EFFECT OF SOME FACTORS ON ROOTING PERCENTAGE AND SUBSEQUENT GROWTH OF MANZANILLO OLIVE CUTTINGS (*Olea europea* L.)

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ABSTRACT

Two separate factorial experiments were conducted during 2004 and 2005 seasons to study rooting and subsequent growth of Manzanillo olive cuttings. The first one study of seven dates of cuttings collection from (1st January to 1st July), monthly intervals and cutting position on the shoot (terminal with 2-3 mm, median with 4-5 mm and basal with 6-8 mm in diameter). While the second experiment include study three dates of cuttings collection (1st April to 1st June), monthly intervals, cutting position on the shoot (median with 3-5 mm and basal with 6-8 mm in diameter), and soaking the cuttings in 4 concentrations of IBA solution 0, 1000, 2000 and 3000 mg.l^{-1} for 5 seconds. The results revealed that the maximum rooting percentage and number of roots per cutting (65.10% and 14.10 respectively) were on basal cuttings which were collected on the 1st of May in the first experiment. While the semi-hardwood basal cuttings with 6-8 mm in diameter which have been collected on the 1st of May and treated with 3000 mg IBA.l^{-1} showed superior rooting percentage, roots number per cutting, root length and shoot length (87.30%, 24.50, 11.40 cm and 10.30 cm respectively) in the second experiment.

INTRODUCTION

Olive trees (*Olea europea* L.) is mentioned both within the Bible and Quran in the context of certain religious events (Tubeileh *et al*., 2004). It is the most important fruit tree in the Mediterranean area (Al-Dehadheh, *et al*., 2004). Manzanillo is the most important table olive variety and the moderate-rooting percentage between 31% - 50% (Wiesman and Lavee, 1995; Tubeileh *et al*., 2004). Many cultivars of olive are mostly propagated by budding or grafting onto seedling, clonal rootstocks, hardwood, semi-hardwood cuttings, or suckrers for old trees (Tubeileh *et al*., 2004). The type of wood, the stage of plant growth at which cuttings are harvested in the time of the year when the cuttings are taken are some of the important factors that influence rooting of plants (Hartmann, *et al.,* 2002). The major constraint in cultivation of the European type of olive (*Olea europea*) is the difficulty to root from its cuttings, with rooting success being low even when the cuttings are treated with up to 3000 ppm IBA solution (Awan *et al*., 2003). Auxins which are plant growth regulators, are well documented as dominating the rooting process of cuttings and they are most widely used to induce adventitious rooting in cuttings (Davis and Hissing, 1990). Treating cuttings with auxins increases the number of cutting that form roots, hastens root initiation, and enhances uniformity of rooting (Hartmann, *et al*., 2002). Indol-3-butyric acid (IBA) is a commercial auxin, that also occurs naturally in many plants.

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It is the preferred one in plant propagation in general because it is nontoxic to plants over a wide concentration range, and it is effective in promoting rooting of a large number of plant species (Nickell, 1982; Hartman, *et al*., 2002). Many researchers have studied the effect of plant section, dates of preparing cuttings and treatment with IBA on rooting ability of olive cuttings as Ibrahim *et al*. (1988) on Ascolano and Frantio cultivars, Ayoub (1994) on cv. Nabali, Wiesman and Lavee (1995) on the cultivars Barnea, Manzanillo and Kalamata, Al- Allaf (2002) on Bashika cultivar, Al- Shawish and Abdul-Hussean (2004) on Ashrasi and Khastawi cultivars, and Khorshid & Abdul (2005) on Ashrasy cultivar).

The present study aims to improve the rooting ability and subsequent growth of *Olea europea* cv. Manzanillo under Mosul region conditions.

MATERIALS AND METHODS

Olive cuttings: Two separate rooting experiments were conducted in the two successive seasons of 2004 and 2005, in a plastic house at the Department of Horticulture and Landscape Design of College of Agriculture and Forestry, University of Mosul, Iraq. The cuttings were prepared from the middle region of uniformly distributed one year old shoots which were collected from 35-year old mother olive trees of Manzanillo cultivar growing at the Nineveh Horticulture Research Station, at Mosul, Iraq. Each length of cuttings are 15 cm length and all leaves removed except the four upper ones on each cutting .

