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Studies on the Ability of Some Jojoba Clones to Propagate by Stem Cuttings and the Appropriate Plant Growth Regulators under the Plastic Tunnels

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Abstract: The present study was carried out during two successive seasons (2017 & 2018) on the sub-terminal cuttings of six jojoba clones (*Simmondsia chinensis* Link Schneider) that previously evaluated in terms of vegetative, productivity, fruit characteristics, oil quality and compare agronomical and chemical characteristics. The clones under this study were 61, 62, 63, 10, 16 and 18. The aim of this study was to find out the appropriate plant growth regulators for the cuttings of the six selected clones by determining the rooting ability of cutting, rooting characteristics and vegetative growth measurements of rooted cuttings, endogenous chemical content that leading to formation of roots as well as histological study. The cutting were treated with Indole-3butric acid (IBA) at 2000 ppm or 4000 ppm and Naphthalene acetic acid (NAA) at 1000 ppm either single or in a combination and planted under plastic tunnel at the first of May in both seasons. Results showed that dipping in IBA 2000 gave significantly superior higher rooting percentage 51.3 & 49.3 for cuttings compared with the control. A wide variation in rooting ability among the evaluated jojoba clones cuttings was detected. The highest values were obtained from clone (10) which treated with NAA 1000 + IBA 2000 or IBA 4000 ppm alone or NAA 1000 ppm which all gave 96% rooting percentage. Anatomical structure of the sub terminal cuttings showed that clone 18 recorded higher percentage of rooting when treated with NAA 1000 ppm. While, clone (10) showed high percentage for forming of roots with NAA 1000 ppm + IBA 2000 ppm, IBA 4000 ppm and NAA 1000 ppm.. Clone (61) recorded 96 % rooting when treated with IBA 2000 ppm while when treated with NAA 100 ppm recorded 8% because of fibers that considered mainly responsible for inhibit and difficult forming of roots. Untreated clones also showed inhibition in forming roots related to increase fiber and oil glands. The formed and initial of root depends on cambium tissue which gave rise to different layers of tissue and formed root initials and primordial of jojoba, also the development of adventitious root primordial took place through the cortex and periderm followed by development of vascular system of those root which become in contact with main vessel of this system.

Key words: Jojoba clones · Cutting · IBA · NAA · Anatomical

INTRODUCTION

Jojoba plant (*Simmondsia chinensis* Link Schneider) which is pronounced as hohoba belongs to family Simmondsiaceae. It is a semi-arid shrub native to Arizona, California and northern Mexico. Jojoba plant has currently received a special attention. Since, their seeds contain a valuable liquid wax called Jojoba oil which is very similar to that obtained from whale sperm. The liquid wax of Jojoba is used as a nature base for a wide range of cosmetics component, i.e., hair oil, shampoo, soap, face creams, sunscreen compounds and many medical products, i.e., dermatitis in children, "Sorana for anus anti-inflammatory for anus, medicament for pneumonic lung and promote healing of wounds. Also, it has a heat resistant lubricating properties and useful material in chemical industry [1-4]. Moreover, Jojoba oil which is waxy in nature may also have a promise in the treatment of industrial waste water for elimination of toxic heavy metals. In addition, the final repressed Jojoba meal usually

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contains about 30 % protein and more than 42 % carbohydrate; it is suitable as food for animals after eliminating the toxicity simmondesin. Jojoba is a difficult species to domesticate because it is highly heterogeneous as a result of being dioecious and cross pollinated and due to its long lifecycle, developmental of true breeding, seed-propagated, cultivars is unlikely in the foreseeable future [5]. In commercial plantations raised from seeds collected from native plants, over 50 % of the population are non- producing males and only a small proportion (less than 1 %) has the potential of yielding economically acceptable yields [6- 8]. Vegetative propagation shortens juvenile stage and enables the establishment of plantations with the desired proportion of male or female plants from pre-selected superior clones [9]. Jojoba is a difficult – root plant and several rooting hormones have been tried with varying success [10]. Rooting hormones or plant growth regulators cause a greater percentage of cuttings to root, speed up the formation of roots, induce more roots of cuttings and increase root uniformity [11, 12]. Two synthetic auxins namely Indole butyric acid (IBA) and a-naphthalene acetic acid (NAA) are mostly used either singly or in a combination [13]. The most naturally occurring auxin in plants is indole acetic acid (IAA), but breaks down easily, hence less effective [14].

The clones under this study have been previously evaluated in terms of vegetative, productivity, fruit characteristics, oil quality and compare agronomical and chemical characteristic, clones appeared the best productivity of seeds weight (1190.5, 797.7, 837.6, 735, 2115, 1500 kg/ feddan) and oil (wax) (58.6, 56.9, 54, 52.6, 47.0, 51.5 %) [15, 16].

The main objective of the present trial was to study the ability of six previously evaluated jojoba clones and proved to have the best agronomical characteristics productivity and oil, to vegetative propagation by stem cutting solutions to get adequate number of new transplants needed for horizontal extension of planting in newly reclaimed soil, also study the difference between the six clones in the ability to rooting and to know the appropriate rooting hormone (IBA and NAA) on rooting and vegetative growth measurements of rooted cuttings, endogenous chemical content as well as histological characteristics that effect on the ability to root were also examined.

MATERIALS AND METHODS

This study was carried out in the nursery of a private orchard located at Cairo-Alexandria desert road, 64 km from Cairo during two successive seasons of 2017 and 2018.

