SINAI Journal of Applied Sciences (ISSN: 2314-6079) Vol. (5) Is. (1), Apr. 2016 83-98

SINAI Journal of Applied Sciences

EFFECT OF SOME GROWTH REGULATORS AND ANTIOXIDANTS ON ROOTABILITY UNDER HYDROPONIC SYSTEM CULTURE OF SOME FRUIT SPECIES CUTTINGS

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ABSTRACT

This study was conducted during the two consecutive seasons of 2012 and 2013 to enhance root ability of three fruit species i.e. Kalamata Olive (*Olea europaea* L.), Betulaefolia Pear (*Pyrus betulaefolia* L.) and Malus Apple (*Malus sylvestris* Mill.), under hydroponic units. From private farms, near to El-Sadat city, one year old mature wood cuttings from the three studied fruit species were collected on the end week of January in both seasons. Woods (50-70 cm in length) were prepared and maintained wet in black plastic bags, next day after collection and in the nursery, woods were cut into (12-15 cm) long sections early in the morning. The terminal cuttings were less than 15 cm length and (2-3 mm) in diameter with terminal bud. Where as sub terminal cuttings were (15-18 cm) in length, (3-4 mm) in diameter. The basal cut was made just below anode. Only olive cuttings with 4-5 leaves retained on the upper portion were used. The base of cutting were treated with one of the following Treatments (500 ppm IBA for 5 seconds - Table beet water extract (solution 5 gL^{-1}) for 30 min - 500 ppm IBA for 5 seconds and retreated with table beet water extract for 30 min – Control). The treatments were arranged in a completely randomized design with three replicates for each treatment. Apples cutting treatment recorded the best results compared with olive cuttings in rooting percentage, root number, vegetative growth and leaf nutrients content as well as total carbohydrates and Indole. Terminal cuttings treatment achieved the best results compared with sub-terminal cuttings in rooting percentage, root number, vegetative growth and leaf nutrients content as well as total carbohydrates and indole. The results of the present study clearly demonstrated the effect of a combined treatment of IBA 500 ppm + table beet extract on stimulation of rooting and survival of rooted cuttings compared with a treatment of IBA or table beet alone. This treatment is of particular importance for rooting of difficult root and moderate-rooting cuttings, but is also beneficial for easy to root cuttings, in increasing the survival rate of rooted plants compared with the common treatment of IBA alone.

Key words: Kalamata Olive, Betulaefolia Pear, Malus Apple, Hydroponic.

INTRODUCTION

The traditional methods used for multiplication of fruit trees since ancient times are the purely asexual method of propagation (suckers or cuttings) and later grafting on seedlings rootstocks. The main techniques which are now used commercially for Olive, Betulaefolia Pear and Apple propagation are rooting of cuttings **(Fontanazza, 1996; Cetintas and Ozkaya, 2005)**. Rooting hormones should be applied to the base of cuttings to increase overall rooting percentages, hasten root initiation, increase the number and quality of roots and encourage uniformity of rooting. The most widely used hormone is

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Indole butyric acid (IBA) **(Wiesman and Epstein, 1987; Dauod *et al.,* 1989; Fernandes *et al.,* 2002; Ozelbaykal and Gezerel, 2005; Bartolini *et al.,* 2008)**. In fact, **Rugini and Fedeli (1990)** reported that the biggest problem in vegetative propagation, in some species of olive, pear and apple is the low ability of regeneration leading to low percentage of rooting. All Mediterranean countries have one or two economically very important but difficult to root olive cultivars **(Asl-Moshtaghi and Shahsavar, 2011).**

Vegetative propagation by cutting is widely used for the propagation of some fruit trees. This technique is considered to be easy, in expensive and appropriate for mass plant production. In spite of the high Morphogenetic potential of the trees, the low rooting ability, unsatisfactory viability and the low rooting quality of cuttings in some fruit trees are limiting factors **(Wiesman and Epstien, 1987; Wiesman and Lavee, 1994)**.

Rooting media should be considered an integral part of the propagation system.The appropriateness of the medium depends on the species, the cutting type, the propagation system used and the cost as well as availability of the medium components synthetic rooting media (*e.g.* peatmoss plus sand) and water culture (Hydroponic system) are also used in the nurseries of some countries **(Hartmann *et al.,* 2002)**. The discovery of auxins as plant growth regulating chemicals and early research into their physiological effects and practical applications form a fascinating story of horticultural research **(Tincker, 1936).**

From these studies, the finding that auxins could stimulate adventitious rooting in cuttings was a major breakthrough for commercial plant propagation **(Arteca, 1996)**.

Thimann and Koepfli (1935) reported the synthetic preparation of indole-3-acetic acid (IAA), a naturally occurring auxin that had recently been found to have root-forming properties. Indole-3-butyric acid was later found to occur naturally in plants as a conversion product of IAA, but occurs at lower concentrations than IAA **(Ludwig-Müller *et al.,* 1993; Ludwig-Müller and Epstein, 1994)**. At present, IBA and NAA are the most widely used auxins for promoting root formation on stem cuttings. Auxin treatments are commonly used in commercial plant propagation to increase overall rooting percentages, hasten root initiation, increase the number and quality of roots, and encourage uniformity of rooting **(Macdonald, 1987; Hartmann, *et al.,* 2002; Eugene *et al.,* 2007).** This study aimed to improve the rooting of three fruit species cuttings *i.e.* Kalamata Olive (*Olea europaea* L.), Betulaefolia Pear (*Pyrus betulaefolia* L.) and Malus Apple (*Malus sylvestris,* Mill.) under hydroponic system.

