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Comparative Study of the Ability of Some Olive Genotypes to Root

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ABSTRACT

This investigation was carried out during the growing seasons of 2022 and 2023 in the experimental farm of Horticulture Research Institute, Agriculture Research Center, Giza, on sub-terminal cuttings of eleven distinctive Olive genotypes resulting through the Olive Genetic improvement program in Egypt, to identify the ability of these genotypes to root formation under treatment with aqueous solution of Indole butyric acid (IBA) at 5000 ppm (that commonly used in Olive propagation), then it was planted under mist condition on planting dates (January, April, July and October). The results revealed a relationship between each of planting date, endogenous constituents, anatomical examination and cability of cuttings to root. The highest increment in root formation was attained by genotype (102) that may be due the increases in carbohydrates, nitrogen content, C/N ratio and total indoles. Moreover, the anatomical study, showed that, the sclerenchyma ring does not remain conjunctiva and disappear during the rooting period that leads to rapid forming adventitious root. Otherwise, the genotype (52) and (99) achieved the low formation of roots; it may be attributed to the decrease in total indoles, carbohydrates, nitrogen content and C/N ratio that important in root formation. Additionally, low rooting percentage might be due the existence of continuous chlorenchyma sheath that forming mechanical barrier to emerge newly roots that decreases the initiate adventurous root from coming out. The eleven genotypes categorized into three groups: genotypes (102 and 66) easy-to-root, moderate as (97, 91, 69, 32 and 138) and difficult-to-root as (92, 99, 48 and 52).

Keywords: Olive genotype – Rooting ability – Propagation – Stem cutting

INTRODUCTION

Olive (*Olea europaea* L.) belongs to family Oleaceae, genus Olea. It is one of the most important and oldest fruit trees in the world native to coastal area of Eastern of Mediterranean Basin, that produces more than (95%) of the olive oil and (75%) of table olive (Vossen, 2007). In the past, sexual propagation by seed was the method that used in propagation, but, the produced plants are not true to the type and take much more time for bearing fruit (Shimon and Giora, 2014). New olive orchards are being planted outside the Mediterranean, calling for an effort to identify the genotypes best adapted to the new conditions, Therefore, using sexual propagation not recommended. Vegetative propagation methods are usually being used for commercial propagation in olive, it is considered to be favorable, easy, an inexpensive and appropriate for mass plant production in a short time (Mikhail, 2015). Rooting by stem cuttings is one of the easiest and economical propagation methods, however difficult to root is one of the major obstacles to economical propagation of many olive cultivars (Gerrakakis and Ozkaya, 2005). A wide difference in the rooting potential of olive cultivars that led to categorized these cultivars into groups (easy, moderate and difficult -to- root) as their ability to root (Fabbri et al., 2004).

Differences in the ability of cuttings to root may be due to several factors as: physiological, biochemical, anatomical, and environmental factors (Pio and Berti, 2005). Adventitious rooting process in cuttings is still unraveled under the genetic point of view, auxin is still having the greatest effect on rooting (Hartmann et al., 2011). Indole butyric acid (IBA) applications had been reported to be successful for rooting of olive cuttings as it helps to promote adventitious root formation in cuttings (Kurd et al., 2010).

Physiological processes of rooting initiation are very complex and it is controlled by several factors as type of cuttings, anatomical structure, environmental conditions, hormone concentration and planting date, not only one factor controlled of rooting ability but constellation between them (Muhammad et al., 2022)

Variations in rooting of cuttings have been associated with the changes in the levels of endogenous growth regulators and other metabolites. Such regulatory processes are controlled through qualitative and quantitative changes in enzymes, such as peroxidases, IAA-oxidase and polyphenol oxidase (Turkoglu and Durmus ,2005). Carbohydrates have been considering optimal markers and the main energetic resource during the rooting formation. The levels of total carbohydrates and C/N ratio in the cuttings are positively related to the rooting formation (Rahman et al., 2002 and Bartolini et al., 2008). In Egypt, as a result of increasing olive cultivation during the last few decades at a remarkable rate, therefore, producing the newly genotypes that achieved accepted agronomical behaviors and quality of the oil become important as many of newly introduced genotypes that resulted from the program of olive improvement in horticultural research institute (Mikhail, 2015), studying the rooting ability of these genotypes are very important to identify the differences among these genotypes before cultivated in newly reclaimed areas (Shimon and Giora, 2014).

The present experiment was set up to identify rooting ability of sub-terminal eleven olive genotypes cuttings, derived through genetic improvement program of olive; these olive genotypes have been previously evaluated for agronomical behaviors and quality of the oil to form adventitious roots and identify the easy and difficult genotypes to root.

MATERIALS AND METHODS

Site description: The present study was conducted in the experimental orchard of Horticulture Research Institute, Giza, Egypt, during 2022 and 2023 seasons.

Plant material: Eight years-old of tested genotypes that selected for their good agronomical characteristics were grouped as shown in **Table (1).**

Table (1). The genotypes sources as the project map of olive improvement program.

	Genotypes number as a project map	Mothers	Derived from	Purpose
1	97	Manzanillo	open pollination	Table
2	102	Manzanillo	open pollination	Table
3	91	Manzanillo	open pollination	Table
4	92	Manzanillo	open pollination	Table
5	99	Manzanillo	open pollination	Table
6	66	Toffahi	♀ Toffahi x Arpequina ♂	Oil
7	69	Toffahi	♀ Toffahi x Kalamata ♂	Dual
8	32	Kalamata	open Kalamata	Table
9	138	Arpequina	♀ Arpequina x Hamed ♂	Oil
10	48	Coratina	♀ Coratina x Toffahi ♂	Oil
11	52	Koroneiki	open Koroneiki	Oil

Cutting collection and preparation: Sub-terminal cuttings of tested genotypes were collected from one-year old uniform shoots in the second week of months of January, April, July and October during 2022 and 2023 seasons. Cuttings lengths were about 12-15 cm, having 4 nodes and 2 pairs of terminal leaves.