These clones were previously evaluated and proved on the cuttings of six evaluated Jojoba clones and proved to have the best agronomical characteristics (productivity and oils). Clones about four years old in a good physiological condition and received normal agriculture produces.

Leafy sub-terminal cutting were collected from tested clones at the first of May during both seasons to study the difference between the six clones in the ability to rooting and to know the effect of dipping in IBA, NAA solutions beside tap water as control on rooting and vegetative growth measurements of cuttings and rooted cutting, respectively. The cuttings were at 15-20 cm long on year shoots/season. Two pairs of terminal leaves on each cutting were retained and the basal cut was made just below the node. Cuttings of six clones were planting at the first of May during each season.

The cuttings were performed by dipping about (2-3) cm basal part of cuttings after scratching their surface layer and then dipped for all studied treatments for 1 minute, the variable pre planting treatments were as follow.

- Dipping in water (control).
- Dipping in NAA 1000 ppm.
- Dipping in IBA 2000 ppm.
- Dipping in IBA 4000 ppm.
- Dipping in NAA 1000 ppm + IBA 2000 ppm.
- Dipping in NAA 1000 ppm + IBA 4000 ppm.

For each of the above mentioned 6 treatments each treatment was replicated three times and every replicate was represented by 25 cutting (75 cuttings per treatment). As soon dipping had been done, cuttings treated within benlate solution as fungicide, then planted to a depth of 5 cm in a plastic box filled with a mixture of beat and sand (1:2). The planted cuttings were put in a rooting bench and covered with plastic tied on a wire in the form of a tunnel then get wet the cuttings avoiding their dehydration in seran shaded house. The cuttings were taken 70 days after the rooting treatments to evaluate the following:

Rooting Parameters

Rooting Percentage: The percentage of rooting was calculated as the number of rooted cuttings with respect to the total number of cuttings.

Number of Roots per Rooted Cutting: The average number of roots/rooted cutting, were counted.

Average Root Length: The average root length/rooted cutting was measured for each clone.

Vegetative Growth Parameters: Number of new shoots/ cutting; length of new shoots/cutting and Number of leaves on the new shoots as compared to the control were recorded

Survival Percentage: It was estimated on the number of rooted cuttings that remained a live year latter from recording the rooting measurements and growing in the green house.

Chemical Analysis: Total phenols and indoles: three samples for each treatment (each of 10 g fresh weight) were excised from the basal portion of the prepared cuttings and placed in 80 % ethanol at °C for 72 hours as described by Daniel and George [17] was concentrated ethanol at 30±°C under vacuum, hence it was diluted to known volume for determination of the total indoles and phenols. Total phenols was determined by using the folin denis colorimetric according to A.O.O.C. [18] method at 730°C wave length the concentration was calculated from a standard curve of pyrogallol as mg/100 gm weight p-dimethyl amino benzaldehyde test (Ethrich regent) as described by Larson *et al*. [19] and modified by Selim *et al*. [20] was used to determine the total indoles and estimated calorimetrically at 530.

Anatomical Studies: Samples of two cuttings per each treatment were taken from the six clones which achieved the lowest and highest rooting percentage to study the formation of adventurous root. The basal portion (5 cm) of Jojoba cuttings was mainly used for anatomical studies. Samples were immediately killed and fixed in FAA solution for softening samples were soaked in tap water for two days before preparation of sections. Sections of about 18-20 microns in thickness were prepared by using a sledge microtome. The sections were stained by the safranine. Pecro-amily-blue method [21]. Sections were dehydrated, cleared in xylol and mounted in canda balsam. Then sections were microscopy examined and photographed.

Statistical Analysis: All data obtained during two experimental seasons for both factorial experiments included in this work were subjected to analysis of variance according to the method described by Snedecor and Cochran [22]. Meanwhile, the significant differences among means were calculated by Duncan's multiple range test Duncan [23].

RESULTS AND DISCUSSIONS

Rooting Parameters

Rooting Percentage: According to Table (1), rooting percentage was variable, whereas it was significantly affected by the clones and the different treatments. It was cleared that rooting % ranged from 12.00 % and 13.33% in clone (63) to reach 72.00% and 71.31% in clone (10), in both seasons, respectively. As for the effect of different growth regulators solutions, it obviously found that, rooting percentage was significantly increased by using of the studied solutions as compared to control, however the most effective treatments was the dipping in IBA at 2000 ppm in both seasons followed by IBA at 4000 ppm in the first season and NAA at1000 ppm in the second season. Additionally, rooting percentage responded significantly to the interaction between the clone and the various growth treatments, the highest values were obtained from clone (10) which treated with NAA 1000 ppm + IBA at 2000 ppm, IBA at 4000 ppm and NAA at 1000 ppm as the same response of rooting percentage.

Number of Roots per Rooted Cutting: Data in Table (2) showed that there were differences between the six Jojoba clones on number of roots per rooted cuttings. The greatest number of roots was found in clone (18) in both seasons. On the contrary, clone (63) & (16) were the least values in both seasons. The effect of dipping cuttings in different growth regulators solutions revealed that number of roots of jojoba cuttings was significantly increased by using growth regulators as compared to control, however, the NAA at 1000 ppm plus IBA at 2000 ppm was significantly the superior in both seasons. Moreover, in the first season, NAA at 1000 ppm + IBA at 4000 ppm or NAA at 1000 ppm + IBA at 2000 ppm as the same result to IBA at 4000 ppm. Concerns the interaction in both seasons when cutting of clone 18 were dipped in NAA at 1000 ppm plus IBA at 4000 ppm produced the maximum number of roots/rooted cutting.