Experiment (1)*:* This experiment was performed in the season of 2004 to determine the effect of cutting position and 7 dates of preparing cuttings. Cuttings were prepared on monthly intervals between 1st of January and 1st of July. For each sampling date, each shoot was divided into 3 portions according to their diameter at the base of cuttings: terminal 2-3 mm in diameter, median 4-5 mm in diameter and basal stem cuttings with 6-8 mm in diameter. Samples from branches were randomly collected at all dates. The cuttings were inserted into a plastic boxes (60×20×30cm) filed with sand and peatmoss (1:1 v/v). The boxes were arranged in a completely randomized design with three replications of 20 cuttings per replicate of each treatment (Roger Mead and Hasted, 2003). The cuttings were inserted to a half of their length in the rooting media on the same day they were taken, and they were watered and sprayed carefully to maintain moist and high level of humidity until they rooted (Hartman, *et al*., 2002). Cuttings were harvested after 120 days from planting and evaluated for the rooting percentage and the average number of roots per cutting.

Experiment (2): A Factorial experiment was carried out during the spring of 2005 to determine the effect of cutting position, 3 dates of preparing cuttings 1st April, 1st May and 1st June and treatment with different IBA concentrations 0 -control, 1000, 2000 and 3000 mg.l^{-1} on the rooting of olive cuttings cv. Manzanillo were category in two groups according to their base diameter, basal 6-8 mm in diameter and median for those with 3-5 mm in diameter.

Samples from branches were randomly collected at all dates. The basal portion to 2cm of the cuttings were dipped in the IBA solution 0, 1000, 2000 and 3000 $mg.l^{-1}$ for 5 seconds. After that each cutting was inserted to one half of its length into the prepared holes in the rooting medium containing a mixture of sand and peatmoss (1:1 v/v), on the same day. Cuttings were firmed using fingers, put under the plastic house and irrigated carefully to maintain sufficient moist. After 120 days from planting, the cuttings were extirpated from medium, and the following characteristics were recorded: rooting percentage, number of roots per cutting, root length (cm) and shoot length (cm).

Carbohydrate determination: At the begening of each date (1st April, 1st May and 1st June,2005), basal ends of cuttings (2 cm long) were cutting divided into a sub sample, which dried at 80 ˚C for 24 hrs and powdered to determine the carbohydrate content using 5% phenol solution and concentrated sulfuric acid. Spectrophotometer reading was taken at 490 nm according to Joslyn (1970).

The factorial experiment was planned in a completely randomized design (CRD) with three replicates : 20 cuttings per replicate.

Data analysis: Data were subjected to analysis at variance and Duncan´s Multiple Range Test to compare treatment means using SAS program (Anonymous, 2001, Roager Mead and Hasted, 2003).

RESULTS AND DISCUSSION

In the first experiment, the cuttings were collected on the 1st of May resulted into the highest number of rooted cuttings (48.56%) and number of roots per cutting (9.87), which was significantly higher when superiority as compared to (Table 1a,1b). With regard to the position of semi-hardwood cuttings, the highest percentage of rooted cuttings and the number of roots per cutting (29.94% and 8.07 respectively) were obtained on the basal stem cuttings with 6-8 mm in diameter, and they were significantly superior to the terminal and median cuttings. Overall, the highest percentage of rooting and the number of roots per cutting (65.10% and 14.10, respectively) were obtained on the basal cuttings harvested on 1st May.

Table (1) a: Effect of date of preparing cuttings and cutting position on rooting of olive cuttings cv. Manzanillo.