Rhizogenic treatments: The basal part of cuttings was dipping for five seconds in aqueous solution of Indole butyric acid (IBA) at 5000 ppm as commercially used in olive followed by dipping in benlate solution (1g

/L) as fungicide. After that, planted in the media of vermiculite and sand (1:2 volume) in a plastic box, in a rooting bench with a basal heating under mist system in the shaded house (Kurd et al., 2010).

Seventy days after planting, the following data was recording:

(1) Rooting ability of cuttings:

- Rooting percentage (%)
- Roots number/ rooted cutting
- Roots length (cm) / rooted cutting

(2) Endogenous constituents of cuttings:

- Carbohydrates content of leaf and stem was estimated according to Masuko et al. (2005).
- Nitrogen content in leaf and stem samples were determined by using the modified microkjeldal method **(**Bremner et al., 1996).
- C/N ratio was calculated as the percentage of total carbohydrates /percentage of total nitrogen.
- Total indoles (mg/g F.W): was estimated according to Singleton et al. (1999).
- Total phenols (mg/g F.W): the method described by Tsimidou et al. (1992).

(3) Anatomical studies: Samples of genotypes that achieved the highest, moderate and lowest rooting percentage was taken for studying the formation of adventurous root. The bottom 5cm of cutting were taken and fixed in FAA solution until sectioning and dehydrated in a normal butyl alcohol series before being embedded in paraffin wax melting point 56-58°C (Johansen 1940). Transverse sections were obtained with a rotary microtome at a thickness of 20-25 microns were stained with safranin and fast green before mounting in Canada balsam. Slides were examined microscopically and photomicrography (Ozkaya et al., 1998).

(4) Statistical layout and analysis:

The experimental layout was in a factorial arrangement, with two factors, dates of cutting propagation and olive genotypes, arranged in Complete Randomized Design (CRD). The obtained data were tabulated to analysis of variance and significant differences among means were determined according to Snedecor and Cochran (1990). Duncan's Multiple range test was used for comparison between means of the studied treatments (Duncan, 1955)

RESULTS AND DISCUSSIONS

(1) The ability of sub terminal cuttings of olive genotypes to root:

In the present study, the adventitious of rooting process in cuttings is still to be unraveled under the genetic point of view. The capability of sub terminal cuttings that treated with the hormonal treatment (IBA at 5000ppm) of rooting was affected by genotypes and planting date which is the second pivotal element and the interaction between genotypes and collection dates during two studied seasons (2022 and 2023) as follow:

- **Rooting percentage:** Among the eleven genotypes under study, the maximum percentage of rooted cuttings, acquired by the genotype (102) which achieved the highest percent (72.44%), follow by genotype (66) and genotype (97). Otherwise, each of genotype (99, 48 and 52) the lowest percent (4.75, 13.08 and13.17%) in the first season and (6.75, 13.92 and13.42%) in the second one. On the contrary, as the effect of planting date, the results in **Table (2)** showed that, the rooted cutting percentage reached to the maximum during April followed by October, while January attained the minimal one in both studied seasons. The overall, as the influence of interaction between genotype and planting date, the highest value was obtained by genotype (66) followed by (102) during April in both seasons.
- **The average rooting number per rooted cutting:** The obtained results in **Table (3)** revealed that, number of roots/cutting was

significantly affected by the tested genotypes and different collected dates in both seasons. The greatest number of roots was recorded by each of genotype (102) and genotype (66), whereas genotype (52) attained the least one in both seasons. Moreover, the highest roots number produced from the cuttings that planted in April, while, January recorded the least one during two studied seasons. Furthermore, there were significant responses to the interaction appearance in the genotype (102) in April plantation during first and second respectively.

Table (2). Rooting percentage of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	57.67i	82.67d	60.33h	69.00f	**67.42C**	55.33k	80.33d	59.33i	68.00f	**65.75C**
102	60.67h	87.67b	65.33g	76.00e	**72.42A**	64.33g	86.33b	65.33g	77.33e	**73.33A**
91	42.67lm	65.33g	44.33l	53.67j	**51.50F**	39.67n	57.00jk	44.67m	52.00l	**48.34G**
92	28.00p	41.67m	25.00q	31.33o	**31.50G**	31.33q	44.00m	27.00r	37.33o	**34.92H**
99	2.33w	11.00t	2.33w	3.33w	**4.75K**	2.67w	15.00s	3.00w	6.33rs	**6.75J**
66	54.00j	91.00a	60.00h	75.00e	**70.00B**	55.33k	92.33a	61.33h	75.33e	**71.08B**
69	25.00t	75.67e	24.33q	35.33n	**51.33F**	33.33p	76.00e	38.67no	58.33ij	**51.58F**
32	42.00m	84.67c	51.67k	64.33g	**60.67D**	43.33m	86.00b	55.00k	65.33g	**62.42D**
138	37.00n	81.00d	41.33m	60.33h	**54.92E**	37.00o	82.33c	42.67m	61.67h	**55.92E**
48	9.33w	22.67t	10.33vw	10.00u	**13.08I**	7.33w	24.33st	9.17vw	15.00u	**13.92I**
52	6.00uv	21.00r	11.00t	14.67s	**13.17I**	7.33w	26.33rs	9.33vw	10.67v	**13.42I**
Mean	**33. 15D**	**60.39A**	**35.99C**	**44.81B**		**34.27D**	**60.90A**	**37.75C**	**47.91B**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

