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Effect of IBA and some natural extracts on rooting and vegetative growth of Picual olive sucker and shoot cuttings

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ABSTRACT

This study was conducted during 2016 and 2017 seasons as atrial to replace the IBA which commonly used in the rooting of Picual olive cuttings by some natural extracts containing auxins as garlic (20%), liquorice at 10 g/l, moringa at 20%, yeast at 10% and algae at 5 cm/l extracts. The cuttings of control treatment were dipped in the IBA solution at 4000 ppm for 5 seconds, while the other treatments were dipped in natural extracts for half hour then planted in plastic flats under tunnel held at greenhouse for five months. The results revealed that the highest number of roots and dry weight of roots per cutting were recorded for cuttings dipped in IBA at 4000 ppm in comparison with other treatments in both seasons. The highest length of roots, shoot numbers, leaf numbers, average length of shoot and aerial portion dry weight per cutting were recorded for IBA, garlic, liquorice and algae extracts in both seasons without significant differences between them. Moringa extract recorded the lowest values in all rooting and vegetative characteristics compared with other treatments in both seasons. Cuttings prepared from suckers gained significantly higher rooting percentage, number of roots, root dry weight, shoot numbers, survival percentage, bud sprouting percentage, number of leaves and aerial portion dry weight per cutting in comparison with cuttings prepared from shoots, while no significant differences were observed between them in length of roots and average length of shoots per cutting in both seasons.

Key words: Olive, Picual, Vegetative propagation, Cutting, Sucker, Shoot, IBA and Natural extracts.

Introduction

The olive (*Olea europaea* L.) is consider an important arid zone fruit crop grown under subtropical conditions in the Mediterranean area as Egypt. About 95% of the olive orchards of the world located in the Mediterranean area, which produces more than 95% of the olive oil and 75% of the table olives (Fabbri *et al*., 2004). Shoot cuttings are considered the most important part used in vegetative propagation. This technique is favorable, easy and an inexpensive, suitable for producing a lot of plants in a short time. The olive cuttings rooting ability is influenced by many factors as cultivars (Fouad *at al*., 1990 and Turkoglu and Durmus, 2005), type of cuttings (Turkoglu and Durmus, 2005) and the auxin-like compounds (Hartmann *et al*., 2002 and Asl Moshtaghi and Shahsavar, 2011). Suckers is a method of vegetative propagation, but not recommended in the nursery as it slow and cost. Suckers contains high levels of carbohydrates and other components, so it is granted by the fact that sufficiently good rooting could only be obtained by cuttings four or more years old, and by relatively large ovules and suckers, which made the availability of propagation material quite scarce (Fabbri *et al*., 2004). So, the cuttings taken from suckers rooted better than those those taken from shoots. In general, suckers must be removed, so, preparing cuttings from suckers may enhance rooting.

The low rooting ability and low quality of roots are limiting factors to olive propagation by cuttings; so, easy-to-root cultivars may be interesting in establishing new olive orchard (Wiesman and Lavee, 1994). Internal concentrations of different materials as hormones and carbohydrates are important in rooting. External application by auxins may be a limiting factor to rooting of many species of olive (Hartman *et al*., 2002; Kelen and Ozkan, 2003; Negash, 2003). Indole butyric acid (IBA) is an important auxin used to increase cuttings rooting ability. However, IBA sometimes don't stimulate rooting of olive cuttings (Wiesman and Lavee, 1995 a&b; Aslmoshtaghi and Shahsavar, 2010).

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Using auxins, mainly IBA, has become an essential treatment to enhance rooting of cuttings in nurseries. To enhance olive cutting rooting, several attempts as wounding had done (Ayoub, 1995). Khursheed and Abdul (2008) found that cuttings of the Cemlik cv. were easy-to-root and gave higher rooting percent 60-90% by IBA which considered the best root-promoting compound in olive propagation from cuttings. However, IBA is not recommended in organic agriculture, as a synthetic product. The main objective of organic agriculture system is to obtain high-quality products while protecting the environment and land fertility. There are natural auxin sources such as algae, moringa, garlic, liquorice and yeast extracts which contains various compounds, which may affects root formation.

The objective of this work is a trial to replace the IBA which used in the rooting of olive cuttings by some natural extracts containing auxins such as garlic, liquorice, moringa and yeast extracts on the rooting of Picual olive cuttings.