Cutting position	Date of preparing cuttings							Mean of cutting position
	1st Jan.	1st Feb.	1st March	1st April	1st May	1st June	1st July	
Terminal	1.5 o	3.8 n	10.30 l	16.10 k	22.97 h	20.00 i	16.10 k	12.97 c
Median	2.30 o	7.2 m	17.20 j	37.60 e	57.60 b	39.8 d	27.10 g	26.97 b
Basal	3.70 n	9.30 l	19.80 i	40.30 d	65.10 a	41.7 c	29.70 f	29.94 a
Mean of dates of preparing cuttings	2.50 g	6.77 f	15.77 e	31.33 c	48.56 a	33.8 b	24.30 d	

Table (1) b : Effect of date of preparing cuttings and cutting position on number of roots per cutting of olive cv. Manzanillo

Terminal	1.50 l	1.90 l	2.30 j-l	3.10 h-j	3.80 gh	3.70 gh	3.10 h-j	2.77 c
Median	2.00 kl	2.80 i-k	3.30 hi	7.90 f	11.70 c	10.50 d	9.80 de	6.86 b
Basal	2.30 kl	3.10 h-j	4.50 g	10.10 de	14.10 a	12.80 b	9.60 e	8.07 a
Mean of dates of preparing cuttings	1.93 g	2.60 f	3.37 e	7.03 d	9.87 a	9.00 b	7.50 c	

Means followed by the same letter along the column are not significantly difference ($P \leq 0.05$).

In the second experiment the results revealed that the basal cutting had significantly higher rooting percentage, root numbr, root length and shoot length , when compared to median cuttings with 3-5 mm in diameter (Table 2). This observation could be related to the chemical composition and morphology of such shoots, since the number of preformed root initials in woody stems distinctly decreases from the base to the tip of the shoot (Haissing, 1972). As well as, the carbohydrate concentration in the basal cuttings (Table.7) may be enhance rooting percentage and subsequent cutting growth. The results in the same table showed that cuttings collected on 1st of May had significantly higher rooting percentage, root number per cutting, root length and shoot length (75.55% ; 18.16 ; 10.16 cm and 8.84 cm, respectively) as compared to other collection dates of cuttings. Based on these findings, 1th May would be the optimal time for cuttings collection, which is more related to the physiological condition of the plant, during which the response of the cutting to environmental conditions is favorable (Hartmann, *et al*., 2002). The time in which cuttings are taken, can play an important role in rooting and there is an optimal period of the year for rooting (Anand and Herber, 1975;Harrison-Murray, 1991). Thus, establishing the time intervals of adventitious root initiation and development enables correlation of sequential physiological and histological events in rooting (Geneve and Kester, 1991). In addition to, the carbohydrate content in the basal cuttings (Table.7) may be improve rooting percentage and subsequent cutting growth.

Table (2): Effect of date of preparing cuttings, cutting position and IBA on some characteristics of olive cuttings cv. Manzanillo.

Characteristics Studied	Mean of cutting position		Mean of date preparing cuttings			Mean of IBA concentrations mg.l^{-1}			
	Basal	Median	1stApril	1stMay	1stJune	0	1000	2000	3000
Rooting ability (%)	59.87 a	55.38 b	46.29 c	75.55 a	51.03 b	48.57 d	55.43 c	61.20 b	65.28 a
Number of roots per cutting	15.92 b	13.46 a	10.74 c	18.60 a	15.70 b	11.06 d	14.03 c	15.96 b	17.70 a
Root length (cm)	9.94 a	9.58 a	8.83 c	10.43 a	10.13 b	8.912 b	9.60 ab	10.08 a	10.43 a
Shoot length (cm)	7.95 a	7.46 b	7.30 b	8.84 a	6.98 b	6.57 c	7.43 b	8.20 a	8.62 a

A same letter in the column indicates that there is no significant difference ($p<0.05$)