MATERIALS AND METHODS

This study was conducted during the two consecutive seasons of 2012 and 2013 at private farm, near to El-Sadat city, El-Monofia Governorate. One year mature woods were collected on the last week of January in both seasons from the three tested fruit species *i.e.* Kalamata Olive, Betulaefolia Pear and Malus Apple. Cutting woods (50-70 cm in length) were collected and maintained wet in black plastic bags, the day after their arrival to the nursery (one day after collection) where prepared in early morning. Cutting woods were cut into 12-15 cm length long sections. The terminal cuttings were less than 15 cm length and 2-3 mm diameter with terminal bud. Where as, sub-terminal cuttings were 15-18 cm length and 3-4 mm diameter. The basal cut was made just below a node. Only olive cutting retained 4-5 leaves on the upper most portion.

Cuttings of each treatment were planted in a plastic basin containing the culture solution covered 5 cm of the basal part of the cuttings. The upper end of the plastic basins was covered with foam a slab. This foam slab was punched with a punching machine to make the holes. These holes in

foam slab were not only to the cuttings but will also to improve aeration. On the other hand, these plastic basins were provided with a heater to regulate the culture solution at 26 ±2^{o}C as well as an air pump to give extra aeration. The mist unit containing Fluorescent lamps at the top. Fresh culture solution was changed every week in both seasons and the cultures were misted for 20 Sec., every 12-15 min.

The tested treatments were:

Growth Regulator and Antioxidant Treatments

Indole Butyric Acid (IBA)

Indole-3-butyric acid solutions at 500 ppm and 5000 ppm were freshly prepared through dissolving IBA powder (0.5g and 5g/l water) in an Alcohol/water (3–7 V/V) solution.

Table Beet Water Extract

The fresh root of table beet was washed three times with tap water to remove any residues of dust then sliced to fine small parts. Those parts were soaked for 24 hr., in distilled water at the rate of 5 g and the mixture was filtered using gauze the final extract (Betalain pigment) was used directly for treatment. Treatments were; Table beet water extract only was applied where 5 gL^{-1}, supplemented with 500 ppm IBA and untreated cuttings (control) using tap water.

Parameters

At the end of the rooting period (4 months after planting), the tested treatments were evaluated through the following parameter determinations:

Root Formation and Development

All the rooted cuttings were uprooted from the media and the roots were washed thoroughly with tap water to free from media, followed by distilled water, to determine the percentage of rooting, root number and root length then. All farmed roots were removed and their fresh weights were recorded and dried in an oven at 80ºC for forty eight hours to determine the dry weights.

Vegetative Growth

Number of leaves/cutting was recorded and all the leaves were removed and their fresh weight was determined and the leaves were put in an oven at 80ºC for forty eight hours to determine the dry weights.

Chemical Determination

Some chemical analyses were done on stem sections (approximately 2 cm long of cutting base - about 5 g) which were collected from each rooted cutting in order to find out any possible relationship between the internal chemical composition and root ability of the un-rooted cuttings.

Total nitrogen (%) was determined using the micro kjeldahl method as described by **(Pregl, 1945)**. Phosphorus (%) was determined colorimetrically using the Spectrophotometer (Model 1600 Jenway Co.) according to **Jackson (1958)**. Potassium (%) was determined using the flame photometer according to **(Brown and Lilleland, 1949)**. Fe content (ppm) was determined using the Atomic Absorption Spectrophotometer (Perkin- Elmer Model 305B). All determinations were carried out by using air-acetylene gas mixture at rate of 5:1 l. min^{-1} according to **Jackson (1958).** Total phenols **(AOAC, 1990).** Total indoles according to **(Fischl and Rabiah 1964).**

Statistical Analysis

The treatments were arranged in a completely randomized design with three replicates for each treatment. Data were analyzed by ANOVA using MSTAT-C computer program package **(Russell, 1986)**. Mean values of treatments were differentiated by using least significant range (Duncan's multiple range tests) at 0.05% level probability **(Duncan, 1955)**.

RESULTS AND DISCUSSION

The effect of fruit cutting species *i.e.* Kalamata Olive, Betulaefolia Pear and Malus Apple, cutting type (terminal or sub-terminal) and IBA or antioxidant on rootability of the three fruit cutting species under hydroponic system are presented in Tables 1-5.

Root Ability Parameters

Rooting (%)

Table (1) and Fig. (1) show that the cuttings of Kalamata olive gave higher rooting percent (28.54 and 28.93%), followed descendingly by the analogous ones of Malus apple (27.18 and 27.69%). Whereas, Betulaefolia pear cuttings recorded the lowest values of rooting percent (25.84 and 26.13) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

Furthermore, terminal cuttings of the three tested fruit species showed superiority in their root ability and recorded 34.29 and 34.76 rooting percent as compared with the analogous ones of subterminal cuttings (20.09 and 20.41) in the first and second seasons, respectively.

In addition, the tested IBA and antioxidant alone or in combination enhanced rooting percent of the three tested fruit species cuttings as compared with control treatment, which failed to root any cutting. However, antioxidant alone or combined with 500 ppm IBA induced similar and higher positive effect on rooting rather than 500 ppm IBA treatment alone.

Finally, the interaction between the three tested factors indicated that terminal cuttings of Kalamata olive treated with 500 ppm IBA supported with antioxidant recorded the highest values of rooting percent, followed descendingly by terminal cuttings of Kalamata olive treated with 500 ppm IBA. On the contrary, non-treated terminal or subterminal cuttings of Betulaefolia pear, Malus apple and Kalamata olive produced the lowest values of rooting percent. Other tested combinations showed an intermediate values in this respect.

Number of Roots /Cutting

Table (1) and Fig. (1) show that the cuttings of Kalamata olive gave higher number of roots/cutting (3.30 and 3.33), followed descendingly by the analogous ones of Malus apple (3.00 and 3.04). Whereas, Betulaefolia pear cuttings recorded the lowest values of number of roots/ cutting (2.88 and 3.04) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

Furthermore, terminal cuttings of the three tested fruit species showed superiority in number of roots/cutting and recorded 3.87 and 3.97 as compared with the analogous ones of subterminal cuttings (2.25 and 2.31) in the first and second seasons, respectively.

