Adv. Hort. Sci., 2020 34(2): 191-204 DOI: 10.13128/ahsc-7904

AHS
Advances in Horticultural Science

The first report: The effect of garlic extract on rooting of cuttings of some ornamental plants and fruit trees

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Key words: antimicrobial property, callus, culture substrate, grape, hormone, sycamore, wild privet.

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Citation:
ABBASIFAR A., VALIZADEHKAJI B., KARIMI M., BAGHERI H., 2020 - *The first report: The effect of garlic extract on rooting of cuttings of some ornamental plants and fruit trees.* - Adv. Hort. Sci., 34(2): 191-204.

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no competing interests.

Received for publication 19 September 2019
Accepted for publication 23 April 2020

Abstract: One of the problems with the use of cuttings, particularly woody and semi-woody ones, is to root them for propagation of various plant species. The use of rooting hormones involves a high cost of foreign exchange and creates many environmental problems. Garlic extract has a lot of antimicrobial properties and can prevent the release of microorganisms in the culture medium of plants. In this study, garlic extract at three concentrations (0, 25, and 50 g/L) was investigated on the rooting of three different species include easy-to-root cuttings (rose, wild privet, and poplar), moderate-root cuttings (sycamore, berry, and grape), and hard-to-root cuttings (apple, sour cherry, and cherry) in three applications of the culture substrate, on the cuttings, and in the callus stage. Results showed that garlic extract can be used at a concentration of 25 g/L at the callus formation stage to improve the quantity and quality of grape cuttings in terms of shooting and rooting. The quantity and quality of shoots and roots for wild privet cuttings can be improved with garlic extract at 25 g/L and be used on the cuttings. Garlic extract at concentrations of 50 and 25 g/L can be used in the callus stage to enhance the quantity and quality of sycamore and berry cuttings, respectively. No positive effects were observed in the other plants, or positive effects were found only either on shooting or on rooting traits.

1. Introduction

Since the uniformity of plants used in gardens and green spaces is important, one of the most effective methods of non-sexual propagation is now the use of various cuttings worldwide. One of the important problems of using cuttings, particularly hardwood and semi-hardwood ones is to root them. To overcome this critical problem, manufacturers apply different methods, one of which is the use of different rooting hormones, particularly auxins (Guan *et al.,* 2015). Although the use of hormones for rooting is very effective, these substances are mostly imported goods that require a large amount of foreign money. In addition, the use of plant-derived substances instead of chemicals and synthetic auxins to deal with adverse environmental effects is an issue that has been considered in the

European Union in recent years. This has led to an increasing interest in the production of substances that can help propagate a variety of plants and, at the same time, are environment friendly (Wojdyła, 2004; Pacholcza *et al.,* 2016). Also, one of the problems during rooting of cuttings is the substrate contamination with pathogens, and consequently the contamination of cuttings and their failure in rooting (Hartmann *et al.,* 2002). According to a previous studies (Wojdyła, 2004; Pacholczak *et al.,* 2016), the use of natural substances can reduce production costs and provide better accessibility compared to chemicals. In addition to various chemical compounds, the use of natural substances in the cultivation of commercial plants is today gaining interest among manufacturers and producers, which has been accompanied by positive and interesting results. In some cases, such substances have even been appropriately replaced chemical compounds due to better results. If plant extracts can be used to root the cuttings, a new step will be taken towards this branch of agricultural science in addition to saving costs and non-dependency on the imports of hormones as well as avoiding environmental contaminants. Plant essential oils play an important role in disinfecting, stimulating, and improving growth, increasing dry matter, and protecting the plant against environmental damages and stresses (Bai *et al.,* 2007).

Garlic extract is a substance with antioxidant, antimicrobial, and antibacterial properties (Harris *et al.,* 2001). Garlic active compounds often accumulate in its underground organ (garlic bulb). Garlic contains sulfide compounds such as allyn, diallyl sulfides, and allicin, with allicin being the most abundant compound in the garlic extract, accounting for approximately 70% of these compounds (Sadaqa *et al.,* 2016). It has been shown that garlic planting in vegetable hydroponic substrates prevents the development of many diseases and reduces microbial population in the substrate (Liu *et al.,* 2014). Garlic extract has many allelopathic chemicals (Wang *et al.,* 2015). The most important chemicals and minerals found in garlic extract are lipids, carbohydrates, fibers, manganese, potassium, sulfur, calcium, phosphorus, magnesium, sodium, vitamin B6, vitamin C, glutamic acid, arginine, aspartic acid, leucine, and lysine (Al Mayahi and Fayadh, 2015).

Given the importance of ornamental trees and flowers and also fruit trees in human health and economics, this study aimed to investigate the possible effects of garlic extract at different concentrations on rooting of cuttings and propagation of rose, wild privet, poplar, sycamore , berry, grape, apple, sour cherry, and cherry cuttings to achieve the best treatment. There is a large body of literature concerning the effect of using hormones on the rooting of cuttings and its optimization (Guan *et al.,* 2015), but no research has so far been conducted on the effect of plant extracts on plant rooting. In the design of this research, therefore, attempts were made to treat the cuttings of different plants with garlic extract in terms of rooting to obtain acceptable results at the beginning of the experiment. This research also tried to use an extract that is suitable for disinfection of the substrate. This was the first report on the use of garlic extract on the rooting of different plants, and it is hoped that the results could pave the ground for further research in this field.

2. Materials and Methods

This research was conducted at the research greenhouse of the Faculty of Agriculture and Natural Resources, University of Arak. To investigate the effect of garlic extract on the rooting of different cuttings, a factorial experiment (cuttings as the first factor and garlic extract concentrations as the second factor) was carried out in a completely randomized design with three replications each with 10 cuttings.