Average Root Length: Data in Table (3) represent root length (cm) per rooted cutting of tested jojoba clones showed variability in the length of root with the different

Table 1: Effect of some growth regulators on rooting percentage of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	Rooting percentage						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00p	0.00p	0.00p	0.00p	0.00p	0.00p	0.00E
Dipping in NAA 1000 ppm.	8.00o	28.00j	12.00n	96.00a	32.00i	92.00b	44.66C
Dipping in IBA 2000 ppm.	96.00a	20.00l	20.00l	64.00f	24.00k	84.00c	51.33A
Dipping in IBA 4000 ppm.	28.00j	28.00j	16.00m	96.00a	24.00k	80.00d	45.33B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	32.00i	72.00e	12.00n	96.00a	16.00m	44.00h	45.33B
Dipping in NAA 1000 ppm + IBA 4000 ppm.	28.00j	60.00g	12.00n	80.00d	12.00n	44.00h	39.33D
Mean	31.67D	34.67C	12.00F	72.00A	18.00E	57.33B	
	Second season; 2018						
Dipping in water (control).	0.00o	0.00o	0.00o	0.00o	0.00o	0.00o	0.00F
Dipping in NAA 1000 ppm.	8.00n	32.00j	24.00k	96.00a	40.0i	92.00b	48.67B
Dipping in IBA 2000 ppm.	88.00c	16.00m	24.00k	60.00f	20.00l	88.00c	49.33A
Dipping in IBA 4000 ppm.	24.00k	32.00j	16.00m	96.00a	20.00l	88.00c	46.00C
Dipping in NAA 1000 ppm + IBA 2000 ppm.	24.00k	64.00e	8.00n	96.00a	20.00l	48.00h	43.33D
Dipping in NAA 1000 ppm + IBA 4000 ppm.	24.00k	56.00g	8.00n	80.00d	16.00m	40.00i	37.33E
Mean	28.00D	33.33C	13.33F	71.33A	19.33E	59.33B	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05.

Table 2: Effect of some growth regulators on number of roots/rooted cutting of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	Number of roots/ rooted cutting						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00r	0.00r	0.00r	0.00r	0.00r	0.00r	0.00D
Dipping in NAA 1000 ppm.	9.33e	8.33f	4.00mn	10.00d	1.00q	8.00f	6.78B
Dipping in IBA 2000 ppm.	6.67gh	4.67kl	5.00jk	5.33j	2.00op	6.00i	4.94C
Dipping in IBA 4000 ppm.	12.67c	5.00jk	3.67n	7.00g	8.33f	7.00g	7.28A
Dipping in NAA 1000 ppm + IBA 2000 ppm.	4.33lm	13.67ab	1.67p	6.67gh	4.33lm	13.33b	7.33A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	8.00f	6.33hi	6.00i	4.67kl	5.00jk	14.00a	7.33A
Mean	6.83B	6.33B	3.39D	5.61C	3.44D	8.06A	
	Second season; 2018						
Dipping in water (control).	0.00r	0.00r	0.00r	0.00r	0.00r	0.00r	0.00E
Dipping in NAA 1000 ppm.	10.33c	6.33j	4.00n	11.00b	1.33q	8.67e	6.94C
Dipping in IBA 2000 ppm.	7.67fg	8.00f	5.00kl	8.00f	1.33q	6.33j	6.06D
Dipping in IBA 4000 ppm.	14.00a	5.33k	3.00o	6.33j	9.33d	6.67ij	7.44B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	4.67lm	14.33a	2.00p	9.00de	5.00kl	14.33a	8.22A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	7.00hi	7.33gh	5.00kl	4.67lm	4.33mn	14.33a	7.11C
Mean	7.28B	6.89C	3.17E	6.50C	3.56D	8.39A	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

Table 3: Effect of some growth regulators on root length (cm) of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	Root length (cm)						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00m	0.00m	0.00m	0.00m	0.00m	0.00m	0.00F
Dipping in NAA 1000 ppm.	5.00i	10.33c	8.00f	6.00h	7.00g	4.00j	6.72B
Dipping in IBA 2000 ppm.	5.83h	6.00h	7.33g	4.67i	2.00l	3.00k	4.81E
Dipping in IBA 4000 ppm.	7.00g	6.00h	4.00j	6.00h	5.00i	3.33k	5.22D
Dipping in NAA 1000 ppm + IBA 2000 ppm.	8.57e	12.67a	6.00h	6.00h	7.00g	4.00j	7.37A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	8.33ef	11.83b	5.00i	4.67i	6.00h	1.67l	6.25C
Mean	5.79B	7.81A	5.06C	4.56D	4.50D	2.67E	
	Second season; 2018						
Dipping in water (control).	0.00o	0.00o	0.00o	0.00o	0.00o	0.00o	0.00E
Dipping in NAA 1000 ppm.	5.00j	11.87c	8.33e	7.17f	7.00f	3.87k	7.21B
Dipping in IBA 2000 ppm.	6.17hi	6.00hi	5.00j	6.00hi	1.90n	2.70m	4.63D
Dipping in IBA 4000 ppm.	6.00hi	5.00j	3.00lm	5.00j	6.43gh	3.27l	4.78D
Dipping in NAA 1000 ppm + IBA 2000 ppm.	9.00d	14.00a	7.00f	5.73i	6.83fg	4.00k	7.76A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	8.00e	12.87b	5.00j	4.87j	6.33gh	1.90n	6.49C
Mean	5.69B	8.29A	4.72C	4.79C	4.75C	2.62D	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

treatments of growth regulators. The highest increase was produced from cutting treated with NAA at 1000 ppm plus IBA at 2000 ppm in both seasons, while control (treated with water) was the lowest. On the other hand, clone (62) produced the tallest roots in both seasons.