Table (3). Rooting number of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	7.00 ij	14.00 c	8.67 gh	9.33 f	**9.75B**	8.00hi	13.00c	8.33h	9.00g	**9.58B**
102	8.67gh	18.00a	8.33h	10.67d	**11.42A**	9.33g	16.00a	11.00d	10.33ef	**11.67A**
91	4.67o	7.33i	4.33op	6.33kl	**5.67F**	4.00r	6.33mn	4.33qr	6.33mn	**5.25E**
92	4.00 p	7.33 i	3.33 q	5.67mn	**5.08 G**	5.00p	7.67ij	6.00no	7.33jk	**6.50D**
99	4.33op	7.00ij	4.00p	4.33op	**4.92G**	4.00r	5.67o	4.33qr	5.00o	**4.75F**
66	10.00e	16.33b	11.00d	7.33i	**11.17A**	10.00f	15.33b	10.33ef	10.67de	**11.58A**
69	4.33op	9.00fg	4.33op	6.33kl	**6.00 E**	4.33qr	7.00kl	4.00r	6.33mn	**5.52E**
32	5.67mn	10.00e	6.00lm	8.33h	**7.50C**	6.33mn	9.00g	6.67lm	7.67ij	**7.42C**
138	5.67mn	8.67gh	5.33n	7.33i	**6.75D**	4.67pq	9.33g	4.67pq	7.33jk	**6.50D**
48	2.33r	6.67jk	3.00q	6.33kl	**4.58H**	2.67t	6.67lm	3.33s	6.67lm	**4.84F**
52	1.00t	4.67o	1.33st	1.67s	**2.17I**	1.67u	4.67pq	1.67u	2.00u	**2.50G**
Mean	**5.24D**	**9.91A**	**5.42C**	**6.70B**		**5.45D**	**9.15A**	**5.88C**	**7.15B**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

- **Rooting length (cm) per rooted cutting:**

Tabulated data in **Table (4)** demonstrated that, planting date differed significantly in both studied seasons; and the highest length was recorded in April plantation (10.69 and 9.58 cm) whereas, the lowest length (6.95 and 7.58 cm) was gained by cutting planted in July in the first and second seasons, respectively. Similarly, the eleven genotypes of olive exhibited a slight variability in length of roots in the first season, whereas, the maximum roots length were associated by the genotype (97) in the second season. The lowest rooting length was detected by the genotype (52) in both seasons. A significant interaction was observed between genotypes and planting date, whereas, the highest length was obtained in April from each of genotypes

(66) and (138) in 2022 season and (97) in 2023 season.

The response of sub terminal cuttings of the eleven genotypes illustrated that, the ability of cuttings for rooting formation was significantly influenced by genotype as well as the period of cuttings collection, whereas genotype 102 appears the superiority followed by the genotypes of 66, 97, 32 and 138 as compering with other genotypes. These results are in full agreement with Cirillo et al. (2017) and Lazaj et al. (2015), they found that, a significantly affected of rooting aptitude to cultivars rooting strongly depended on many factors: cultivar, planting date and type of cuttings. Additionally, the seasonal trend for rooting percentage with the maximum in spring followed by autumn and decreased to the minimum during summer and winter (Mahmood et al., 2016 and Shereen, 2019). Meantime, there was correlation between ability of cutting to root and average number of roots for olive cultivars (Ismail et al., 2011, and Mohamed *et al*., 2018). Olive cultivars were classified according to the standards of the International Olive Council (IOC) to 4 main groups: Unable to rooting from 0-5%, Low rooting ability from 5-40%, Moderately rooting ability from 40 to less than70% and High rooting ability from70-100%. According this categorized the eleven genotypes under study can be classification as genotypes (102 and 66) easy-to-root, moderate as (97, 91, 69, 32 and 138) and difficult-to- root as genotypes (92, 99, 48 and 52) that attained low rooting ability. Our results are consistent with Fontanazz (1993), Wiesman and Lavee (1994) and Yamen et al. (2020).

Table (4). Rooting length (cm) of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	9.25gh	12.55b	8.07j-l	9.27gh	**9.78A**	11.00bc	12.00a	10.67bc	11.00bc	**11.17A**
102	9.96ef	10.73d	7.93j-l	10.20df	**9.71A**	9.67d-f	11.33b	10.00de	10.33cd	**10.33B**
91	7.47k-m	11.39c	4.67uv	8.93g-i	**8.11D**	7.67gh	11.00bc	4.67lm	9.67d-f	**8.25F**
92	7.37lm	10.33de	8.13jk	9.10gh	**8.73C**	8.33g	11.00bc	9.00f	10.00de	**9.58CD**
99	4.40v	5.90p-r	5.17s-u	6.23o-q	**5.43F**	4.33m	6.33j	5.00kl	6.00j	**5.42H**
66	6.57n-p	14.79a	6.42o-q	10.33de	**9.53AB**	7.00i	8.00gh	7.00i	7.33hi	**7.33G**
69	6.94m-o	8.64h-j	6.61n-p	7.96j-l	**7.54E**	9.67df	11.00bc	8.00gh	9.00f	**9.42D**
32	8.37ij	12.89b	8.10jk	9.57fg	**9.73A**	7.67gh	11.00bc	8.00gh	9.99f	**8.29E**
138	6.03pr	14.95a	7.17mn	9,27gh	**9.35B**	9.33ef	10.33cd	9.67d-f	10.00de	**9.83C**
48	5.37r-t	9.57fg	6.60n-p	8.07j-l	**7.40E**	6.00j	8.00gh	7.00i	8.00gh	**7.25G**
52	4.73t-v	5.80q-s	4.30v	4.87t-v	**4.93G**	4.33m	5.33k	4.33m	5.00kl	**4.75I**
Mean	**6.95C**	**10.69A**	**6.95D**	**8.53B**		**7.73C**	**9.58A**	**7.58C**	**8.67B**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

(2) Endogenous constituents of sub terminal cuttings:-

- Leaf and stem carbohydrates content: The mean values of the presented data in **Tables (5 and 6)** interpret that, each of planting date and genotypes had a clear effect on the stem and leaves carbohydrate content. The terminal cuttings that planted in April significantly recorded the highest value of carbohydrate content (14.81 and 15.01) in leaves and (24.39 and 22.77) in stem during 2022 and 2023 seasons, respectively. Otherwise, the lowest value was obtained by July planting date. Moreover, the maximum value of leaves and stem carbohydrate content associated with genotype (102), whereas, the minimal content was attained by genotype (52). According to the interaction effect, each of genotypes (97 and 102) exhibits the highest value in both of leaves and stem during April planting date in both studied seasons.