Materials and Methods

This investigation was carried out during two successive seasons (2016 and 2017) in a private plastic greenhouse at Belbies district, Sharkia Governorate, Egypt. The semi hardwood cuttings taken from the middle part portion were prepared from one year old for two different parts shoots and suckers in November of each season. The prepared cuttings were about 15 cm length and 7-9 mm in diameter with five nodes and two pairs of leaves.

The experimental procedures

The cuttings of Picual olive cv. were subjected to the following six dipping treatments:
1- Dipping in IBA solution at 4000 ppm (as a control).
2- Dipping in moringa extract at 20 %.
3- Dipping in garlic extract at 20 %.
4- Dipping in liquorice extract at 20 $g.l^{-1}$.
5- Dipping in yeast extract at 10 %.
6- Dipping in algae extract at 5 $cm.l^{-1}$.

Cuttings of control treatment were dipped in the IBA solution for 10 seconds, while the other treatments were soaked in the natural extracts for half hour then planted at a depth of five cm in plastic flats filled with a mixture of silt, peat moss and sand (1: 1: 1 by volume). The flats were kept under tunnels held at greenhouse for five months after cuttings planting.

The response of the two different tested parts of olive cuttings was evaluated through the following parameters:

1- Rooting characteristics:

Rooting percentage, number of roots/cutting, root length and root dry weight.

2- Growth measurements:

Survival percentage, shoot numbers/ cutting, bud sprouting percentage, leaf numbers/ rooted cutting, average length of shoot per cutting (cm) and aerial portion dry weight (g).

Statistical analysis:

The experimental design was the randomized complete blocks design with three replicates (six cuttings/ replicate) for each treatment. Data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1980) using the Co-Stat program. Differences between means were compared by Duncan's multiple range test at 0.05 level (Duncan, 1958).

Results and Discussion

Rooting percentage

Results in Table (1) show that soaking Picual cuttings in some natural extracts and IBA significantly affected rooting percentage in the two seasons. However, IBA at 4000 ppm (control treatment) recorded the highest rooting percentage (88.87 and 91.65 %) compared with all treatments in both seasons, except those treated with algae at 5 cm/l and garlic 20% (83.32 and 77.78%) respectively, in the first season only. The lowest rooting percentage was gained by moringa extract at 20% (13.88 and 16.66 %) in the first and second seasons, respectively.

All cuttings taken from the suckers significantly recorded higher rooting percentage in both seasons compared with cuttings taken from shoots. Dipping suckers cuttings in IBA recorded higher rooting percentage than shoots cuttings in both seasons.

These findings are in agreement with those reported by Hamooh, (2014), Lazaj *et al.* (2015) and Mohamed (2015). They all reported that IBA increased rooting percentage. Similar trends were confirmed with using algae and garlic extracts (Urbanek Krajnc *et al.*, 2012, Vinoth *et al.*, 2012 and Lazaj *et al.*, 2015).

Table 1: Effect of IBA, natural extracts and plant organ on rooting percentage of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	100.00 a	77.73 bc	**88.87 A**	94.43 ab	88.87 abc	**91.65 A**
Moringa 20 %	11.10 f	16.66 f	**13.88 D**	22.22 g	11.10 g	**16.66 D**
Garlic 20 %	88.89 ab	66.66 cd	**77.78 AB**	77.78 bcd	72.21 cde	**74.99 B**
Liquorice 10 g/l	77.76 bc	55.56 de	**66.66 BC**	83.32 abcd	66.64 de	**74.98 B**
Yeast 10 %	66.66 cd	44.41 e	**55.54 C**	55.52 ef	44.41 f	**49.97 C**
Algae 5 cm/l	88.87 ab	77.78 bc	**83.32 A**	100.00 a	77.76 bcd	**88.88 B**
Plant organ av.	**72.21 A**	**56.47 B**		**72.21 A**	**60.16 B**	

Means in each column which have the same letter(s) are not significantly different.