It was clearly that the specific effect of both investigated factors (clones and dipping in various growth regulators solutions) were appeared the difference between the results, thus the highest values were obtained by clone (62) which treated with NAA 1000 plus IBA at 2000 ppm in both seasons. The ability of sub terminal jojoba cuttings for rooting formation was significantly different for the studied clones of jojoba under different concentration of growth regulators [24-26]. Also, it was the same trend with the studied obtained by Bing and Dong [27] who found that the rooting ratio of semi-arid wood cuttings was increased by plant hormone treatment, especially treated by IBA at 1000 ppm for "*Simmondsia chinensis*". On the other hand, Ttirkoglu and Durmus [28] found that IBA hormone usage on olive varieties increased the rooting and the best performance according to root number, root length, leaf number and shoot length, as hormone intake increased. The increase was especially significant in higher concentrations (5000 ppm). It is evident from the data that differences among clones in rooting ability were mostly attributed to genotype, this is consistent with Low and Hackett [29]; Prat *et al*. [30], Yigzaw and Reddy [31] and Bashir *et al*. [32] who reported large clone differences in the rooting efficiency of the jojoba clones they studied.

Effect of Some Growth Regulators and Different Jojoba Clones on Vegetative Growth Parameters.

Number of New Shoots/ Cutting: It was obviously in Table (4) that the maximum number of new shoots was obtained by application of NAA at 1000 ppm + IBA at 2000 ppm or IBA at 2000 ppm followed by IBA at 4000 ppm treatment in the first season while NAA at 1000 ppm + IBA at 2000 ppm was the superior in both seasons. Moreover, the data showed marked differences between the six clones in number of new shoots. The greatest number of new shoots was found in clone (61) in both seasons followed by clone (62) while clone (63) was the lowest clone in both seasons.

Regards the specific effect of both investigated factors (clones and various growth regulators solutions), the most greatest number of shoots was shown in clone (61) when the cutting was treated with NAA 1000 ppm in both seasons.

Length of New Shoots/Cutting: Data in Table (5) showed that the length of new shoots was significantly increased by using of growth regulators solutions as compared to control especially IBA 2000 ppm followed by NAA at 1000 ppm + IBA at 2000 ppm. Furthermore, clone (10) contained the highest significantly length of new shoots in both seasons. While clones (63) and (16) produced the least length of new shoots in both seasons. The interaction appearance in cuttings of clone (18), (61) and (10) when treated with IBA at 2000 ppm, IBA at 4000 ppm and NAA at 1000 ppm + IBA at 4000 ppm, respectively in the first

Table 4: Effect of some growth regulators on number of new shoots of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	No. of new shoots						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00k	0	0.00k	0.00k	0.00k	0.00k	0.00E
Dipping in NAA 1000 ppm.	3.50a	2.23d	0.00k	1.20ij	1.00j	1.00j	1.49C
Dipping in IBA 2000 ppm.	3.00b	1.00j	1.67fg	1.33hi	3.00b	2.00e	2.00A
Dipping in IBA 4000 ppm.	2.00e	3.00b	0.00k	1.80ef	1.27hi	1.63fg	1.62B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	3.00b	2.67c	1.00j	2.00e	0.00e	1.00j	1.94A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	1.67fg	2.00e	1.00j	1.83ef	1.50gh	0.00k	1.33D
Mean	2.19A	1.82B	0.61F	1.36D	1.46C	0.94E	
	Second season; 2018						
Dipping in water (control).	0.00m	0.00m	0.00m	0.00m	0.00m	0.00m	0000E
Dipping in NAA 1000 ppm.	5.00a	2.83cd	0.00m	1.27j-l	1.00l	1.23kl	1.89B
Dipping in IBA 2000 ppm.	3.33b	1.33i-k	1.33i-k	1.73f-h	2.33e	1.87fg	1.99AB
Dipping in IBA 4000 ppm.	2.00f	3.00c	0.00m	1.53h-k	1.57h-k	1.60g-i	1.62C
Dipping in NAA 1000 ppm + IBA 2000 ppm.	3.00c	3.00c	1.00l	2.33e	2.00f	1.00l	2.06A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	2.00f	2.67d	0.00m	1.60g-i	1.00l	0.00m	1.21D
Mean	2.56A	2.14B	0.39E	1.41C	1.32C	0.95D	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

Table 5: Effect of some growth regulators on number of new shoots of sub terminal jojoba clones cuttings during 2017 and 2018 seasons.