The data presented in Table (2) indicate that IBA promoted the adventitious root formation on the stem cuttings and consequently root number, root length

and shoot length. Rooting increased proportionately with increasing in IBA concentrations and was highest for the cuttings soaked in 3000 mg.l^{-1}. This level gave the highest rooting percentage, root number, root length and shoot length (65.28%; 17.70; 10.43 cm and 8.62 cm, respectively), and was significantly superior over the other IBA concentrations. Soaking cuttings in water without IBA gave the lowest rooting percentage, number of root per cutting, root length and shoot length (48.57%; 11.06; 8.92 cm and 6.57 cm, respectively). These increases in growth parameter at the higher IBA rates would be expected due to the effect of plant growth regulator. The most reliable growth regulators in stimulating adventitious root production in cuttings are the auxin: Indol- 3- butyric acid (IBA) IBA enhances rooting via increased internal-free IBA, or may synergistically modify the action of IAA or increase endogenous synthesis of IAA and increased endogenous IAA and Indol-3- acetyl- aspartic acid (IAA-sp) before root differentiation occurs (Vander- Krieken *et al.*, 1994;Garicia-Gomez, *et al.*, 1994). High auxin concentration stimulates ethylene production, and it has been shown that ethylene alone can stimulate adventious rooting in cuttings. Adventitious root formation is a direct response to auxin or due to auxin-stimulated-ethylene production (Hopkins and Hüner, 2004). This was because IBA treatment inhibits budbreak during the rooting of cutting, primarily due to elevated ethylene levels, as demonstrated by (Rivo and Yang, 1989; Sun and Bassuk, 1993). It has been reported that IBA stimulates meristematic activity in the base zone of the cuttings (Wiesman and Lavee, 1995). The data presented in Tables (3,4,5 and 6) that good response of rooting percentage and vegetative growth and parameters of roots by all interactions between the study factors. Generally, semi-hardwood basal cuttings of Manzanillo cultivar with 6-8 mm in diameter which have been taken on the 1st of May and treated with 3000 mg IBA.l^{-1} showed superior effect in rooting percentage, roots number per cutting, root length and shoot length (87.30%, 24.50, 11.40 cm and 10.30 cm, respectively.

Table (3)a: Effect of date of preparing cuttings, cutting position and IBA on zooting ability of olive cuttings cv. Manzanillo.

Concentrations of IBA mg.l^{-1}	Date of preparing cuttings					
	1st of April		1st of May		1st June	
	Cutting position					
	Basal	Median	Basal	Median	Basal	Median
0	38.40 mn	36.80 n	67.30 de	64.70 e	43.40 j-l	40.80 L-n
1000	47.30 ij	41.70 k-m	76.10 c	70.10 d	50.30 hi	47.10 ij
2000	50.10 ih	45.80 i-k	81.80 b	77.80 bc	58.60 f	53.10 gh
3000	58.10 f	52.10 gh	87.30 a	79.30 bc	59.70 f	55.20 fg

Table (3)b: Effect of date of preparing cuttings and IBA on rooting ability of olive cuttings.

Dates	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
1st April	37.60 h	44.50 g	47.95 f	55.10 e

1st May	66.00 d	73.10 c	79.80 b	83.30 a
1st June	42.10 g	48.70 f	55.85 e	57.45 e

Table (3)c: Effect of date of preparing cuttings and cutting position on rooting ability of olive cuttings cv. Manzanillo.

Cutting Position	Date of preparing cuttings		
	1st of April	1st of May	1st June
Basal	48.48 d	78.13 c	53.00 c
Median	44.10 e	72.98 b	49.05 d

Table (3)d: Effect of cutting position and IBA on rooting ability of olive cuttings cv. Manzanillo.

Cutting Position	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
Basal	49.70 e	57.90 c	63.50 b	68.37 a
Median	47.43 e	52.97 d	58.90 c	62.20 b

A same letter in the column indicates that there is no significant difference ($p<0.05$).

Table (4)a: Effect of date of preparing cuttings, cutting position and IBA on number of roots per cutting of olive cv. Manzanillo.

Concentrations of IBA mg.l^{-1}	Date of preparing cuttings					
	1st of April		1st of May		1st June	
	Cutting position					
	Basal	Median	Basal	Median	Basal	Median
0	9.80 i-k	7.60 k	14.70 fg	11.10 h-j	12.77 gh	10.40 h-j
1000	11.40 h-j	9.30 jk	17.30 de	17.20 de	16.90 d-f	12.10 hi
2000	12.30 g-i	11.10 h-i	20.10 bc	19.30 b-d	18.38 c-e	14.60 fg
3000	12.80 gh	11.60 h-i	24.50 a	21.10 b	20.10 bc	16.10 ef

Table (4)b: Effect of date of preparing cuttings and IBA on number of roots per cutting of olive cv. Manzanillo.

