراسة أن البراعم الزهرية لأشجار الهوهوبا سواء المذكرة أو المؤنثة تحمل إبطيا على العقد بالتبادل على الفروع حديثة النضج. عادة ما تتكون الأزهار بالتبادل على العقد و هو الوضع السائد لعادة التزهير في كل الذكور التي تمت دراستها وهي SM3 ، SM2 و SM1 وفي سلالة مؤنثة واحدة وهي SF4. وقد تتكون الأزهار على جميع العقد كما في السلالتين المؤنثتين SF3 و SF1. اتجهت كل الشجيرات المدروسة عموما إلى إنتاج الأزهار بكلتا الطريقتين على نفس الشجيرة، ولكن عادة ما يسود أحد الطرز فقط. ويتضح من الدراسة أن عادة حمل الأزهار تبدو بصفة مبدئية تحت التحكم الوراثي المعرض للتحوير بواسطة بعض الظروف البيئية.

تحمل الثمار في شجيرات الهوهوبا محل الدراسة فرديا حيث لم يتم الحصول على ثمار ثنائية أو متعددة على نفس العقدة، كما اختلفت نسبة الثمار ذات البذرة الواحدة أو البذرتين أو الثلاثة بذور في الشجيرات المدروسة من ٩٠,٣٧ – ٩٦,٠٠٪ ، ٣,٩٤ – ٩,١٢٪ ، صفر – ٠,٥١٪ على التوالي. هذا وقد ثبت وجود اختلافات واضحة بين السلالات في هذا المجال. أما المتوسط العام لمحصول الثلاثة سنوات (٢٠٠٠ ،٢٠٠١ و٢٠٠٢) فكان أعلى ما يمكن في السلالة SF3 (حيث أعطت الشجيرة ٢١٥٨,٣٣٥ جم) هذا وقد اختلف أيضا تأثر السلالات بالتغييرات الموسمية لتلك الصفة بدرجة كبيرة.