	Length of new shoots/cutting						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00m	0.00m	0.00m	0.00m	0.00m	0.00m	0.00E
Dipping in NAA 1000 ppm.	3.00j	5.00g	0.00m	7.33e	1.50l	8.00d	4.14C
Dipping in IBA 2000 ppm.	8.33cd	3.00j	6.00f	0.00m	2.33k	9.33a	6.33A
Dipping in IBA 4000 ppm.	9.00ab	3.00j	0.00m	9.00ab	3.67i	8.33cd	5.50B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	6.00f	6.33f	2.00k	8.00d	2.00k	8.67bc	5.50B
Dipping in NAA 1000 ppm + IBA 4000 ppm.	3.00j	5.00g	2.33k	9.00ab	1.33l	0.00m	3.44D
Mean	4.89C	3.72D	1.72E	7.06A	1.81E	5.72B	
	Second season; 2018						
Dipping in water (control).	0.00n	0.00n	0.00n	0.00n	0.00n	0.00n	0.00F
Dipping in NAA 1000 ppm.	2.97j	6.00e	0.00n	6.67d	1.90l	8.00c	4.26D
Dipping in IBA 2000 ppm.	9.67a	2.92j	8.00c	8.77b	2.70jk	10.00a	7.01A
Dipping in IBA 4000 ppm.	8.83b	3.00j	0.00n	8.00c	4.33h	9.00b	5.53C
Dipping in NAA 1000 ppm + IBA 2000 ppm.	7.00d	6.63d	1.00m	9.00b	2.33k	9.13b	5.85B
Dipping in NAA 1000 ppm + IBA 4000 ppm.	3.67i	5.57f	0.00n	9.17b	1.00m	0.00n	3.23E
Mean	5.36C	4.02D	1.50F	6.93A	2.04E	6.02B	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

season while clone (61 & 18) were the highest length of new shoots when treated with IBA 2000 ppm in the second season.

Number of Leaves on the New Shoots: Data in Table (6) illustrated that cuttings when treated with IBA 4000 ppm recorded the highest number of leaves on new shoots in the first season while NAA at 1000 ppm + IBA at 2000 ppm as the same with IBA at 2000 or at 4000 ppm recorded the highest number of leaves on the new shoots in second season. Besides, clone (10) surpassed the others in number of leaves on new shoots in both seasons.

Table 6: Effect of some growth regulators on number of new shoots of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	Number of leaf/new shoots						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00j	0.00j	0.00j	0.00j	0.00j	0.00j	0.00F
Dipping in NAA 1000 ppm.	2.67i	10.00de	0.00j	6.00g	2.00i	10.00de	5.11E
Dipping in IBA 2000 ppm.	12.00c	5.00gh	6.00g	10.00de	6.00g	12.00c	8.50C
Dipping in IBA 4000 ppm.	14.00b	6.00g	0.00j	14.00b	9.00ef	15.00b	9.67A
Dipping in NAA 1000 ppm + IBA 2000 ppm.	6.00g	17.00a	4.00h	14.00b	4.00h	10.00de	9.17B
Dipping in NAA 1000 ppm + IBA 4000 ppm.	8.00f	12.00c	6.00g	12.00c	2.00i	0.00j	6.67D
Mean	7.11D	8.33B	2.67F	9.33A	3.83E	7.83C	
	Second season; 2018						
Dipping in water (control).	0.00p	0.00p	0.00p	0.00p	0.00p	0.00p	0.00D
Dipping in NAA 1000 ppm.	2.00n	12.00e	0.00p	8.00i	2.00n	9.00h	5.50C
Dipping in IBA 2000 ppm.	11.00f	5.00k	6.00j	10.00g	5.00k	13.00d	8.33A
Dipping in IBA 4000 ppm.	13.00d	5.00k	0.00p	9.00h	7.75i	14.00c	8.13A
Dipping in NAA 1000 ppm + IBA 2000 ppm.	5.00k	16.00a	4.00l	13.00d	3.00m	8.00i	8.17A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	9.00h	13.00d	0.00p	15.00b	1.00o	0.00p	6.33B
Mean	6.67D	8.50B	1.67F	9.17A	3.13E	7.33C	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

Table 7: Effect of some growth regulators on survival percentage of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	Survival percentage						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.00y	0.00y	0.00y	0.00y	0.00y	0.00y	0.00F
Dipping in NAA 1000 ppm.	33.30u	80.95e	0.00y	87.50c	70.80l	73.90i	57.74C
Dipping in IBA 2000 ppm.	77.70g	33.33u	60.00o	75.00h	27.77w	92.06a	60.98B
Dipping in IBA 4000 ppm.	42.85t	28.57v	50.00r	83.30d	72.20j	61.60n	56.42D
Dipping in NAA 1000 ppm + IBA 2000 ppm.	45.80s	68.50m	77.77g	79.17f	75.00h	90.90b	72.86A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	71.40k	60.00o	22.22x	68.33m	55.55p	54.50q	55.33E
Mean	45.18D	45.23D	35.00E	65.55A	50.22C	62.16B	
	Second season; 2018						
Dipping in water (control).	0.00t	0.00t	0.00t	0.00t	0.00t	0.00t	0.00F
Dipping in NAA 1000 ppm.	33.33q	75.00g	0.00t	87.50c	70.00k	72.46i	56.38E
Dipping in IBA 2000 ppm.	84.85d	25.00r	66.66l	73.33h	33.33q	92.40b	62.60B
Dipping in IBA 4000 ppm.	50.00p	25.00r	50.00p	80.55f	73.30h	65.15m	57.33D
Dipping in NAA 1000 ppm + IBA 2000 ppm.	50.00p	75.00g	66.60l	84.72d	73.33h	97.20a	74.48A
Dipping in NAA 1000 ppm + IBA 4000 ppm.	83.30e	71.42j	16.66s	66.66l	58.33n	53.30o	58.28C
Mean	50.25D	45.24E	33.32F	65.46A	51.38C	63.42B	

Values having the same letter (s) within the same raw or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05.