Table (5). Leaves carbohydrates content of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	16.56f	19.37a	15.99g	17.11de	**17.26B**	16.22f	19.96a	15.17h	17.34d	**17.17B**
102	17.33d	19.38a	17.98c	18.62b	**18.33A**	17.33d	18.50b	17.52cd	18.35b	**17.93A**
91	11.67o	13.70k	11.11q-s	13.15lm	**12.41E**	11.11xy	14.98hi	11.56vw	12.67pq	**12.58G**
92	11.1qr	12.63n	10.69t	12.53n	**11.76F**	11.29wx	12.05st	12.90op	11.98s-u	**12.06H**
99	11.53op	12.40n	10.15u	11.34pq	**11.36G**	10.89yz	12.87op	11.50vw	12.11rs	**11.84I**
66	15.41h	16.31hi	13.19l	14.12j	**14.51C**	13.00op	16.01f	14.68ij	15.52g	**14.80C**
69	13.55k	15.10i	11.00rs	13.78k	**13.36D**	12.41qr	14.31kl	13.19o	14.12lm	**13.51E**
32	13.22l	14.32j	14.13j	15.889g	**14.39C**	13.75n	14.55jk	13.83mn	14.86h-j	**14.25D**
138	16.88e	17.30d	17.26d	17.98c	**17.36B**	16.80e	17.30d	16.56e	17.70c	**17.09B**
48	11.15qr	12.44n	12.63n	12.91m	**12.28E**	11.75t-v	13.99l-n	11.67uv	13.68n	**12.77F**
52	10.4st	11.01rs	10.68t	10.92r-t	**10.86H**	10.5z	11.63u-w	11.69uv	11.41v-x	**11.33J**
Mean	**13.57C**	**14.81A**	**13.16D**	**14.40B**		**13.19D**	**15.10A**	**13.66C**	**14.52B**	

Means in each column having different letters showed statistically significant differences ($P < 0.05$)

Table (6). Stem carbohydrates content of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	24.31g	29.63a	27.68cd	26.92e	**27.14B**	21.68gh	26.16b	24.31c	25.4b	**24.50B**
102	27.33de	29.3a	27.98c	28.62b	**28.33A**	24.26c	27.30a	24.18c	26.19b	**25.48A**
91	19.59u	20.10o-r	18.00tu	19.78q-s	**19.36H**	18.97rs	21.22hi	1.32tu	20.48k-n	**19.75F**
92	19.1s	20.01 bc	20.69 l-o	20.53m-p	**20.08G**	19.57pq	21.65gh	18.66st	23.55d	**20.86E**
99	17.53u	20.40n-q	18.15tu	18.34t	**18.61H**	19.94n-p	22.11fg	20.10m-p	21.22hi	**20.84E**
66	27.67cd	20.03p-r	28.11bc	28.15bc	**25.99C**	22.30f	24.39c	21.13h-j	23.9cd	**22.90C**
69	19.56rs	21.37jk	19.99p-r	21.11k-m	**20.51G**	19.25qr	21.21hi	17.99u	20.41l-o	**19.72F**
32	24.22g	27.32de	24.13g	25.89f	**25.39D**	20.73i-l	22.44ef	20.11m-p	20.99i-k	**21.07E**
138	23.84g	26.34f	22.11hi	24.17g	**24.12E**	20.18l-o	23.48d	20.65j-m	22.91e	**21.81D**
48	21.15k-m	24.44g	22.63h	21.91ij	**22.53F**	18.50s-u	20.17l-o	18.36tu	20.11m-p	**19.29G**
52	20.88k-n	21.30kl	19.26s	20.98k-n	**20.61G**	19.83op	20.33l-o	18.00u	19.98n-p	**19.54F**
Mean	**22.11D**	**24.39A**	**22.61C**	**23.31B**		**20.46C**	**22.77A**	**20.16D**	**22.32B**	

Means in each column having different letters showed statistically significant differences ($P < 0.05$)

- Leaf and stem nitrogen content: There were considerable differences in leaf and stem nitrogen content among the tested genotypes in **Tables (7and 8).** The leaf nitrogen content showed slight variations among the genotypes under study, whereas, each of (97, 102, 66, 32 and 138) genotypes were superiority than others. Furthermore, the highest leaf nitrogen content was detected in the October planting date and the lowest was found in both of April and July **(Table 7).** Moreover, the nitrogen content in cuttings of different olive genotypes were fluctuated due to difference in dates of planting **(Table 8)**. Each of genotypes (102 and138) possessed the highest significant level. Otherwise, the genotypes (91, 48 and 52) attained the least percent in both seasons. Additionally, stems of tested genotypes gave the highest nitrogen content during January than April which attained the least value. Additionally, the maximum leaf nitrogen content as the effect of interaction was acquired by genotype (66) in October. While, the genotype (138) attained the, the highest stem nitrogen content in January.