In addition, the tested IBA and antioxidant alone or in combination enhanced number of roots/cutting of the three tested fruit species cuttings as compared with control treatment, which failed to number of roots on any cutting. However, antioxidant alone or combined with 500 ppm IBA induced similar and higher positive effect on number of roots /cutting rather than 500 ppm IBA treatment alone.

Finally, the interaction between the three tested factors indicated that terminal cuttings of Kalamata olive treated with 500 ppm IBA supported with antioxidant and terminal cuttings of Betulaefolia pear treated with 500 ppm IBA recorded the highest values of number of roots /cutting.

On the contrary, non-treated terminal or subterminal cuttings of Betulaefolia pear,

Table (1): Effect of fruit species, cutting type and (IBA and antioxidant) on rooting (%) and number of roots /cutting of Kalamata Olive, Betulaefolia Pear and Malus apple under hydroponic system culture during 2012 and 2013 seasons.

Fruit species	Rooting (%)							No. of roots /cutting						
	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean
Cutting type	Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal		Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal	
Season I (2012)														
Control "tap water"	0.00 l	0.00 l	0.00 l	0.00 l	0.00 l	0.00 l	**0.00 c**	0.00 e	0.00 e	0.00 e	0.00 e	0.00 e	0.00 e	**0.00 c**
500 ppm IBA	65.87ab	0.00 l	61.23 f	15.53 i	62.17 e	0.00 l	**34.13b**	7.67 a	0.00 e	7.67 a	1.67 d	6.67 b	0.00 e	**3.95 b**
Antioxidant "Table beet"	16.83 h	63.47d	0.00 l	65.4bc	14.10 k	65.10bc	**37.48a**	1.76 d	7.67 a	0.00 e	7.00 b	1.33 d	6.67 b	**4.07 a**
500 ppm IBA + Antioxidant	66.73 a	15.4 ij	64.57c	0.00 l	59.93 g	16.13hi	**37.13a**	8.00 a	1.33 d	6.67 b	0.00 e	6.67 b	2.68 c	**4.23 a**
Mean for:	Kalamata olive (28.54a) Betulaefalia Pear (25.84c) Malus Apple (27.18b) Terminal cuttings (34.29a) subterminal cuttings (20.09b)							Kalamata olive (3.30a) Betulaefalia Pear (2.88c) Malus Apple (3.00b) Terminal cuttings (3.87a) subterminal cuttings (2.25b)						
LSD at 5% for interaction	**0.827**							**0.413**						
Season II (2013)														
Control "tap water"	0.00 l	0.00 l	0.00 l	0.00 l	0.00 l	0.00 l	**0.00 c**	0.00 g	0.00 g	0.00 g	0.00 g	0.00 g	0.00 g	**0.00 c**
500 ppm IBA	66.27ab	0.00 l	62.30ef	16.2jk	62.37ef	0.00 l	**34.52b**	7.33 b	0.00 g	8.33 a	2.00 e	6.33 c	0.00 g	**4.00 b**
Antioxidant "Table beet"	17.53h	63.67d	0.00 l	65.6 bc	15.83 k	65.5bc	**38.02a**	2.00 e	7.33 b	0.00 g	7.67 b	1.33 f	6.33 c	**4.11 a**
500 ppm IBA + Antioxidant	66.90a	17.10hi	64.97c	0.00 l	61.00 g	16.8hij	**37.80a**	8.67 a	1.33 f	6.33 c	0.00 g	7.33 b	3.00 d	**4.44 a**
Mean for:	Kalamata olive (28.93a), Betulaefalia Pear (26.13c), Malus Apple (27.69b) Terminal cuttings (34.76a), subterminal cuttings (20.41b)							Kalamata olive (3.33a), Betulaefalia Pear (3.04b), Malus Apple (3.04b) Terminal cuttings (3.97a), subterminal cuttings (2.31b)						
LSD at 5% for interaction	**0.827**							**0.413**						

Means followed by the same letter(s) within each column or row are not significantly different at 0.05 level, according to Duncan's multiple range test.

Fig. (1): Rooting of (A) Kalamata Olive, (B) Betulaefolia Pear and (C) Malus Apple cuttings under hydroponic system.

Malus apple and Kalamata olive produced the lowest values of number of roots /cutting. Other tested combination showed an intermediate values in this respect.

Vegetative Growth

Number of Branches/ Cutting

Results in Table (2) and Fig. (2) reveal that the cuttings of Malus apple achieved the highest values of number of branches/ cutting (4.71 and 5.46). On the contrary, the least values of number of branches/ cutting were obtained by Kalamata olive and Betulaefolia pear cuttings (4.46 and 5.21) and (4.46 and 5.21) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

Furthermore, sub-terminal cuttings of the three tested fruit species gave the highest values of number of branches/ cutting and recorded 4.85 and 5.42 as compared with the analogous ones of terminal cuttings (4.50 and 5.17) in the first and second seasons, respectively. Similar results were reported by **(Hansen, 1989; Lin and Lin, 1990).**

Also, data indicate that the combination IBA and antioxidant enhanced number of branches/cutting of the three tested fruit species as compared with control treatment which gave the lowest values.

As for, the interaction effect between the three tested factors; results indicated that the highest values in the two seasons came from terminal cutting of Malus apple or Kalamata olive or Betulaefalia Pear treated with IBA 500 ppm + antioxidant. While, non-treated terminal or subterminal cuttings of Betulaefolia pear, Malus apple and Kalamata olive produced the lowest values of number of branches/ cutting. Other tested combinations showed an intermediate values in this respect.

Number of Leaves/ Cutting

Results in Table (2) and Fig. (2) reveal that the cuttings of Kalamata olive achieved the highest values of number of leaves/ cutting (29.67 and 30.88), followed by Malus apple cuttings (29.33 and 30.63). On the contrary, the least values of number of leaves/cutting were obtained by Betulaefolia pear cuttings (27.50 and 28.88) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

Furthermore, terminal cuttings of the three tested fruit species gave the highest values of number of leaves/ cutting and recorded 29.22 and 31.00 as compared with the analogous ones of sub-terminal cuttings (28.45 and 29.25) in the first and second seasons, respectively. Similar results were reported by **Hansen (1989) abd Lin and Lin (1990)**.