Number of roots per cutting

The obtained results in Table (2) reveal that number of roots/cutting was significantly affected by the tested treatments in both seasons. The highest root numbers/ cutting was recorded for IBA at 4000 ppm (17.50 and 17.03 roots/cutting), followed by those dipped in 5 ml/l algae (10.95 and 11.54 roots/cutting) in the first and second seasons, respectively. The least number of roots/cutting was gained by cuttings dipped in moringa extract at 20 % (2.75 and 2.69 roots/ cutting) in the two seasons, respectively.

All cuttings gathered from suckers, recorded significant higher number of roots/ cutting than those gathered from shoots in both seasons. The interaction between plant organ and treatments showed that the sucker cuttings dipped in IBA at 4000 ppm produced the highest roots/ cutting, while moringa at 20% induced the lowest root numbers/ cutting without with no significant differences between suckers and shoots.

The obtained results are in harmony with those reported by Hamooh (2014); Porghorban *et al.* (2014); Jan *et al.* (2015); Lazaj *et al.* (2015) and Mohamed (2015) who reported that using IBA increased number of roots on olive cuttings. Jones and *van* Staden (1997) cleared that Kelpak (commercial seaweed) increased rooting percentage and improved rooting quality above that of the control and developed vigorous root system consisting of numerous lateral roots.

Table 2: Effect of IBA, natural extracts and plant organ on number of roots/ cutting of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	18.47 a	15.63 b	**17.50 A**	18.37 a	15.69 b	**17.03 A**
Moringa 20 %	2.91 i	2.60 i	**2.75 E**	2.92 g	2.47 g	**2.69 E**
Garlic 20 %	9.64 de	7.59 fg	**8.62 C**	9.67 de	7.93 e	**8.80 C**
Liquorice 10 g/l	9.06 def	7.96 ef	**8.51 C**	9.27 de	8.07 e	**8.67 C**
Yeast 10 %	5.68 gh	4.39 gi	**5.04 D**	5.83 f	4.82 f	**5.32 D**
Algae 5 cm/l	11.73 c	10.17 cd	**10.95 B**	12.10 c	10.98 cd	**11.54 B**
Plant organ av.	**9.58 A**	**8.06 B**		**9.69 A**	**8.33 B**	

Means in each column which have the same letter(s) are not significantly different.

Length of roots per cutting (cm)

It is clear from Table (3) that no significant differences in root length were obtained between IBA, garlic, liquorice and algae. Moringa extract significantly reduced root length in both seasons. No significant difference was observed between suckers and shoots cuttings in both seasons. The interaction between cuttings source and treatments was insignificant. So, no significant differences were found between sucker and shoot cuttings soaked in IBA, garlic, liquorice and algae extracts.

These findings are in contrast with those reported by Porghorban *et al*. (2014); Hamooh (2014); Jan *et al.* (2015) and Lazaj *et al.* (2015) who reported that IBA increased root length. Jones and *van* Staden (1997) cleared that Kelpak (commercial seaweed) improved rooting quality and developed vigorous root system consisting of numerous lateral roots above that of the control. In this respect, Ibrahim (2013) found that root growth of two-year-old olive cultivar Hojblanca was increased by seaweed extracts (Sea force).

Table 3: Effect of IBA, natural extracts and plant organ on average length of roots/ cutting of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	10.49 a	9.87 a	**10.18 A**	11.08 a	9.71 ab	**10.40 A**
Moringa 20 %	3.00 c	2.58 c	**2.79 C**	2.99 c	2.65 c	**2.82 C**
Garlic 20 %	9.94 a	9.71 a	**9.83 A**	10.08 ab	9.65 ab	**9.87 A**
Liquorice 10 g/l	9.82 a	8.93 ab	**9.38 A**	10.22 ab	9.34 ab	**9.78 A**
Yeast 10 %	7.66 b	7.27 b	**7.47 B**	7.70 b	7.66 b	**7.68 B**
Algae 5 cm/l	10.05 a	9.59 a	**9.82 A**	10.01 ab	9.42 ab	**9.72 AB**
Plant organ av.	**8.49 A**	**7.99 A**		**8.68 A**	**8.07 A**	

Means in each column which have the same letter(s) are not significantly different.

Dry weight of roots (g)

Data it Table (4) illustrate that IBA maintained significantly higher dry weight of roots compared with other treatments in the two seasons. No significant differences were traced between garlic, liquorice and algae extracts in dry weight of roots in both seasons. The least root dry weight was exhibited by soaking cuttings in moringa extract in the two seasons.