Table (7). Leaves nitrogen content of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	1.20fg	1.11i-k	1.16g-i	1.38bc	**1.21A**	1.19gh	1.09ij	1.14hi	1.39c	**1.20A**
102	1.20fg	1.07j-l	1.09jk	1.41b	**1.19A**	1.18gh	1.09ij	1.09ij	1.44bc	**1.20A**
91	1.16g-i	1.04l	1.05kl	1.28e	**1.13B**	1.13hi	1.05j	1.03j	1.30de	**1.13B**
92	1.17g-i	1.05kl	1.07j-l	1.30de	**1.15B**	1.14hi	1.06j	1.05j	1.30de	**1.14B**
99	1.15g-i	1.03l	1.05kl	1.34cd	**1.14B**	1.14hi	1.05j	1.05j	1.33d	**1.14B**
66	1.17g-i	1.06j-l	1.07j-l	1.53a	**1.21A**	1.19gh	1.06j	1.0ij	1.58a	**1.23A**
69	1.14g-i	1.03l	1.06j-l	1.29de	**1.13B**	1.14hi	1.03j	1.05j	1.25ef	**1.12B**
32	1.17g-i	1.07j-l	1.07j-l	1.42b	**1.18A**	1.19gh	1.08ij	1.09ij	1.45b	**1.20A**
138	1.18gh	1.06j-l	1.07j-l	1.48a	**1.20A**	1.20fg	1.09ij	1.09ij	1.48b	**1.22A**
48	1.13hi	1.05kl	1.07j-l	1.29de	**1.14B**	1.14hi	1.06j	1.06j	1.25ef	**1.13B**
52	1.12h-j	1.04l	1.06j-l	1.25ef	**1.12B**	1.14hi	1.04j	1.06j	1.23fg	**1.12B**
Mean	**1.16B**	**1.06C**	**1.07C**	**1.36A**		**1.16B**	**1.06C**	**1.07C**	**1.36A**	

Means in each column having different letters showed statistically significant differences ($P < 0.05$)

Table (8). Stem nitrogen content of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	0.767e	0.692k-m	0.713ij	0.792d	**0.741B**	0.781de	0.700mn	0.725g-k	0.795d	**0.750B**
102	0.890b	0.677m-o	0.700j-l	0.749f	**0.754A**	0.898b	0.670pq	0.711k-m	0.741fg	**0.755AB**
91	0.709i-k	0.615uv	0.665o-q	0.718h-j	**0.677E**	0.714j-m	0.643r-t	0.672o-q	0.722g-l	**0.688E**
92	0.774e	0.624s-u	0.681m-o	0.700j-l	**0.695D**	0.782de	0.638r-t	0.700mn	0.710k-n	**0.708CD**
99	0.734f-h	0.637rs	0.700j-l	0.736f-h	**0.702CD**	0.737f-h	0.635r-t	0.703l-n	0.741fg	**0.704D**
66	0.864c	0.658pq	0.714ij	0.732f-h	**0.742B**	0.870c	0.671o-q	0.720g-m	0.738f-h	**0.750B**
69	0.720g-i	0.619tu	0.700j-l	0.734f-h	**0.693D**	0.733f-j	0.650rs	0.710k-n	0.736f-i	**0.707CD**
32	0.738fg	0.649qr	0.711i-k	0.740f	**0.710C**	0.741fg	0.655qr	0.716i-m	0.747f	**0.715C**
138	o.613a	634 r-t	0.700j-l	0.769e	**0.754A**	0.925a	0.644r-t	0.712k-m	0.773e	**0.764A**
48	0.739f	0.617t-v	0.669n-p	0.687lm	**0.678E**	0.740fg	0.631st	0.677op	0.690no	**0.685E**
52	0.711i-k	0.600v	0.683l-n	0.711i-k	**0.676E**	0.720g-m	0.625t	0.700mn	0.718h-m	**0.691E**
Mean	**0.778A**	**0.638D**	**0.694C**	**0.733B**		**0.786A**	**0.651D**	**0.704C**	**0.737B**	

Means in each column having different letters showed statistically significant differences ($P < 0.05$)

- **Leaves and stem C/N ratio:** Data in **Tables (9 and 10)** demonstrated that, the maximum records of C/N ratio in leaves and stems were obtained by genotype (102) followed by genotype (97) as comparing with other genotypes. Whereas, the genotype (52) was the least one. Continually, April preparation date induced the highest significant effect. According to the interaction between genotypes and collection date, both (102) and (97) genotypes achieved the highest ratio in each of leaves and stem in April preparation date.

Table (9). Leaf C/N ratio of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	Season 2022					Season 2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	13.80h	17.45b	13.78h	12.40k	**14.73B**	13.63h	18.31a	13.31ij	12.47lm	**14.43B**
102	14.44g	18.11a	16.50c	13.21ij	**15.56A**	14.69e	16.97b	16.07c	12.74k	**15.12A**
91	10.06t	13.17j	10.58q	10.27rs	**11.02G**	9.83u	14.27f	11.22pq	9.75k	**11.27G**
92	9.49u	12.03mn	9.99t	9.64u	**10.29I**	9.90u	11.37hi	12.29m	9.22w	**10.69H**
99	10.03t	12.04mn	9.67u	8.46x	**10.05J**	9.55v	12.26m	10.95rs	9.11w	**10.47I**
66	13.17j	15.39e	12.33kl	9.23v	**12.53D**	10.92s	15.10d	14.68e	9.82u	**12.63D**
69	11.89no	14.66f	10.38r	10.68q	**11.90F**	10.89s	13.89g	12.56kl	11.30p	**12.16E**
32	11.30p	13.38i	13.21ij	11.19p	**12.27E**	11.55o	13.47hi	12.69kl	10.25t	**11.99F**
138	14.31g	16.32cd	16.13d	12.15lm	**14.36C**	14.00g	15.87c	15.19d	11.95n	**14.26C**
48	9.87t	11.5no	11.0o	10.01t	**10.8H**	10.31t	13.20j	11.01q-s	10.94rs	**11.36G**
52	9.29v	10.59q	10.08st	8.74w	**9.67K**	9.21w	11.18p-r	11.03q-s	9.28w	**10.17J**
Mean	**11.60C**	**14.09A**	**12.22B**	**10.54D**		**11.32C**	**14.17A**	**12.2B**	**10.62D**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