Table (2): Effect of fruit species, cutting type and (IBA and antioxidant) on number of branches and leaves/ cutting of Kalamata Olive, Betulaefolia Malus Pear and apple under hydroponic system culture during 2012 and 2013 seasons.

Fruit species / Cutting type	No. of Branches / cutting							No. of Leaves/ cutting						
	Kalamata oliv		Betulaefalia Pea		Malus Appl		Mea	Kalamata oliv		Betulaefalia Pea		Malus Appl		Mea
	Termina	Sub Termina	Termina	Sub Termina	Termina	Sub Termina		Termina	Sub Termina	Termina	Sub Termina	Termina	Sub Termina	
Season I (2012)														
Control "tap water"	0.00 f	0.00 f	0.00 f	0.00 f	0.00 f	0.00 f	**0.00 d**	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	**0.00 d**
500 ppm IBA	7.33 c	8.33 b	7.33 c	8.33 b	7.33 c	8.33 b	**7.83 b**	45.67 c	45.67 c	41.67 d	41.67 d	44.67 c	44.67 c	**44.00b**
Antioxidant "Table beet"	1.33 e	1.67 e	1.33 e	1.67 e	2.33 d	2.67 d	**1.83 c**	15.33 g	21.33 e	11.33 h	17.33 f	14.33 g	20.33 e	**16.66 c**
00 ppm IBA + Antioxidant	9.00 a	8.00 b	9.00 a	8.00 b	9.00 a	8.00 b	**8.50 a**	56.67 a	52.67 b	56.00 a	52.00 b	55.67 a	55.00 a	**54.66 a**
Mean for:	lamata olive (4.46b), Betulaefalia Pear (4.46b), Malus Apple (4.71a) Termina cuttings (4.50b), subterminal cuttings (4.85a)							Kalamata olive (29.67a), Betulaefalia Pear (27.50c), Malus Apple (29.33b) Terminal cuttings (29.22a), subterminal cuttings (28.45b)						
LSD at 5% for interaction	**0.413**							**1.655**						
Season II (2013)														
Control "tap water"	0.00 f	0.00 f	0.00 f	0.00 f	0.00 f	0.00 f	**0.00 d**	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	**0.00 d**
500 ppm IBA	8.33 c	9.67 a	8.33 c	9.67 a	8.33 c	9.67 a	**9.00 b**	46.67c	46.67 c	42.67d	42.67 d	58.67 a	45.67 c	**47.17b**
Antioxidant "Table beet"	2.33 e	2.67 e	2.33 e	2.67 e	3.33 d	3.67 d	**2.83 c**	17.00f	21.33 e	13.00g	17.33 f	16.00 f	20.33 e	**17.50 c**
500 ppm IBA + Antioxidant	9.67 a	9.00 b	9.67 a	9.00 b	9.67 a	9.00 b	**9.33 a**	59.67a	55.67 b	59.67a	55.67 b	58.67 a	45.67 c	**55.84 a**
Mean for:	Kalamata olive (5.21b), Betulaefalia Pear (5.21b), Malus Apple (5.46a) Terminal cuttings (5.17b), subterminal cuttings (5.42a)							Kalamata olive (30.88a) Betulaefalia Pear (28.88b) Malus Apple (30.63a) Terminal cuttings (31.00a) subterminal cuttings (29.25b)						
LSD at 5% for interaction	**0.413**							**1.655**						

Means followed by the same letter(s) within each column or row are not significantly different at 0.05 level, according to Duncan's multiple range test.

Fig. (2): Vegetative growth of (A) Kalamata Olive, (B) Betulaefolia Pear and (C) Malus Apple cuttings under hydroponic system.

Also, data indicate that the combination between IBA and antioxidant enhanced number of leaves/cutting of the three tested fruit species cuttings as compared with control treatment which gave the lowest values.

As for, the interaction effect between the three tested factors indicated that the highest values in the two seasons came from terminal cutting of Malus apple or Kalamata olive or Betulaefalia Pear treated with IBA 500 ppm + antioxidant.

While, non-treated terminal or subterminal cuttings of Betulaefolia pear, Malus apple and Kalamata olive produced the lowest values of number of leaves/ cutting. Other tested combinations showed an intermediate values in this respect.

Chemical Constituents

Leaf N%, P% and K% Content

Results in Tables (3 and 4) indicat that the cuttings of Malus apple achieved the highest values of leaf N%, P% and K% content (1.80 and 1.82), (0.16 and 0.17) and (1.32 and 1.33), respectively. On the contrary, the least values of leaf N% and P% content were obtained by Kalamata olive cuttings (1.69 and 1.70) and (0.14 and 0.14), but Betulaefolia pear cuttings gave the lowest values of leaf K% (1.28 and 1.30) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

As shown in the same Tables, terminal cuttings of the three tested fruit species gave the highest values and significantly increased each of leaf N%, P% and K% and recorded (1.79 and 1.81), (0.15 and 0.17) and (1.30 and 1.31) as compared with the analogous ones of sub-terminal cuttings (1.69 and 1.70), (0.15 and 0.16) and (1.29 and 1.30) in the first and second seasons, respectively. Similar results were obtained by **(Hansen, 1989; Lin and Lin, 1990).**

Furthermore, data indicate that combination of 500 ppm IBA and antioxidant gave the highest leaf mineral content from N%, P% and K%, as compared with control treatment which gave the lowest values. Also, results proved that the interaction effect between the three tested factors indicated that the highest values in the two seasons came from terminal cutting of Malus apple treated with IBA 500 ppm + antioxidant. While, non-treated terminal or subterminal cuttings of Betulaefolia pear, Malus apple and Kalamata olive produced the lowest values of leaf N%, P% and K%. Other tested combinations showed an intermediate values in this respect.