Dates	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
1st April	8.70 g	10.35 f	11.70 ef	12.20 e
1st May	12.90 e	17.25 c	19.70 b	22.80 a
1st June	11.59 ef	14.50 d	16.49 c	18.10 c

Table (4)c: Effect of cutting position and IBA on number of roots per cutting of olive cv. Manzanillo.

Cutting Position	Date of preparing cuttings		
	1st of April	1st of May	1st June
Basal	11.58 d	19.15 a	17.03 b
Median	9.90 e	17.18 b	13.30 c

Table (4)d: Effect of date of cutting position and IBA on number of roots per cutting of olive cv. Manzanillo.

Cutting Position	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
Basal	12.42 d	15.20 c	16.93 b	19.13 a
Median	9.70 e	12.87 d	15.00 c	16.27 bc

A same letter in the column indicates that there is no significant difference ($p<0.05$)

Table (5)a: Effect of date of preparing cuttings, cutting position and IBA on root length (cm) of olive cuttings cv. Manzanillo.

Concentrations of IBA mg.l^{-1}	Date of preparing cuttings					
	1st of April		1st of May		1st June	
	Cutting position					
	Basal	Median	Basal	Median	Basal	Median
0	8.30 cd	8.10 d	9.70 a-d	9.20 a-d	9.20 a-d	9.00 b-d
1000	8.90 b-d	8.30 cd	10.30 a-d	10.10 a-d	10.20 a-d	9.80 a-d
2000	9.10 a-d	8.90 b-d	10.90 ab	10.80 ab	10.60 a-c	10.20a-d
3000	9.80 a-d	9.20 a-d	11.40 a	11.00 ab	10.90 ab	10.30 a-d

Table (5)b: Effect of date of preparing cuttings and IBA on root length (cm) of olive cuttings cv. Manzanillo.

Dates	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
1st April	8.20 e	8.60 de	9.00 c-e	9.50 b-e
1st May	9.45 b-e	10.20 a-c	10.85 ab	11.20 a
1st June	9.10 c-e	100.00a-d	10.40 a-c	10.60a-c

Table (5)c: Effect of date of preparing cuttings and cutting position on root length (cm) of olive cuttings cv. Manzanillo.

Cutting Position	Date of preparing cuttings		
	1st of April	1st of May	1st June
Basal	9.03 bc	10.58 a	10.23 a
Median	8.63 c	10.28	9.83 ab

Table (5)d: Effect of cutting position and IBA on root length (cm) of olive cuttings.

Cutting Position	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
Basal	9.07 de	9.8 bc	10.2 ab	10.7 a
Median	6.77 e	9.40 cd	9.97 bc	10.17 ab

A same letter in the column indicates that there is no significant difference ($p<0.05$)

Table (6)a: Effect of date of preparing cuttings, cutting position and IBA on shoot length of olive cuttings cv. Manzanillo.

Concentrations of IBA mg.l^{-1}	Date of preparing cuttings					
	1st of April		1st of May		1st June	
	Cutting position					
	Basal	Median	Basal	Median	Basal	Median
0	6.50 g-j	6.10 h-j	7.90 c-g	7.30 e-h	5.90 I	5.70 j
1000	7.70 d-g	6.70 f-j	8.60 b-e	8.10 c-f	6.70 f-h	6.80 f-j
2000	7.90 c-g	7.50 e-h	9.40 a-c	9.20 a-d	8.10 c-f	7.10 f-j
3000	8.20 c-f	7.80 d-g	10.30 a	9.90 ab	8.20 c-f	7.30 e-h

Table (6)b: Effect of date of preparing cuttings and IBA on shoot length of olive cuttings cv. Manzanillo.