Table (10). Stem C/N ratio of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	2022					2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	31.69n-p	43.48b	38.82g	33.99l	**36.86B**	27.76rs	37.37b	33.53h	31.95k	**32.65B**
102	30.71q	47.28a	39.97e	38.21h	**38.04A**	27.02t	40.75a	34.01fg	34.34d	**34.28A**
91	27.63v	32.68m	27.07w	27.55v	**28.73I**	26.57u	33.00i	27.26t	28.37op	**28.80G**
92	24.68y	39.62f	30.38q	29.33r	**32.97E**	25.03y	33.93g	26.66u	33.17i	**29.70DE**
99	23.88z	32.03n	25.93x	24.92y	**26.69J**	27.06t	34.82e	28.59o	28.64o	**29.78D**
66	32.03n	30.44q	39.37f	38.46h	**35.07C**	25.63w	36.35c	29.35m	32.38j	**30.93C**
69	27.17w	34.52k	28.56t	28.76st	**29.75H**	26.26v	32.63j	25.34x	27.73rs	**27.99I**
32	32.82m	42.10c	33.94l	34.99j	**35.96C**	27.98qr	34.26f	28.09pq	28.10pq	**29.61E**
138	26.11x	41.55d	31.59op	31.43p	**32.67F**	21.82z	36.46c	29.00n	29.64l	**29.23F**
48	28.62st	28.91s	33.83l	31.89no	**33.49D**	25.00y	31.97k	27.12t	29.14mn	**28.31H**
52	29.37r	35.50i	28.20u	29.51r	**30.64G**	27.54s	32.63j	25.71w	27.83q-s	**28.40H**
Mean	**28.61D**	**37.10A**	**32.51B**	**31.73C**		**26.15D**	**34.91A**	**28.61C**	**30.21B**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

- **Total Indole content:** Data of eleven genotype in **Table (11)** showed that, the statically appears, superiority of genotype (102), followed by genotypes (97and138) in both season with partnership of genotype (96) in the first season and genotype (66) in the second one. On the other hand, the genotype (52) considered the minimal one. Furthermore, April planting date gave the highest level than others. As regard to the interaction effect, genotype (102) achieved the highest total indole content in April in both seasons.

Table (11). Total indole of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	2022					2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	0.211e-g	0.236b-d	0.200f-h	0.217ef	**0.216B**	0.204f-j	0.241ab	0.200g-k	0.223b-f	**0.217AB**
102	0.222c-e	0.260a	0.213e-g	0.229b-e	**0.231A**	0.216d-g	0.253A	0.200g-k	0.231b-e	**0.225A**
91	0.110st	0.214e-g	0.104t	0.191hi	**0.155EF**	0.123p	0.234a-d	0.108p	0.198g-k	**0.166E**
92	0.149m-o	0.195g-i	0.133o-r	0.152l-n	**0.157E**	0.172lm	0.231b-e	0.150o	0.211e-i	**0.191D**
99	0.113st	0.166j-l	0.115st	0.134o-q	**0.1320G**	0.126p	0.171l-n	0.118P	0.145o	**0.140G**
66	0.165j-l	0.219de	0.142n-p	0.200f-h	**0.1815D**	0.197g-k	0.239a-c	0.192h-l	0.214d-h	**0.210B**
69	0.200f-h	0.243b	0.198f-i	0.223c-e	**0.216B**	0.156m-o	0.200g-k	0.148o	0.179kl	**0.171E**
32	0.179i-k	0.223c-e	0.182h-j	0.200f-h	**0.1962C**	0.190i-l	0.229b-e	0.173lm	0.211e-i	**0.201C**
138	0.199f-h	0.239bc	0.189hi	0.213e-g	**0.210B**	0.201g-j	0.239a-c	0.191i-l	0.219c-g	**0.213B**
48	0.134o-q	0.162k-m	0.116r-t	0.143n-p	**0.1386G**	0.148o	0.182j-l	0.126p	0.151no	**0.119F**
52	0.125p-s	0.195g-i	0.117q-t	0.154l-n	**0.148F**	0.118p	0.188j-l	0.115p	0.150o	**0.143FG**
Mean	**0.164C**	**0.214A**	**0.155D**	**0.170B**		**0.168C**	**0.219A**	**0.156D**	**0.194B**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

- **Total Phenol content:** According to the total phenol content in **Table (12),** the perusal of data showed no significant differences among tested genotypes in each of first and second season, except genotype (48) in the first season that attained the highest level. Moreover, January planting date gave the least phenol content, whereas no differences among the other three collection dates (April, July and October). As the effect of interaction, a narrow variation was obtained among tested genotype under different collection dates.

Table (12). Total phenol of sub terminal cuttings of olive genotypes at different planting dates during 2022 and 2023 seasons.