Leaf Fe (ppm) Content

Results in Table (4) indicate that the cuttings of Kalamata olive achieved the highest values of leaf Fe (ppm) content (72.55 and 75.50), followed by Betulaefolia pear cuttings which recorded (70.64 and 75.03). While, the least values of leaf Fe (ppm) content were obtained by Malus apple

Table (3): Effect of fruit species, cutting type and (IBA and antioxidant) on leaves N and P content (%) of Kalamata Olive, Betulaefolia Pear and Malus apple under hydroponic system culture during 2012 and 2013 seasons.

Fruit species / Cutting type	N content (%)							P content (%)						
	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean
	Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal		Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal	
Season I (2012)														
Control "tap water"	0.00 m	0.00 m	0.00 m	0.00 m	0.00 m	0.00 m	**0.00 d**	0.00 i	0.00 i	0.00i	0.00i	0.00 i	0.00 i	**0.00 d**
500 ppm IBA	2.40 fg	2.34 g	2.70 b	2.65 bc	2.65 bc	2.37 g	**2.52 b**	0.29abc	0.28bcd	0.22ef	0.30a-d	0.24 de	0.18 f	**0.25 b**
Antioxidant "Table beet"	1.95 h	1.74 jk	1.67 kl	1.86 i	1.77 j	1.63 l	**1.77 c**	0.08gh	0.06 h	0.08gh	0.08f	0.11 g	0.08 gh	**0.08 c**
500 ppm IBA + Antioxidant	2.60 cd	2.53 de	2.86 a	2.72 b	2.83 a	2.48 ef	**2.67 a**	0.30abc	0.28bcd	0.26cde	0.32ab	0.33 a	0.26 cde	**0.29 a**
Mean for:	Kalamata olive (1.69c), Betulaefalia Pear (1.71b), Malus Apple (1.80a)							Kalamata olive (0.14c), Betulaefalia Pear (0.15b), Malus Apple (0.16a)						
	Terminal cuttings (1.79a), subterminal cuttings (1.69b)							Terminal cuttings (0.15a), subterminal cuttings (0.15a)						
LSD at 5% for interaction	**0.082**							**0.041**						
Season II (2013)														
Control "tap water"	0.00 k	0.00 k	0.00 k	0.00 k	0.00 k	0.00 k	**0.00 d**	0.00g	0.00g	0.00 g	0.00 g	0.00 g	0.00g	**0.00 d**
500 ppm IBA	2.49 e	2.39 f	2.74 cd	2.71 cd	2.68 d	2.39 f	**2.57 b**	0.34a	0.31abc	0.30 a-d	0.29 bcd	0.26 d	0.20 e	**0.28 b**
Antioxidant "Table beet"	1.89 g	1.68 i	1.69 i	1.79 h	1.79 h	1.59 j	**1.74 c**	0.09f	0.08f	0.08 f	0.09 f	0.08 f	0.09 f	**0.09 c**
500 ppm IBA + Antioxidant	2.69 d	2.48 e	2.86 ab	2.78 bc	2.90 a	2.56 e	**2.71 a**	0.27cd	0.29bcd	0.32 ab	0.31 abc	0.34 a	0.27 cd	**0.30 a**
Mean for:	Kalamata olive (1.70c), Betulaefalia Pear (1.74b), Malus Apple (1.82a)							Kalamata olive (0.14c), Betulaefalia Pear (0.16b), Malus Apple (0.17a)						
	Terminal cuttings (1.81a), subterminal cuttings (1.70b)							Terminal cuttings (0.17a), subterminal cuttings (0.16b)						
LSD at 5% for interaction	**0.082**							**0.041**						

Means followed by the same letter(s) within each column or row are not significantly different at 0.05 level, according to Duncan's multiple range test.

Table (4): Effect of fruit species, cutting type and (IBA and antioxidant) on leaves K (%) and Fe content (ppm) of Kalamata Olive, Betulaefolia Pear and Malus apple under hydroponic system culture during 2012 and 2013 seasons.

Fruit species / Cutting type	K content (%)							Fe content (ppm)						
	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean
	Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal		Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal	
Season I (2012)														
Control "tap water"	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	**0.00 d**	0.00 m	0.00 m	0.00 l	0.00 m	0.00 l	0.00 m	**0.00 d**
500 ppm IBA	1.75 e	1.80 cd	1.78 de	1.74 e	1.80 cd	1.81 cd	**1.78 b**	108.6d	98.90 g	107.4de	99.30 g	10.40l	101.7f	**87.72b**
Antioxidant "Table beet"	1.56 gh	1.60 fg	1.54 h	1.52 h	1.61 f	1.59 fg	**1.57 c**	79.90 h	69.60jk	70.80 ij	68.40 k	116.5a	72.40 i	**79.60c**
500 ppm IBA + Antioxidant	1.86 ab	1.8abc	1.82bcd	1.86 ab	1.88 a	1.87 a	**1.85 a**	114.8 a	108.6cd	112.7 b	106.5 e	116.5a	109.5 c	**111.4a**
Mean for:	Kalamata olive (1.30b) Betulaefalia Pear (1.28c) Malus Apple (1.32a)							Kalamata olive (72.55a) Betulaefalia Pear (70.64b) Malus Apple (65.88c)						
	Terminal cuttings (1.30a) subterminal cuttings (1.29b)							Terminal cuttings (69.80a) subterminal cuttings (69.58b)						
LSD at 5% for interaction														
Season II (2013)														
Control "tap water"	0.00 j	0.00 j	0.00 j	0.00 j	0.00 j	0.00 j	**0.00 d**	0.00 l	0.00 l	0.00 l	0.00 m	0.00 l	0.00 m	**0.00 d**
500 ppm IBA	1.72 f	1.79 de	1.81 cd	1.76 ef	1.79 de	1.83bcd	**1.78 b**	110.2e	104.2f	112.9cd	101.5 g	104.6 f	104.2 f	**106.2b**
Antioxidant "Table beet"	1.57 hi	1.63 g	1.56 hi	1.55 i	1.64 g	1.60gh	**1.59 c**	78.60i	80.20hi	81.30h	76.40 j	74.20 k	75.60 jk	**77.72c**
500 ppm IBA + Antioxidant	1.87 ab	1.8abc	1.83bcd	1.86 ab	1.89 a	1.88 a	**1.86 a**	118.1a	112.7cd	116.3b	111.8 de	114.3 c	110.8 e	**114.0a**
Mean for:	Kalamata olive (1.30b) Betulaefalia Pear (1.30b) Malus Apple (1.33a)							Kalamata olive (75.50a) Betulaefalia Pear (75.03b) Malus Apple (72.96c)						
	Terminal cuttings (1.31a) subterminal cuttings (1.30b)							Terminal cuttings (75.88a) subterminal cuttings (73.12b)						
LSD at 5% for interaction														