Meanwhile, the interaction between clones and growth regulators it was found that clone (62) had the highest number of leaves when the cuttings treated with NAA at 1000 ppm + IBA at 2000 ppm in both seasons while the lowest number of leaves were the clone (16) when the cuttings treated with NAA at 1000 ppm + IBA at 4000 ppm and clone 63 when treated with IBA at 4000 ppm or NAA at 1000 ppm in both seasons.

The results were in the same line with those obtained by Ttirokoglu and Durmus [28] who found that IBA hormone increased the leaf number and shoot length as hormone intake increased and Sharaf *et al*. [24] who proved that dipping the cuttings of jojoba in NAA, IBA, PP_{333} significantly increased the average length diameter of the main shoot and total number of leaves per every rooted cutting.

Survival Percentage: It was clear that the survival increments were pronounced by NAA at 1000 ppm + IBA at 2000 ppm followed by IBA at 2000 ppm in both seasons while the clone (10) was the superior in the survival percentage followed by clone (18) in both seasons (Table 7).

The highest percentage of survival under the interaction between clone and growth regulators were the clone (18) when treated with IBA 2000 ppm followed by NAA at 1000 ppm + IBA at 2000 ppm in the first season, while in the second season when cuttings of clone (18) were dipped in NAA at 1000 ppm + IBA at 2000 ppm recorded the best survival.

Chemical Analysis

Total Indoles Concentration: It was revealed that (Table, 8) the highest value of indoles concentration was obtained from IBA at 2000 ppm treatment followed by IBA at 4000 ppm in both seasons.

On the other hand, the clone (18) was the greatest value of indoles concentrations followed by clone (10) in both seasons. Regard to the interaction it was found that clone (18) when treated with IBA at 2000 ppm and at 4000 ppm was the highest concentration of indoles in the second season, while clone 62 was the highest concentration of indoles in the first season when treated with dipping in NAA at 1000 ppm + IBA at 2000 ppm.

Total Phenols Concentration: The obtained results in Table (9) indicated that phenols concentration decreased in the cuttings after dipping in growth regulators, the highest concentration were found in control treatment in both seasons. Whereas, clone (63) and (16) had the highest concentrations of phenols in both seasons. The results indicated that the least concentration were found in clone (18) & (10) when treated with NAA 1000 ppm and IBA 4000 ppm or NAA 1000 + IBA 2000 ppm in both seasons.

The present study was in agreement with Zhou [33]; Cao and Gao [34] and Hafez *et al*. [35] on the auxin effect on the cuttings of jojoba and guava. Also, Ercisli *et al*. [36] showed that IBA application improved over all rooting hardwood cuttings of Rosa dumalis, average number of roots for olive cultivars that was reported by Riaz *et al*. [37].

Finally it was found from our study that clone (10 & 18) were the best clones in most of the measurements when culturing under plastic tunnel conditions showing a range between 8 % to 96 % rooting. These results were considered suitable when no tools such as mist propagation system are available in same places. The use of polyethylene sheet tunnel for jojoba cuttings propagation is considered a successful cheaper technique compared with greenhouse or mist propagation chambers while the clone (63) was the lowest root percentage in both seasons [38, 39].

Anatomical Studies: The results of the rooting percentage of jojoba cutting are showed in photos (9), (10) and (11) which revealed that significant highest percentage of rooting was observed in clone (10) Table (1) which showed the highest percentage for forming of roots which keep the highest values for two seasons in the treatments (NAA at 1000 + IBA at 2000 ppm), (IBA at 4000 ppm) and (NAA at 1000 ppm) which recorded by 96 %, 96 % and 96 % for first season and at the same treatments for the same clone recorded at the second season for rooting percentage about 96 % for all treatments. On the other hand, clone (61) percentage of rooting was about 96 % for treated cuttings with IBA at 2000 ppm whereas, clone (61) in treatment NAA at 1000 ppm verified that fibers considered mainly responsible for inhibit and difficult forming of roots which reached the lowest percentage of roots by 8 % and that clear whereas increment and condense of fibers which inhibit forming of roots for two seasons at the same treatments.

Only increment for forming roots exhibited in clone (62) with NAA at 1000 + IBA at 2000 treatment which recorded the only increase over all treatments in clone (62) which recorded 72 % rooting. It is obvious from data mentioned in photo (1) that clone (18) cleared an increment for two seasons at treatment (NAA at 1000 ppm) which recorded in first season increment by 84%, 80% and 92% rooting whereas in the second season was noticed an increase in rooting percentage by 88 %, 88 % and 92 % rooting as the same treatments.

Untreated clones (control) showed inhibit forming root related to increase fibers and oil glands which responsible for decrease or inhibit for forming roots.

It is obvious from data mentioned before in Photo (10, 11 & 12) that Sayed *et al*. [40] stated that formed and initials of root depends on cambium tissue which resumed its activity by cell division and gave rise to the different layers of tissue which formed root initials and primordial of jojoba, also the development of adventitious roots primordial took place through the cortex and priderm followed by development of vascular system of those roots which become in contact with main vessel of these system.