Genotypes	2022					2023				
	Jan	Apr	July	Oct	Mean	Jan	Apr	July	Oct	Mean
97	0.010fg	0.026a-g	0.032a-e	0.023a-g	**0.023B**	0.012e	0.026a-e	0.029a-e	0.026a-e	**0.023A**
102	0.012e-g	0.028a-g	0.030a-g	0.024a-g	**0.023B**	0.012e	0.027a-e	0.027a-e	0.025a-e	**0.023A**
91	0.010fg	0.031a-f	0.037ab	0.022a-g	**0.025B**	0.012de	0.031a-e	0.034a-c	0.028a-e	**0.026A**
92	0.016c-g	0.030a-g	0.033a-d	0.025a-g	**0.026B**	0.015c-e	0.030a-e	0.031a-e	0.027a-e	**0.026A**
99	0.019b-g	0.029a-g	0.034a-d	0.024a-g	**0.026B**	0.019a-e	0.028a-e	0.033a-d	0.026a-e	**0.026A**
66	0.014d-g	0.029a-g	0.030a-g	0.025a-g	**0.024B**	0.016c-e	0.030a-e	0.030a-e	0.026a-e	**0.025A**
69	0.011e-g	0.025a-g	0.027a-g	0.023a-g	**0.022B**	0.012e	0.027a-e	0.028a-e	0.024a-e	**0.023A**
32	0.020a-g	0.027a-g	0.029a-g	0.024a-g	**0.025B**	0.018b-e	0.029a-e	0.030a-e	0.026a-e	**0.026A**
138	0.017b-g	0.028a-g	0.030a-g	0.026a-g	**0.025B**	0.018b-e	0.030a-e	0.030a-e	0.028a-e	**0.027A**
48	0.039a	0.035a-c	0.037ab	0.033a-d	**0.036A**	0.011e	0.0372ab	0.0394a	0.036a-c	**0.031A**
52	0.010g	0.028a-g	0.025a-g	0.029a-g	**0.023B**	0.012e	0.030a-e	0.030a-e	0.028a-e	**0.025A**
Mean	**0.016B**	**0.029A**	**0.031A**	**0.026A**		**0.014B**	**0.030A**	**0.031A**	**0.027A**	

Means in each column having different letters showed statistically significant differences (P < 0.05)

This study outcome is confirmed by many researches that carried out to clarify the relationship between rooting ability and endogenous growth regulators. The highest endogenous content of carbohydrates, nitrogen, C/N ratio and total indole correlated with the highest rooting ability in tested genotypes. This agree with many investigations reported that, seasonal changes in rooting ability of olive cuttings is related to the seasonal changes of carbohydrates in reproductive and vegetative shoots (Delrio et al., 1991). Cuttings of easy-to-root cultivars have been characterized with higher carbohydrate content than the cuttings of difficult-to-root cultivars (Denaxa et al., 2012 and Sheeren, 2019). Similar results detected by other workers may support the present findings, such as those of Fadl and Hartman (1976) and Caballero (1979), they reported that, the rooting capacity of many cuttings has been correlated with their carbohydrates content that's important to root formation as energy and structural materials of cell to initiate root primordial. It has been considering optimal markers since they are the main energetic resource during root formation (Bartolini et al., 2008). The availability and mobilization of carbohydrates towards the base of cuttings appear to be major factors related to rooting of olive cuttings (Elham and Shahsavar, 2010). The high carbohydrate and C/N ratio during the growing season coincided with the high rooting in olive cuttings (Hambrick et al., 1991). Nitrogen levels considered an important predictor for rooting potential of stem cuttings, but not always, high N supply to the stock plants or high N content of cutting tissues decreases propagation success through cuttings. Reduced rooting rate when high N levels are applied is due to reduction in starch reserves in the cutting tissue (Druege et al., 2000). Additionally, plant hormones, enzymes and the total phenolic content play a significant role for controlling the mechanism of rooting in olives. Phenolic compounds from olive leaf are known to have diverse biological activities and may also be responsible for the pharmacological actions of olive leaf (Artajo et al., 2006). Variations in rooting of cuttings have been associated with the changes in the levels of endogenous growth regulators and other metabolites. Such regulatory processes are controlled through qualitative and quantitative changes in enzymes, such as peroxidases, IAA-oxidase and polyphenol oxidase (Ercan and Ozkaya, 2008). On the other hand, phenolic compounds such as monophenols and m-diphenols can inhibit the rooting process by stimulating IAA oxidation or promoting IAA decarboxylation, while some other phenolics have no regulatory effect on IAA content in plant tissues (Aslmoshtaghi & Shahsavar, 2010).

(3) Anatomical studies:

Root primordium in stems of olive originates from the cambial zone (cambium cells or ray cells). This primordium must pass to the periphery by extending through phloem fibers and the sclerenchyma ring did not remain intact and disappear during the rooting period, then emerge from the bark. This appears in the genotypes easy to root as genotype (102) that presented in **Fig (1).** In a genotype that classified as a moderate -to-root as the example genotype (91) that presented in **Fig (2),** slightly interrupted of the sclerenchyma ring, that helping for getting out a number of adventitious roots. In difficult- to- root genotypes as the example genotype (52) that presented in **Fig (3)**, the least adventitious root formation may be due to the correlated with the density of continuity of the sclerenchyma ring in cortex, forming mechanical barriers that prevent the organization of new cells to form root primordial that led to inhibit forming of adventitious root. These findings were a line of several anatomical studies which suggested that, a correlation between difficulty in rooting and the presence of continuous sclerenchyma layer that may be act as a physiological barrier to adventitious root initiation or a mechanical barrier to root emergence (Salama and Mustafa, 2006, Ayoub and Qrunfleh, 2007 and Mohamed and Attia, 2017). Similarly, the lower rooting percentage might be due the presence of continuous sclerenchyma sheath, that forming mechanical barrier to emergence of newly rootlets (Caballero, 1979, El Said et al., 2013, Sara, 2016 and Sheeren, 2019).

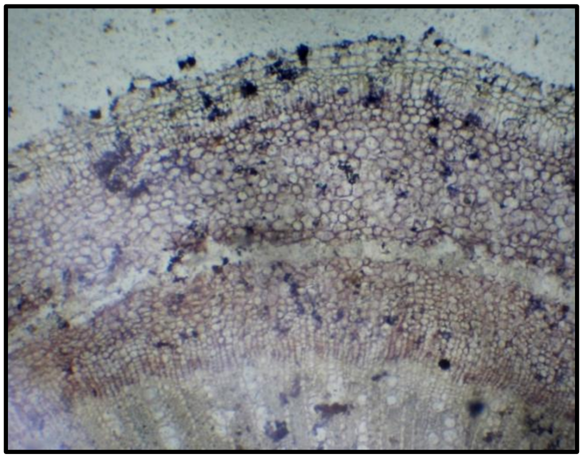

Fig (1): Transverse sections of cuttings of genotype (102) easy- to root.