Means followed by the same letter(s) within each column or row are not significantly different at 0.05 level, according to Duncan's multiple range test.

cuttings (65.88 and 72.96) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

In the same Tables, data revealed that, terminal cuttings of the three tested fruit species gave the highest values and significantly increased leaf Fe (ppm) content and recorded (69.80 and 75.88) as compared with the analogous ones of sub-terminal cuttings (69.58 and 73.12) in the first and second seasons, respectively. Whereas, data indicate that combination of 500 ppm IBA and antioxidant gave the highest leaf Fe (ppm) content as compared with control treatment which gave the lowest values.

In the same line, results proved that the interaction effect between the three tested factors indicated that the highest values in the two seasons came from terminal cutting of Kalamata olive treated with IBA 500 ppm + antioxidant. While, non-treated terminal or subterminal cuttings of Betulaefolia pear, Malus apple and Kalamata olive produced the lowest values of leaf Fe (ppm) content. Other tested combinations showed an intermediate values in this respect.

Leaf Organic Constituents

Soluble Phenol Content (%)

Results in Table (5) indicate that the cuttings of Malus apple achieved the highest values of soluble phenols content (0.15 and 0.15%). While, the least values of soluble phenols content were obtained by Kalamata olive and Betulaefolia pear cuttings (0.12 and 0.13) and (0.12 and 0.13) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

In the same Tables, data revealed that, sub-terminal cuttings of the three tested fruit species gave the highest values significantly increases of soluble phenols content and recorded (0.13 and 0.13%) as compared with the analogous ones of terminal cuttings (0.12 and 0.13%) in the first, on the contrary in second seasons, respectively.

Where as, data indicate that treated with antioxidant "Table beet" gave the highest soluble phenols content % as compared with control treatment which gave the lowest values.

In the same line, results proved that the interaction effect between the three tested factors indicated that the highest values in the two seasons came from sub-terminal cutting of Malus apple treated with antioxidant "Table beet". While, non-treated terminal or subterminal cuttings of Betulaefolia pear, Malus apple and Kalamata olive produced the lowest values of soluble phenols content (%). Other tested combination showed an intermediate values in this respect.

Soluble Indoles Content (%)

Results in Table (5) revealed that the cuttings of Kalamata olive achieved the highest values of soluble indoles content (2.42 and 2.66%), followed by Malus apple cuttings (1.90 and 2.00%). On the contrary, the least values of soluble indoles content were obtained by Betulaefolia pear cuttings (1.84 and 1.92%) in the first and second seasons, respectively. However, the differences between the three tested fruit species were significant from the statistical standpoint.

Whereas, terminal cuttings of the three tested fruit species gave the highest values of soluble indoles content and recorded (2.26 and 2.39%) as compared with the analogous ones of sub-terminal cuttings (1.85 and 1.99%) in the first and second seasons, respectively. And also, data indicate that the combination IBA and antioxidant enhanced soluble indoles content of the three tested fruit species cuttings as compared with control treatment which gave the lowest values.

Table (5): Effect of fruit species, cutting type and (IBA and antioxidant) on soluble phenol and indole content (%) of Kalamata Olive, Betulaefolia Pear and Malus apple under hydroponic system culture during 2012 and 2013 seasons.

Fruit species / Cutting type	Soluble Phenols (%)							Soluble Indoles (%)						
	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean	Kalamata olive		Betulaefalia Pear		Malus Apple		Mean
	Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal		Terminal	Sub-Terminal	Terminal	Sub-Terminal	Terminal	Sub-Terminal	
Season I (2012)														
Control "tap water"	0.00 k	0.00 o	0.00 k	0.00 o	0.00 k	0.00 o	**0.00 d**	0.00 q	0.00 r	0.00 q	0.00 r	0.00 q	0.00 r	**0.00 d**
500 ppm IBA	0.13 j	0.14 i	0.15 h	0.16 g	0.14 i	0.16 g	**0.15 b**	2.96 g	2.50 i	1.96 k	1.88 l	2.72 h	2.34 j	**2.39 b**
Antioxidant "Table beet"	0.21 d	0.25c	0.19 f	0.20 e	0.28 b	0.35 a	**0.25 a**	0.89 o	0.68 p	0.86 o	0.36 q	1.06 m	1.00 n	**0.81 c**
500 ppm IBA + Antioxidant	0.09 n	0.11m	0.13 k	0.11 l	0.12 l	0.13 k	**0.12 c**	7.25 a	5.10 b	4.98 c	4.71 d	4.46 e	3.62 f	**5.02 a**
Mean for:	Kalamata olive (0.12b) Betulaefalia Pear (0.12b) Malus Apple (0.15a) Terminal cuttings (0.12b) subterminal cuttings (0.13a)							Kalamata olive (2.42a) Betulaefalia Pear (1.84c) Malus Apple (1.90b) Terminal cuttings (2.26a) subterminal cuttings (1.85b)						
LSD at 5% for interaction														
Season II (2013)														
Control "tap water"	0.00 k	0.00 o	0.00 k	0.00 o	0.00 k	0.00 o	**0.00 d**	0.00 q	0.00 r	0.00 q	0.00 r	0.00 q	0.00 r	**0.00 d**
500 ppm IBA	0.15 gh	0.14gh	0.17 f	0.16 f	0.15 g	0.17 f	**0.16 b**	2.98 g	2.75 i	2.05 k	1.96 l	2.85 h	2.45 j	**2.51 b**
Antioxidant "Table beet"	0.25 c	0.23 d	0.21 e	0.21 e	0.29 b	0.32 a	**0.25 a**	0.92 n	0.87 o	0.94 n	0.42 p	1.18 m	1.20 m	**0.92 c**
500 ppm IBA + Antioxidant	0.12 ij	0.11 j	0.17 f	0.12 ij	0.13 i	0.14 h	**0.13 c**	8.14 a	5.60 b	5.10 c	4.86 d	4.57 e	3.77 f	**5.34 a**
Mean for:	Kalamata olive (0.13b) Betulaefalia Pear (0.13b) Malus Apple (0.15a) Terminal cuttings (0.13a) subterminal cuttings (0.13a)							Kalamata olive (2.66a) Betulaefalia Pear (1.92c) Malus Apple (2.00b) Terminal cuttings (2.39a) subterminal cuttings (1.99b)						
LSD at 5% for interaction														