The sucker cuttings showed significant increase in roots dry weight in comparison with shoot cuttings in both seasons.

The interaction between cutting source and treatments was significant in both seasons. The largest root dry weights (0.652 & 0.603 g) were recorded for sucker cuttings treated with IBA at 4000

ppm in the two seasons, respectively. Sucker and shoot cuttings dipped in moringa extracts produced the smallest root dry weights in the two seasons. The other combinations produced in-between dry weights.

These results are in line with those reported by Khajehpour *et al*. (2014); Mayer *et al*. (2014), Sharma *et al*. (2014) and Jan *et al*. (2015) on different fruit species. They all stated that IBA increased dry weight of roots.

Jones and *van* Staden (1997) and Thorsen *et al.* (2010) cleared that Kelpak (commercial seaweed) improved rooting quality above that of the control and significantly increased total root weight and the individual weight of roots produced in cuttings. Abdulrahman-Amira (2013) and Ibrahim (2013) found that root dry weight was increased by seaweed extracts. The highest root fresh mass was exhibited by Kelpak treated cuttings (Krajnc *et al*., 2012).

Table 4: Effect of IBA, natural extracts and plant organ on roots dry weight of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	0.652 a	0.563 b	**0.608 A**	0.603 a	0.542 b	**0.573 A**
Moringa 20 %	0.143 f	0.130 f	**0.137 D**	0.135 ef	0.113 f	**0.124 C**
Garlic 20 %	0.295 c	0.185 e	**0.240 B**	0.260 c	0.173 de	**0.217 B**
Liquorice 10 g/l	0.295 c	0.203 de	**0.249 B**	0.292 c	0.193 d	**0.243 B**
Yeast 10 %	0.187 e	0.143 f	**0.165 C**	0.175 de	0.137 ef	**0.155 C**
Algae 5 cm/l	0.298 c	0.225 d	**0.262 B**	0.272 c	0.205 d	**0.238 B**
Plant organ av.	**0.312 A**	**0.242 B**		**0.289 A**	**0.227 B**	

Means in each column which have the same letter(s) are not significantly different.

Shoot numbers per cutting

Results presented in Table (5) reveal that shoot numbers per cutting was significantly IBA, garlic and algae extracts in both seasons. While, the least shoot numbers per cutting was induced for moringa extract. Sucker cuttings produced higher shoot number per cutting in the second season only. The interaction between cuttings source and treatments was insignificant in both seasons. The lowest shoot numbers per cutting was produced by shoot cuttings soaked in moringa extract.

Table 5: Effect of IBA, natural extracts and plant organ on number of shoots/ cutting of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	2.89 ab	3.02 ab	**2.95 A**	2.91 abc	2.32 abcd	**2.61 AB**
Moringa 20 %	0.93 d	0.83 d	**0.88 C**	2.07 cd	0.67 e	**1.37 C**
Garlic 20 %	3.18 a	2.41 abc	**2.79 AB**	2.88 abc	3.00 abc	**2.94 A**
Liquorice 10 g/l	2.29 abc	1.96 bcd	**2.13 B**	3.25 a	2.38 abcd	**2.82 A**
Yeast 10 %	2.85 ab	1.68 cd	**2.26 AB**	2.22 bcd	1.85 d	**2.03 BC**
Algae 5 cm/l	2.51 abc	2.30 abc	**2.41 AB**	3.05 ab	2.60 abcd	**2.83 A**
Plant organ av.	**2.44 A**	**2.03 A**		**2.73 A**	**2.14 B**	

Means in each column which have the same letter(s) are not significantly different.

Opposite trends were reported by Roshdy (2014), Sharma *et al.* (2014); Jan *et al*. (2015) and Jana *et al*. (2015). They all cleared that IBA increased shoot numbers per cutting of fruit species.

The increase in shoot characteristics might also be due to the auxins content in the seaweed extracts which have an effective role in cell division and enlargement; this leads to increase the shoot

growth, leaf area and plant dry weight (Gollan and Wright, 2006). Arthur *et al*. (2003) showed that seaweed improves root-growth, vegetative and reproductive growth of many plants. Mansour *et al*. (2006) and Abd El Moniem – Eman and Abd-Allah (2008) showed that the application of algae extract was very effective in stimulating the growth characters.