Dates	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
1st April	6.30 ef	7.20 c-e	7.70 b-d	8.00 bc
1st May	7.60 b-d	8.35 b	9.30 a	10.10 a
1st June	5.80 f	6.75 d-f	7.60b-d	7.75 b-d

Table (6)c: Effect of date of preparing cuttings and cutting position on shoot length of olive cuttings cv. Manzanillo.

Cutting Position	Date of preparing cuttings		
	1st of April	1st of May	1st June
Basal	7.58 b	9.05 a	7.23 bc
Median	7.03 bc	8.63 a	6.73 c

Table (6)d: Effect of cutting position and IBA on shoot length of olive cuttings cv. Manzanillo.

Cutting Position	IBA concentrations mg.l^{-1}			
	0	1000	2000	3000
Basal	6.77 de	7.67 bc	8.47 ab	8.90 a
Median	6.37 e	7.20 cd	7.93 bc	8.33 ab

A same letter in the column indicates that there is no significant difference ($p< 0.05$)

Basal cuttings collected on 1st May had the highest total carbohydrate content (27.80%) at the basal end, as compared to the other collection dates. Previous studies have reported best rooting of cuttings when more stored carbohydrate and less nitrogen were available at the of the cuttings (Hartnann, *et al*., 2002). Carbohydrates have been shown to affect auxin metabolism and the low carbohydrate content may a major reason for inhibited development and poor survival of rooted plants (Meir *et al*., 1989; and Wiesman and Lavee, 1995).

Table (7): Effect of date of preparing cuttings and cutting position on carbohydrate percentage of olive cuttings cv. Manzanillo.

Cutting position	Date of preparing cuttings			Rate of cutting position
	1st April	1st May	1st June	

Median	21.30 c	24.49 b	19.40 cd	21.73 b
Basal	23.67 b	27.80 a	19.00 d	23.49 a
Rate of dates	22.49 b	26.15 a	19.20 c	

A same letter in the column indicates that there is no significant difference ($p<0.05$)

تأثير بعض العوامل في نسبة التجذير والنمو اللاحق لعقل الزيتون صنف مانزينلو (*Olea europaea* L.)

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الخلاصة

نفذت تجربتين عامليتين منفصلتين خلال موسمي ٢٠٠٤ و٢٠٠٥ لدراسة تجذير ونمو عقل الزيتون صنف مانزينلو. تم دراسة تأثير سبعة مواعيد لجمع العقل شهريا" (من الاول من كانون الثاني الى الاول من تموز ٢٠٠٤) وموقع العقلة على الفرع (عقل طرفية بقطر ٢-٣ ملم وعقل وسطية بقطر ٤-٥ ملم وعقل قاعدية بقطر ٦-٨ ملم) في التجربة الاولى . بينما في التجربة الثانية تم دراسة تأثير مواعيد جمع العقل (من ١/نيسان الى ١/حزيران شهريا" أيضا") وموقع العقلة على الفرع (عقل وسطية بقطر ٣-٥ ملم وعقل قاعدية بقطر ٦-٨ ملم) والتي تم غمرها في أربعة تراكيز من محلول الـ IBA هي صفر و ١٠٠٠ ، ٢٠٠٠ و ٣٠٠٠ ملغم IBA .لتر$^{-1}$ ولمدة خمسة ثواني. أشارت النتائج الى الحصول على اكبر نسبة تجذير للعقل وعدد الجذور١ ٦٥ % و١ ١٤ على التوالي لعقل الزيتون القاعدية المأخوذة في الاول من شهر ايار ٢٠٠٤ في التجربة الاولى. بينما تم الحصول من العقل القاعدية بقطر ٦ -٨ ملم والمأخوذة في الاول من شهر أيار والمعاملة بتركيز ٣٠٠٠ ملغمIBA.لتر$^{-1}$ ٣٠ ٨٧ % و٥ ٢٤ و٤ ١١ سم و ١٠ سم لنسبة التجذير وعدد الجذور وطول الجذر وطول الفرع على التوالي في التجربة الثانية .

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