Means followed by the same letter(s) within each column or row are not significantly different at 0.05 level, according to Duncan's multiple range test.

Data in same table of the interaction effect between the three tested factors indicated that the highest values in the two seasons came from terminal cutting of Kalamata olive treated with IBA 500 ppm + antioxidant. While, non-treated terminal or subterminal cuttings of Betulaefolia pear,

Malus apple and Kalamata olive produced the lowest values of soluble indoles content. Other tested combination showed an intermediate values in this respect.

REFERENCES

AOAC (1990). Official Methods of Analysis. 15th Ed., Association of Official Agriculture Chemists Washington D.C., USA.

Arteca, R.N. (1996). Plant Growth Substances: Principles and Applications. Chapman and Hall, New York.

Asl-Moshtaghi, E. and Shahsavar, A.R. (2011). The Effects of IBA and H_2O_2 on Rooting of two olive cultivars. Journal of Chemical Health Risks, 1(1): 35-38.

Bartolini, G.; Petrucceli, R. and Pestelli, P. (2008). Preliminary study on *in vivo* rooting of two *Olea europaea* L. genotypes. Acta Hort., 791:191-195.

Brown, J.D. and Lilleland, O. (1949). Rapid determination of potassium and sodium in plant material and soil extracts by flamephotometery. Proc. Ame. Soc. Hort. Sci., 48: 341-346.

Cetintas, A. and Ozkaya, M. (2005). Effects of cutting size, rooting media and planting time on rooting of Domat and Ayvalik olive (*Olea europaea* L.) cultivars in shaded polyethylene tunnel. Tarim Bilimleri Dergisi., 11: 334–338.

Dauod, D.A.; Agha, J.T.; Abu-lebda, K.H. and Al-khaiat, M.S. (1989). Influence of IBA on rooting of leafy olive cuttings. Sci. and Tech., 6(27): 28-30.

Duncan, B.D. (1955). Multiple Range and Multiple F test. Biometrics, 11:1-42.

Eugene, K.; Sibley, J.L.; Tilt, K.M. and Ruter, J.M. (2007). Methods of auxin application in cutting propagation: A review of 70 years of scientific discovery and commercial practice. J. Environ. Hort., 25(3): 166–185.

Fernandes, J.M.; Serrano, M.C. and Amaral, E. (2002). Effect of different hormone treatments on rooting of *Olea europaea* cv. Galega vulgar cuttings. Acta Hort., 586: 875-877.

Fischl, J. and Rabiah, S. (1964). Determination of Free and Total Indole-3-acetic Acid and of the Indole Index. Ame. Association of Clinical Chem., 10 (4): 281-291.

Fontanazza, G. (1996). Genetic aspects and propagation techniques for intensive cultivation. World Olive Encyclopedia. Proc. Int. Olive Oil Council, Principe de Vergara, Madrid, Spain., 154: 113 -144.

Hansen, O.B. (1989). Propagating apple rootstocks by semi-hardwood cuttings. Norwegian J. Agric. Sci., 3 (4): 351-365.

Hartmann, H.T.; Kester, D.E.; Davies, F.T. and Geneve, R.L. (2002). Hartmann and Kester's Plant Propagation: Principles and Practices. 7th Ed. Prentice Hall, Upper Saddle River, NJ.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice hall Inc. Englewood Cliffs, NJ, USA.

Lin, H.S. and Lin, C.H. (1990). Rooting of semi-hardwood and hardwood cuttings of oriental pear (*Pyrus serotina* Rehd.). Garten Bauwissen Schaft, 55(2): 66-68.

Ludwig-Müller, J. and Epstein, E. (1994). Indole-3-butyric acid in *Arabidopsis thaliana* III. *In vivo* biosynthesis. Plant Growth Regulat., 14:7–14.

Ludwig-Müller, J.; Sass, S.; Sutter, E.G.; Wodner, M. and Epstein, E. (1993). Indole-3-butyric acid in *Arabidopsis thaliana* I. Identification and quantification. Plant Growth Regulat., 13: 179–187.

Macdonald, B. (1987). Practical Woody Plant Propagation for Nursery Growers. Timber Press, Portland, OR.

Ozelbaykal, S. and Gezerel, O. (2005). The effects of the different dose of IBA on the rooting performance in the reproduction of (Gmilk) and (Domat) olive trees by using the green twig procedure in the ecology of cukurova region. J. Cent. Europ. Agric., 6: 481-484.

Pregl, F. (1945). Quantitative Organic Micro-Analysis. 4th Ed. and A. Churchill, LTD London.