At contrast, Sadak-Mervat (2016) reported that yeast extract caused significant decreases in number of shoot of *Pisum sativum* L. plants.

Survival percentage of cuttings

Results in Table (6) indicate that, the highest survival percentage was recorded for IBA, garlic and algae treatments without significant differences between them in both seasons and liquorice extract in the second season only. The least survival percentage was gained by moringa extract (19.43 and 38.87 %) in both seasons.

Sucker cuttings showed significantly higher survival percentage than shoot cuttings in both seasons. The interaction between cuttings source and treatments showed that the highest survival percentage was exhibited by sucker or shoot cuttings dipped in IBA and algae in both seasons without significant differences between them. The lowest percentage was produced by cuttings of both organs soaked in moringa extract in both seasons.

Similar trends were reported by Mayer *et al.* (2014); Jan *et al*. (2015) and Soni *et al*. (2016). They all reported that IBA increased survival percentage of cuttings in different fruit species (olive, pear, apple, peach, plum, citrus and grapevine). In addition, Canozer and Ozahci (1994) concluded that the treatment with 4000 ppm IBA was for 5 s. There is a wide variation in survival percentage of cuttings among the different cultivars. De Almeida *et al.* (2008) showed that the vegetative propagation by rooting of herbaceous cuttings of the Malay apple is possible; however, both IBA treatments and basal incision have not shown significant effect on the analysed variables: percentage of survival and rooting of the cuttings, number and mean length of roots per cutting.

Vinoth *et al*. (2012) mentioned that the application of algae extract was very effective in stimulating growth characters especially survival percentage of cuttings. Arthur *et al*. (2003) showed that seaweed increases seedling quality and survival, improves root-growth, vegetative and reproductive growth of many plants.

Table 6: Effect of IBA, natural extracts and plant organ on survival percentage of cuttings of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	100.00 a	77.78 ab	**88.89 A**	94.43 ab	88.87 ab	**91.65 A**
Moringa 20 %	27.76 cd	11.10 d	**19.43 D**	55.52 de	22.22 f	**38.87 B**
Garlic 20 %	94.43 a	66.64 b	**80.54 AB**	77.73 abcd	72.21 bcd	**74.97 A**
Liquorice 10 g/l	77.76 ab	66.66 b	**72.21 BC**	83.32 abc	77.78 abcd	**80.55 A**
Yeast 10 %	77.76 ab	41.63 c	**59.69 C**	61.07 cde	47.20 e	**54.13 B**
Algae 5 cm/l	94.43 a	83.32 ab	**88.88 A**	100.00 a	77.76 abcd	**88.88 A**
Plant organ av.	**78.69 A**	**57.86 B**		**78.68 A**	**64.34 B**	

Means in each column which have the same letter(s) are not significantly different.

Bud sprouting percentage

Results in Table (7) indicate that, the highest bud sprouting percentage was recorded for IBA, garlic and algae treatments without significant differences between them in both seasons and liquorice extract in the second season only. The least significant bud sprouting percentage was gained by moringa extract (8.33 and 18.75 %) in both seasons, respectively.

All sucker cuttings showed significantly higher bud sprouting percentage than shoot cuttings in both seasons. The interaction between treatments and source of cutting on bud sprouting percentage was significant in both seasons. The highest percentages of bud sprouting were gained by sucker

cuttings dipped in IBA and algae compared with other combinations. Sucker and shoot cuttings dipped in moringa extract revealed the lowest bud sprouting percentages in both seasons.

The obtained results are in line with those reported by Patil *et al.* (2001), Gill *et al.* (2014) and Mayer *et al*. (2014) who reported that IBA improved sprouting percentage.

Table 7: Effect of IBA, natural extracts and plant organ on bud sprouting percentage of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	72.23 a	53.23 abcd	**62.73 A**	66.67 ab	51.38 bcd	**59.03 A**
Moringa 20 %	8.33 f	8.33 f	**8.33 D**	30.57 ef	6.93 g	**18.75 B**
Garlic 20 %	70.82 a	38.92 bcde	**54.87 AB**	48.60 bcde	55.53 abcd	**52.07 A**
Liquorice 10 g/l	58.35 abc	34.72 de	**46.53 BC**	62.57 abc	49.98 bcd	**56.28 A**
Yeast 10 %	50.00 abcd	24.98 ef	**37.49 C**	37.52 de	15.28 fg	**26.40 B**
Algae 5 cm/l	59.70 ab	36.11 cde	**47.90 ABC**	73.60 a	47.17 cde	**60.38 A**
Plant organ av.	**53.24 A**	**32.71 B**		**53.25 A**	**37.71 B**	

Means in each column which have the same letter(s) are not significantly different.