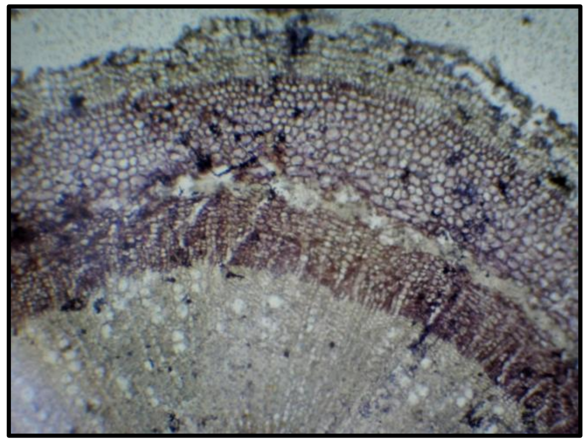

Fig (2): Transverse sections of cuttings of genotype (91) moderate - to root.

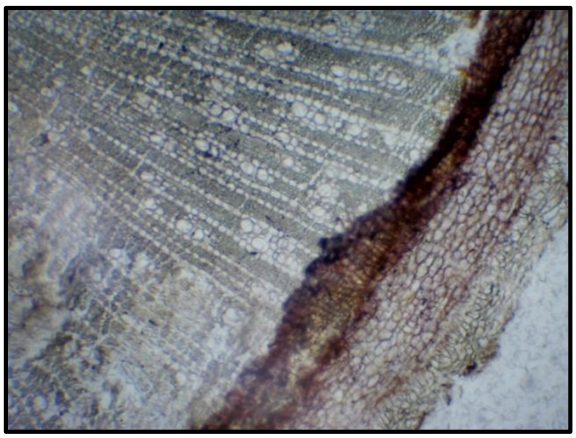

Fig (3): Transverse sections of cuttings of genotype (52) difficult - to root.

CONCLUSION:

Results of morphological parameter and chemical analysis were studied by mean of appropriate statistical analysis, illustrated a significant variation in different planting dates. The exogenous IBA hormone at (5000 ppm) increases the rooting ability in the easy -to- root genotypes, but it was ineffective in stimulating rooting in the difficult -to-root. The highest increment in root formation was attained by genotype (102) that may be due the increases in carbohydrates, nitrogen content, C/N ratio and total indole. Moreover, the anatomical study revealed that, the sclerenchyma ring did not remain intact and disappear during the rooting period that leads to rapid formation of adventitious root. Otherwise, the genotype (52) achieved the lowest formation of roots that may be attributed to decrease in carbohydrates, total indole, nitrogen content and C/N ratio that important for rooting formation. Additionally, low rooting percentage might be due the presence of continuous sheath of chlorenchyma, forming mechanical barrier to emerge of newly formed roots that decreases the appearance of initiate adventurous root. From this study, eleven genotypes under study were categorized into three groups: genotypes

(102and 66) easy -to-root, moderate as (97, 91, 69, 32 and 138) and difficult to -root as (92, 99, 48 and 52).

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الملخص العربى

دراسة مقارنة لقدرة بعض التراكيب الوراثية للزيتون على التجذير

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قسم بحوث الزيتون وفاكهة المناطق شبه الجافة ، معهد بحوث البساتين ، مركز البحوث الزراعية ، الجيزة ، مصر

أجري هذا البحث في المزرعة البحثية بمعهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، خلال موسمين متتاليين لعامي 2022 و 2023 على العقل الفرعية لأحد عشر تركيب وراثي متميز للزيتون تم إدخالها من خلال برنامج التحسين الوراثي للزيتون في مصر، والتي تم اختبارها وتقييمها لتحديد قدرة هذه التراكيب الوراثية على تكوين الجذور بواسطة المعاملة بحمض الإندول بيوتيريك 5000 جزء في المليون (كما هو مستخدم تجاريًا في الزيتون) وزُرعت فى صوبة تحت ظروف الضباب المتقطع في أربعة مواعيد (يناير وأبريل ويوليو واكتوبر).

أظهرت النتائج العلاقة بين كل من موعد الزراعة والمكونات الداخلية والفحص التشريحي وقابلية العقلة للتجذير، وتم الحصول على أعلى زيادة في تكوين الجذور من خلال التركيب الوراثي (102)، وقد يكون ذلك بسبب زيادة الكربوهيدرات، محتوى النيتروجين، نسبة الكربون/النيتروجين والإندولات الكلي. كما أشارت الدراسة التشريحية إلى أن الحلقة الاسكلرنشيمية لم تظل سليمة وتحللت خلال فترة التجذير مما أدى إلى تكوين جذر عرضي بشكل سريع، وبخلاف ذلك، حقق التركيب الوراثي (52 و99) انخفاض في تكوين الجذور الذي يمكن أن يعزى إلى انخفاض مستوي الإندول الكلي والكربوهيدرات ومحتوى النيتروجين وانخفاض نسبة النيتروجين/الكربون المهمة لتكوين التجذير. بالإضافة إلى ذلك، فقد يكون انخفاض نسبة التجذير بسبب وجود غلاف من الكلورنشيما، مما يشكل حاجزًا ميكانيكيًا لظهور الجذور المشكلة حديثًا ويقلل من ظهور الجذور النامية.

ومن هذه الدراسة تم تصنيف التراكيب الوراثية الأحد عشر إلى ثلاث مجموعات: التراكيب الوراثية (102 و66) سهلة التجذير، ومتوسطة التجذير(32،69،91،97 و138) وصعبة التجذير (48،99،92، 52).