Rugini, E. and Fedeli, E. (1990). Olive as oil seed crop. In: J.P.S. Bajai (ed), Biotechnology in agriculture and foresty, Vol. 10, Legumes and oil seed crops I. Springes-Verlag Berlin, Heiderbeg.

Russell, D.F. (1986). MSTATC Director, Crop and Soil Sci. Dept., Michigan State Univ., Computer Program Package Version 2. 10.

Thimann, K.V. and Koepfli, J.B. (1935). Identity of the growth promoting and root-forming substances of plants Nature, 135: 101–102.

Tincker, M.A.H. (1936). The relation of growth-substances, or hormones, to horticultural practice: A review. J. Royal Hort. Soc., 61: 380– 388.

Wiesman, Z. and Epstein, E. (1987). Metabolism and transport of 5-H-indol-butyric acid in cuttings of olive Olea, 18: 29-33.

Wiesman, Z. and Lavee, S. (1994). Enhancement of IBA stimulatory effect on rooting of olive cultivar stem cuttings. Sci. Hort., 62: 189-198.

الملخص العربى

تأثير بعض منظمات النمو ومضادات الأكسدة على القدرة التجذيرية لعقل بعض أنواع الفاكهة تحت نظام الزراعة الهيدروبونيك

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أجريت هذه الدراسة خلال موسمي ٢٠١٢ و٢٠١٣ م بهدف دراسة تأثير بعض منظمات النمو ومضادات الأكسدة المستخلصة من البنجر على المقدرة التجذيرية لعقل بعض أنواع الفاكهة صعبة الإكثار بالعقلة وهي الزيتون الكلاماتا وأصل الكمثرى بيتشيفوليا وأصل التفاح مالص. أجريت هذه التجربة في إحدى المزارع الخاصة، بالقرب من مدينة السادات، حيث أخذت العقل من خشب ناضج عمر عام في الأسبوع الأخير من نهاية شهر يناير خلال موسمين متتاليين من ثلاثة أنواع وهى الزيتون، الكمثرى، والتفاح. تم إعداد العقل بطول (٥٠- ٧٠ سم) ووضعها فى أكياس بلاستيك سوداء للحفاظ على الرطوبة لحين الوصول للمشتل. قد أعدت في الصباح الباكر لليوم التالى حيث قطعت إلى عقل طرفية بمتوسط طول من ١٢-١٥ سم وقطر يتراوح بين (٢-٣ ملم) مع وجود براعم طرفية. في حين كان متوسط طول العقل القاعدية من ١٥-١٨ سم، و٣-٤ ملم في القطر. وتم القطع للعقل أسفل برعم جانبى وتم ترك من (٤-٥) ورقات فقط على الجزء العلوى من عقل الزيتون. وتم معاملة قواعد العقل باحدى المعاملات التالية (الغمس في محلول أندول حمض البيوتيريك بتركيز ٥٠٠ جزء فى المليون لمدة ٥ ثوانى - النقع في محلول مستخلص البنجر (٥ جرام بنجر/ لتر) لمدة ٣٠ دقيقة، الغمس في محلول اندول حمض البيوتيريك بتركيز ٥٠٠ جزء فى المليون لمدة ٥ ثوانى، ثم النقع في مُستخلص البنجر لمدة ٣٠ دقيقة. وقد غمرت قاعدة كل القطع لمدة ٤٨ ساعة فى ماء جارى قبل الغرس قبل المعاملة. نظمت المعاملات في تصميم تام العشوائية، مع ثلاث مكررات لكل معاملة، وقد مثلت كل مكررة بـ ٦ عقل وأوضحت النتائج أن المعاملة بأندول حمض البيوتيريك بتركيز ٥٠٠ جزء في المليون مع مضادات الاكسدة (مستخلص البنجر) على العقل الطرفية للزيتون كلاماتا سجلت اعلى قيمة لعدد الجذور، ونسبة التجذير بالمقارنة بالعقل القاعدية في حين سجل أصل الكمثرى البيتشيفوليا أقل قيمة لنسبة التجذير، وعدد الجذور وكانت أقل قيمة للتجذير، وعدد الجذور من نصيب معاملة المقارنة. وسجل أصل التفاح مالص أعلى معدل للتفريع، وعدد الاوراق وذلك تحت تأثير المعاملة أندول حمض البيوتيريك بتركيز ٥٠٠ جزء في المليون مع مضادات الأكسدة (مستخلص البنجر) وكانت أقل نسبة تفريع من نصيب زيتون كلاماتا، وقد أعطت العقل القاعدية أعلى معدلات للتفريع، وعدد الأوراق بالمقارنة بالعقل الطرفية، في حين كانت العقل الطرفية لأصل التفاح ملص المرتبة الأولى فى محتواه من العناصر الكبرى N.P.K، بينما أحتل الزيتون كلاماتا المرتبة الاخيرة فى محتواة من العناصر الكبرى والمرتبة الأولى فى تركيز عنصر الحديد Fe، بينما سجل أصل البيتشيفوليا أقل قيمة فى إحتوائه على عنصر الحديد Fe. وكانت أعلى قيمة للعناصر الكبرى والصغرى من نصيب المعاملة ب ٥٠٠ جزء في المليون من أندول حمض البيوتيريك مدعماً بمضادات الأكسدة (مستخلص البنجر) بينما كانت أقل قيمة للعناصر من نصيب معاملة المقارنة. فيما يتعلق بمحتوى الأوراق من الفينولات والاندول فقد أعطت المعاملة بأندول حمض البيوتيريك ٥٠٠ جزء في المليون مع مضادات الاكسدة (مستخلص البنجر) على العقل الطرفية لأصل التفاح مالص أعلى نسبة من الفينولات، وعلى العكس فقد سجلت العقل القاعدية للزيتون الكلاماتا أعلى قيمة فى إحتوائها على الأندول.

الكلمات الاسترشادية: منظمات النمو، مضادات الأكسدة، القدرة التجذيرية، نظام الزراعة الهيدروبونيك، الزيتون، الكمثرى، والتفاح.

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