Table 8: Effect of some growth regulators on total indoles (mg/100g d.wt.) of sub terminal jojoba clones cuttings during 2017 and 2018 seasons

	Total indoles						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.020st	0.080p	0.011t	0.033rs	0.012t	0.020st	0.029F
Dipping in NAA 1000 ppm.	0.040r	0.855l	0.880k	1.030cd	1.020de	1.012e	0.806D
Dipping in IBA 2000 ppm.	1.010e	0.750n	0.930g	0.900ij	0.970f	1.095b	0.943A
Dipping in IBA 4000 ppm.	0.897i-k	0.890jk	0.690o	1.022de	0.920gh	1.092b	0.919B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	0.890jk	1.220a	0.062q	1.040c	0.880k	1.033cd	0.854C
Dipping in NAA 1000 ppm + IBA 4000 ppm.	0.930g	1.036cd	0.037rs	1.010e	0.825m	0.910hi	0.791E
Mean	0.631E	0.805C	0.435F	0.839B	0.771D	0.860A	
	Second season; 2018						
Dipping in water (control).	0.010o	0.086m	0.020o	0.032no	0.013o	0.027no	0.031F
Dipping in NAA 1000 ppm.	0.050mn	0.900gh	0.850ij	1.037bc	1.030b-d	1.022cd	0.815D
Dipping in IBA 2000 ppm.	1.050b	0.831jk	0.890h	0.940f	0.930f	1.100a	0.957A
Dipping in IBA 4000 ppm.	0.900gh	0.920fg	0.720l	1.037bc	0.940f	1.097a	0.936B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	0.970e	1.032b-d	0.058m	1.039bc	0.890h	1.031b-d	0.837C
Dipping in NAA 1000 ppm + IBA 4000 ppm.	0.920fg	1.040bc	0.049mn	1.010d	0.820k	0.920fg	0.793E
Mean	0.650E	0.802C	0.431F	0.849B	0.771D	0.866A	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

Table 9: Effect of some growth regulators on total phenols (mg/100g d.wt.) of sub terminal jojoba clones cuttings during 2017 and 2018 seasons.

	Total phenols						
	Clones						
Treatments	61	62	63	10	16	18	Mean
	First season; 2017						
Dipping in water (control).	0.094bc	0.060g-j	0.092b-d	0.094bc	0.097b	0.089b-f	0.088A
Dipping in NAA 1000 ppm.	0.090b-e	0.041j-o	0.135a	0.020p	0.050j-m	0.020p	0.059B
Dipping in IBA 2000 ppm.	0.26n-p	0.055h-k	0.033l-p	0.038k-p	0.069g-i	0.026n-p	0.041D
Dipping in IBA 4000 ppm.	0.032l-p	0.040k-p	0.045j-n	0.022op	0.072e-h	0.024op	0.039D
Dipping in NAA 1000 ppm + IBA 2000 ppm.	0.032l-p	0.023op	0.070f-i	0.020p	0.074d-h	0.040k-p	0.043CD
Dipping in NAA 1000 ppm + IBA 4000 ppm.	0.033l-p	0.030m-p	0.076c-g	0.026n-p	0.077c-g	0.052i-l	0.049C
Mean	0.051B	0.042C	0.075A	0.037C	0.073A	0.042C	
	Second season; 2018						
Dipping in water (control).	0.098a	0.066e-i	0.087a-d	0.092a-c	0.097ab	0.080b-e	0.087A
Dipping in NAA 1000 ppm.	0.079c-f	0.045j-m	0.029m-p	0.020p	0.050i-l	0.020p	0.041B
Dipping in IBA 2000 ppm.	0.022op	0.052h-k	0.032op	0.022op	0.060g-j	0.019p	0.035B
Dipping in IBA 4000 ppm.	0.030m-p	0.042k-n	0.40k-o	0.019p	0.061f-j	0.020p	0.035B
Dipping in NAA 1000 ppm + IBA 2000 ppm.	0.035k-p	0.021op	0.072d-g	0.020p	0.062e-j	0.038k-p	0.041B
Dipping in NAA 1000 ppm + IBA 4000 ppm.	0.036k-p	0.022op	0.070d-h	0.025n-p	0.066e-i	0.024n-p	0.041B
Mean	0.050B	0.041C	0.055B	0.033D	0.066A	0.034D	

Values having the same letter (s) within the same row or column are not statistically significant according to Duncan's New Multiple Range t-Test at P = 0.05

In addition root percentage differed according to presence or absent of IBA, NAA or interaction between each other which helps to increase the forming and percentage of rooting. Also, propagation of jojoba shows difficult in rooting without auxin, several authors reported improved rooting in jojoba by using different auxins in varying concentration and combinations [41-46]. Also, Thomson [47] reported that by using IBA or NAA and interaction between them may cause genetic variability and that led to plant variation in rooting potential additional to stock plant age can also play an important role in cutting root ability.

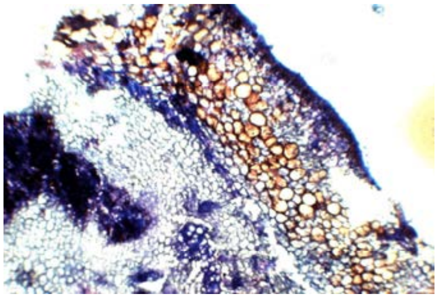

Photo 1: Clone 61 (control)

Photo 2: Clone 62 (NAA 1000 ppm)

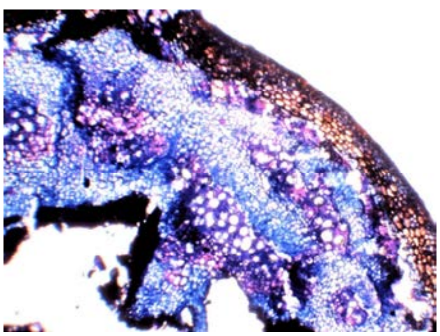

Photo 3: Clone 63 (IBA 2000 ppm)

Photos (1, 2 and 3): A cross section in jojoba plant stem cutting showing big layers of fibers and oil glands which decrease forming root.