Leaf numbers per rooted cutting

As shown in Table (8), the highest number of leaves per cutting was gained by IBA, liquorice and algae treatments in the two seasons, without significant differences between them. Moringa extract induced the lowest number of leaves per cutting in both seasons.

Sucker cuttings significantly produced higher number of leaves per cutting than shoot cuttings in the second season only. The interaction between treatments and source of cuttings on leaf numbers per rooted cutting was significant in both seasons. The highest number of leaves/cutting was recorded for each of the combinations IBA, liquorice and algae × sucker cuttings, IBA and algae × shoot cuttings in both seasons without significant differences between them. All combinations of moringa extract gave the lowest number of leaves/ cutting in both seasons.

Table 8: Effect of IBA, natural extracts and plant organ on number of leaves/ rooted cutting of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	8.31 ab	6.99 abc	**7.65 AB**	7.92 ab	7.35 ab	**7.64 AB**
Moringa 20 %	1.77 d	1.38 d	**1.58 D**	1.74 d	1.31 d	**1.53 D**
Garlic 20 %	6.50 bc	5.91 c	**6.21 BC**	7.39 ab	6.21 bc	**6.80 B**
Liquorice 10 g/l	7.26 abc	6.39 bc	**6.82 ABC**	8.72 a	6.25 bc	**7.49 AB**
Yeast 10 %	5.47 c	5.68 c	**5.58 C**	4.79 c	4.51 c	**4.65 C**
Algae 5 cm/l	8.70 a	6.72 abc	**7.71 A**	8.85 a	8.30 a	**8.58 A**
Plant organ av.	**6.33 A**	**5.51 A**		**6.57 A**	**5.66 B**	

Means in each column which have the same letter(s) are not significantly different.

These findings are entirely in agreement with those reported by Patil *et al.* (2001); Sharma *et al.* (2014) and Jan *et al*. (2015). They all found that IBA increased leaf numbers/ cutting of fruit species (olive, pear, apple and grapevine). On the other hand, Dolor *et al*., (2010) cleared that IBA did not significantly affect leaf numbers / cutting.

Mansour *et al.* (2006); Abd El Moniem–Eman and Abd-Allah (2008); Vinoth *et al.* (2012); Abdulrahman – Amira (2013) and Ibrahim (2013) reported that application of algae extract was very effective in stimulating the growth characters (i.e., leaf numbers/cutting) of olive cv. Hojblanca .

Babilie *et al.* (2015) mentioned that liquorice roots and seaweed extracts significantly increased plant height, length of the tallest leaf and number.

Zaki - Safinaz and Rady (2015) showed that *Moringa oleifera* leaf extract (MLE) significantly increased growth characteristics (i.e., shoot length, number and area of leaves per plant, and plant dry weight) when compared with the controls.

Taha- Lobna *et al.* (2016) cleared that yeast extract had no significant effect on shoot diameter, number of leaves /plant and root length. On the other hand, Sadak - Mervat (2016) mentioned that yeast extract caused significant decreases in number of leaves of *Pisum sativum* L. plants.

Average length of shoot per cutting

Data in Table (9) cleared that IBA, garlic, liquorice and algae treatments gained the highest average length of shoot per cutting in the two seasons, without significant differences between most of them. Moringa extract significantly induced the lowest average length of shoot per cutting in both seasons.

No significant differences were obtained between sucker and shoot cuttings in the first season, while sucker cuttings significantly increased average length of shoot per cutting compared with shoot cuttings in the second season.

The interactions between treatments and source of cutting on shoot length was significant in both seasons. The tallest shoot lengths were recorded for sucker and shoot cuttings dipped in IBA and algae while those dipped in moringa extract exhibited the shortest shoot length in the two seasons.

These results are in agreement with those reported by Hegazi *et al*. (2010); Da Silva *et al*. (2013), Khajehpour *et al*. (2014); Sharma *et al*. (2014); Jan *et al*. (2015) and Jana *et al*. (2015). They all revealed that IBA increased shoot length of fruit species (olive, pear, apple and citrus).

Arthur *et al*. (2003) showed that seaweed increases seedling quality and survival, improves root-growth, vegetative and reproductive growth of many plants. Mansour *et al.* (2006) and Abd El Moniem–Eman and Abd-Allah (2008); Vinoth *et al.* (2012); Ibrahim (2013);Popescu and Popescu (2014) mentioned application of algae extract was very effective in stimulating shoot length.

Zaki - Safinaz and Rady (2015) cleared that application of *Moringa oleifera* leaf extract (MLE) significantly increased growth characteristics (i.e., shoot length, number and area of leaves per plant, and plant dry weight) when compared with the controls. Babilie *et al*. (2015) mentioned that of liquorice roots and seaweed extracts treatments significantly increased plant height, length of the tallest leaf and number.

Table 9: Effect of IBA, natural extracts and plant organ on average length of shoot/ cutting of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	4.47 a	4.10 ab	**4.28 A**	4.62 a	4.21 abc	**4.42 A**
Moringa 20 %	1.02 de	0.97 e	**0.99 C**	1.48 ef	0.84 f	**1.16 D**
Garlic 20 %	4.25 a	3.13 abc	**3.69 A**	4.07 abc	3.03 cd	**3.54 BC**
Liquorice 10 g/l	3.50 abc	3.30 abc	**3.40 AB**	4.50 ab	3.39 bcd	**3.94 AB**
Yeast 10 %	2.75 bc	2.48 cd	**2.62 B**	2.84 d	2.62 de	**2.73 C**
Algae 5 cm/l	4.56 a	3.46 abc	**4.01 A**	3.71 abcd	3.59 abcd	**3.65 AB**
Plant organ av.	**3.43 A**	**2.91 A**		**3.54 A**	**2.95 B**	

Means in each column which have the same letter(s) are not significantly different.

Aerial portion dry weight (g)

Data in table (10) showed that aerial portion dry weight of Picual olive variety was significantly affected by the tested treatments in the two seasons. The highest dry weight of aerial portion was gained by IBA and garlic treatments (0.916 and 0.921 g) in the first season, respectively, while from liquorice

and algae (0.852 and 0.836 g) in the second season, respectively without significant differences between them. The least aerial portion dry weight was induced by moringa treatment in the two seasons.

The sucker cuttings gave a significant higher aerial portion dry weight than shoot cuttings in both seasons.

The interaction between cutting source and treatments was significant in both seasons. The uppermost values of aerial portion dry weights 1.053 & 1.032 g were recorded for sucker cuttings treated with algae and liquorice in the first and second seasons, respectively. The lowest aerial portion dry weights (0.298 & 0.213 g) were induced for shoot cuttings dipped in moringa extract in the first and second seasons, respectively. The other combinations produced in-between dry weights.

These results are in line with those reported by Khajehpour *et al*. (2014), Sharma *et al.* (2014) and Jana *et al.* (2015) who reported that IBA increased shoot dry weight (g) of olive, pear and apple.

Zuhair (2010) stated that liquorice extract at 2 g/l reduced significant increase in average leaf area and foliage dry weight, but when applied at 4g/l caused a significant increase in total chlorophyll content of two strawberry varieties.

Kelpak biostimulator contains auxin-like and cytokinin-like natural compounds with dominant Indole-3-acetic acid (IAA), which improves the cell growth and the cell elongation, root growth and improves the root quality and branching and plants' activities (Jenkins and Mahmood, 2003 and Magyar *et al*., 2008).