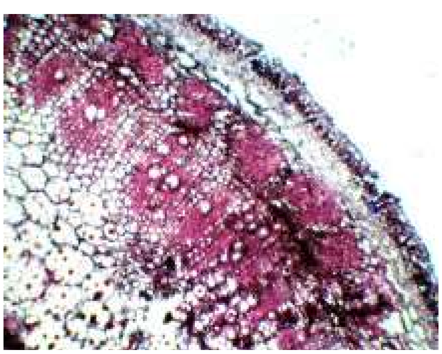

Photo 4: Clone 62 (control)

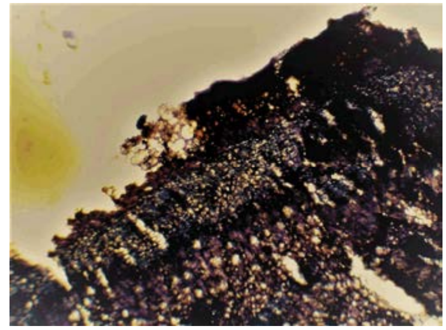

Photo 5: Clone 63 (control)

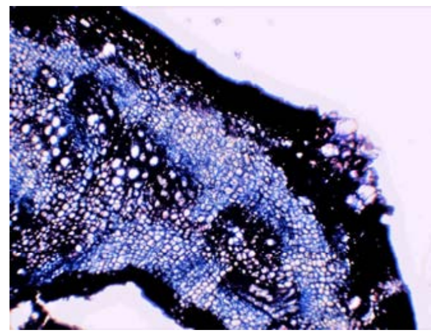

Photo 6: Clone 16 (control)

Photo (4, 5 & 6): Cross section in jojoba plant stem cutting showing inhibit forming root related to increase fiber which responsible for inhibit forming roots.

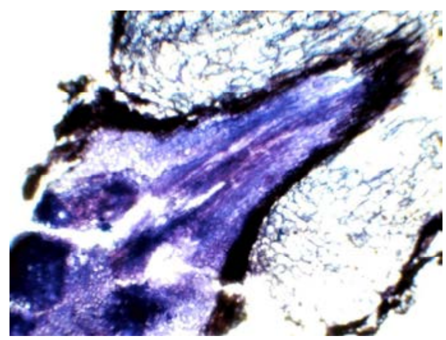

Photo 7: Clone 61 (IBA 2000 ppm)

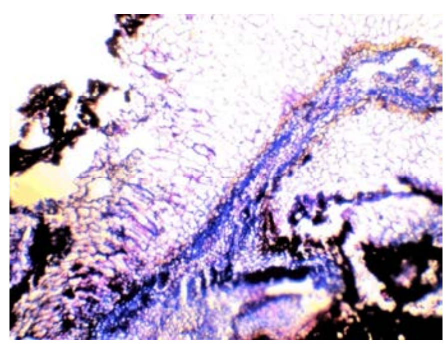

Photo 8: Clone 62 (IBA 2000 ppm + NAA 1000 ppm)

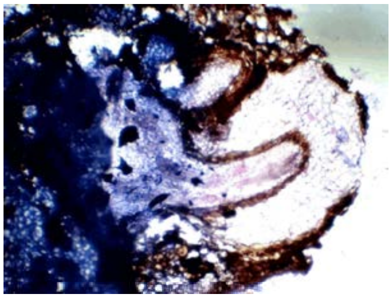

Photo 9: Clone 10 (NAA 1000 ppm)

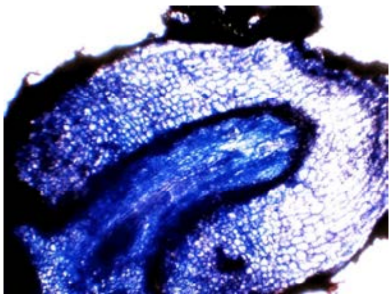

Photo 10: Clone 10 (IBA 2000 ppm + NAA 1000 ppm)

Photos (7, 8, 9 and 10): Cross section in jojoba plant stem cutting showing early stage of root primordial periphery initiated from the cortex zone.

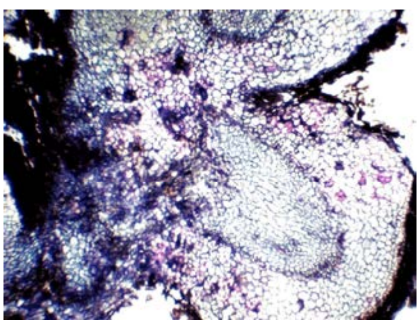

Photo 11: Clone 10 (IBA 4000 ppm)

Photo (11): A Cross section in jojoba plant stem cutting showing the beginning of vascular bundle connection between the adventitious roots and corresponding tissues of the cutting.

Photo 12: Clone 18 (NAA 1000 ppm)

Photo (12): A Cross section in jojoba plant stem cutting showing the well developed root.

CONCLUSION

The study recommended that clones (10 and 18) were the best in the most of measurements under the plastic tunnels.

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