Blunden *et al.* (1991) evaluated of effects of seaweed extracts applied to established plants. However, the mode of action of seaweed extracts to beneficially influence plant growth is not completely understood. The increased growth of these crops may be due to the presence of some growth promoting substances present in the seaweed extract. Krajnc *et al*. (2012) showed a statistically significant increase in shoot fresh mass for all Kelpak applications when compared to untreated controls, but the highest root fresh mass and shoot/root ratio as well as the maximum number of leaves had developed 2.0 % Kelpak treated cuttings. The increase in shoots characteristics might also be due to the auxins content in the seaweed extracts which have an effective role in cell division and enlargement; this leads to increase the shoot growth, leaf area and plant dry weight (Gollan and Wright, 2006). Seaweed extracts contain cytokinins as well in which induce the physiological activities (for instance activating some enzymes that involved in photosynthesis) and increase the total chlorophyll in the plant, this will positively reflect on the activity of photosynthesis and the synthesized materials which will positively reflect on shoots characteristics (Thomas, 1996). Arthur *et al.* (2003) showed that seaweed increases seedling quality and survival, improves root-growth, vegetative and reproductive growth of many plants. Mansour *et al*. (2006), Abd El Moniem – Eman and Abd-Allah (2008) and Roshdy (2014) showed that application of algae extract was very effective in stimulating the growth characters.

Zaki - Safinaz and Rady (2015) showed that application of *Moringa oleifera* leaf extract (MLE) significantly increased growth characteristics.

Hanafy *et al.* (2012) found that, the highest values of fresh and dry weight of leaves/plant were obtained with garlic extract followed by yeast extract.

Table 10: Effect of IBA, natural extracts and plant organ on aerial portion dry weight of Picual olive cuttings (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Plant organ			Plant organ		
	Sucker	Shoot	Trea. av.	Sucker	Shoot	Trea. av.
IBA 4000 ppm	1.048 ab	0.783 c	**0.916 A**	0.818 c	0.742 d	**0.780 B**
Moringa 20 %	0.368 fg	0.298 g	**0.333 D**	0.375 g	0.213 i	**0.294 E**
Garlic 20 %	0.980 ab	0.862 c	**0.921 A**	0.713 de	0.653 f	**0.683 C**
Liquorice 10 g/l	0.970 b	0.618 d	**0.794 B**	1.032 a	0.672 ef	**0.852 A**
Yeast 10 %	0.548 de	0.423 f	**0.486 C**	0.400 g	0.282 h	**0.341 D**
Algae 5 cm/l	1.053 a	0.508 e	**0.781 B**	0.938 b	0.733 d	**0.836 A**
Plant organ av.	**0.828 A**	**0.582 B**		**0.713 A**	**0.549 B**	

Means in each column which have the same letter(s) are not significantly different.

On the other hand, Sadak-Mervat (2016) declared that yeast extract caused significant decreases in fresh and dry weights of shoots of *Pisum sativum* L. plant. Auxins have been shown to have the greatest effect on rooting. Numerous reports have indicated the involvement of auxin in the initiation of adventitious roots, and that division of root initials depends on exogenous and endogenous auxin. Synthetic auxins, such as IBA have been shown to be more effective than the naturally occurring indole-3-acetic acid (IAA) for rooting. IBA is actually commonly used in propagating olives by cuttings.

Natural extracts contain various compounds, which affects rooting. Algae extract is a biofertilizer containing various nutrients, polyamines, growth regulators and vitamins, which improves vegetative growth, nutritional status, yield and fruit quality attributes (Abd El-Moniem-Eman and Abd-Allah; 2008 and Spinelli *et al.*, 2009). Moringa leaves contains zeatin, as natural alternative cytokinin source (Fuglie, 2000). In addition, it also contains ascorbates, phenols, carotenoids, calcium and potassium, which promote plant growth by application as exogenous plant growth promoter (Foidl *et al.,* 2001). It also contains Indole acetic acid and plant growth regulators (Sachan *et al.,* 2011). Garlic extract contains vitamins, flavonoids, minerals, sulphur, and ascorbic acid. In addition, it contains about seventeen amino acids. The garlic extract effects on plant characteristics was reported by Sayeeda and Ahmed (2005) and El- Shayeb (2009). The liquorice extract contains various compounds. The most important contents of liquorice are phenolic compounds and saponins (as glycyrrhizin) (Shibata, 2000 and Shabani *et al*., 2009). In addition, yeast is a source of many growth substances, and nutritional elements (Na, Ca, Fe, K, P, S, Mg, Zn and Si), vitamins, cytokinines, amino acids and some organic materials (Nagodawithana, 1991).

Suckers contains high amounts of energy compounds, i.e. carbohydrates which explains the better root and growth characteristics of sucker cuttings than shoot ones (Fabbri *et al*., 2004).

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