Plant materials

Three types of cuttings including easy-to-root cuttings (rose, wild privet, and poplar), moderate-root cuttings (plane, berries, and grapes), and hard-to-root cuttings (apple, sour cherry, and cherry) were prepared from healthy and genetically uniform native plants in the planting season (December). The cuttings were 10-15 cm in length with a thickness of 5-7 mm.

Extraction of garlic cloves

The garlic cloves were first peeled and grated for each independent experiment. Then, 10 g of the grated garlic was placed in 10 ml of water at room temperature for 24 h. The garlic extract was obtained after passing through filter papers.

Preparation of seedbed, planting of cuttings, and application of treatments

The sandstone culture substrate was similar for all cuttings. Each experiment was consisted of three replicates each with 10 cuttings. Cuttings were grown in 9 rows at 10 cm spacing on a row and 2 cm spacing between the rows in the substrate. The extract concentrations were 0 (control), 25, and 50 g/L of distilled water for 2 seconds. The extract was used at three times: 1) extract dispersion on the culture substrate during substrate preparation and before planting the cuttings, 2) at planting the cuttings by inserting the bottom half of the cuttings in the extract to disinfect the cuttings, and 3) dispersion on the substrate at the tips of the cuttings in the callus formation stage. After planting, the cuttings were kept and irrigated regularly under greenhouse conditions for 3 months.

Measuring morphological traits

Immediately after the collection of root and aerial samples, their fresh weight was measured using a digital scale. To determine the dry matter content, the samples were placed in an oven at 70°C for 48 h. Finally, the dry weights of shoots and roots were determined with a digital scale. Further measured traits were the number of roots and shoots, root and shoot length, and longest roots and shoots. During the experiment and the growth of cuttings, the average temperature and relative humidity were 22°C and 35%, respectively, in the greenhouse.

Data were independently normalized with such methods as the removal of outliers (data higher and lower than twice the root mean square error) using the equation $X = Y + 0.5$, and were then analyzed using SAS 9.4 software. Mean values were compared with Duncan's multiple range test at $p<0.05$.

3. Results

The use of different concentrations of garlic extract in the substrates of cuttings

Shoot-related characteristics. The interaction effect of garlic extract treatment × the substrate and plant type significantly affected the number of green cuttings, total shoot length, number of shoots, mean shoot length, length of the longest shoots, and fresh and dry weights of the shoots. Increasing the extract concentration elevated the number of green cuttings, total shoot length, average shoot length, length of the longest shoots, and fresh and dry weights of shoots in rose cuttings. Elevated number of green cuttings, total shoot length, average shoot length, and length of the longest shoots were observed in wild privet with the extract levels. In poplar cuttings, all the traits improved markedly at a moderate concentration (25 g/L) (Table 1).

The use of garlic extract in sycamore cuttings had no positive effects on shoot-related traits. In berry cuttings, the moderate concentration had positive impacts on the number of green cuttings and total shoot length, but it was not significant on the other traits (Table 1). In grape cuttings, moderate concentration of garlic extract positively affected the number of green cuttings, average shoot length, and shoot fresh and dry weights, while the high concentration (50 g/L) was not significantly different from the moderate one or had a negative effect. In apple cuttings, the moderate concentration significantly increased the number of green cuttings, and both moderate and high concentrations led to increased number of shoots, but the use of garlic extract had no significant effects on the other traits. In sour cherry cuttings, no positive effects were observed on all the traits. In cherry cuttings, the use of garlic extract at both concentrations had slight positive effects on the number of green cuttings, total shoot length, number of shoots, mean shoot length, and length of the longest shoots (Table 1).

In this experiment, the highest number of green cuttings, total shoot length, and the longest shoot length were obtained in wild privet with 50 g/L, with the highest number of shoots and fresh shoots at 25 g/L of garlic extract. The highest number of green cuttings belonging to wild privet cuttings was not significantly different from berry cuttings treated with a moderate concentration. Also, the average shoot length was higher in poplar cuttings treated with a moderate concentration than the other cuttings (Table 1).

Root-related traits. In this experiment, the interaction of garlic extract concentrations × substrate and plant type was significant on total length of roots, root number, mean root length, longest root length, and root fresh and dry weights. Garlic extract at a concentration of 50 g/L had positive effects on total length of roots, root number, mean root length, longest root length, and root fresh and dry weights of rose roots. Total root length and root number were uppermost in wild privet plant at a high concentration (50 g/L). Also, the moderate concentration (25 g/l) produced the longest roots and the highest root fresh and dry weights in this plant (Table 2).

In poplar cuttings, a concentration of 25 g/l resulted in significant increases in total length of roots, root number, mean root length, longest root length, and root fresh and dry weights. There were no significant increases in root traits of sycamore cuttings with the extract application. The extract application was not useful on rooting traits in berry cuttings. Extract

Table 1 - Effects of different concentration of garlic extract (the culture substrate) on shoot-related characteristics

Treatments	Number of green cuttings	Total length of shoots	Number of shoots	Shoot length mean (cm)	The highest shoot length (cm)	Fresh weight (gr)	Dry weight (gr)
Plant							
Rose	0.56 fg	0.89 e	0.67 ef	0.67 ef	0.78 de	0.02 d	0.00 d
Wild privet	7.44 b	181.50 a	33.00 a	5.63 a	19.62 a	5.27 a	0.58 a
Poplar	1.78 de	21.39 d	2.78 e	4.96 b	8.17 b	0.62 c	0.03 c
Sycamore	2.33 d	2.78 e	2.78 e	0.99 e	1.72 d	0.01 d	0.01 cd
Berry	9.11 a	43.04 b	23.71 a	1.78 d	5.44 c	0.05 d	0.01 cd
Grape	7.33 b	33.22 c	11.55 c	2.62 c	8.28 b	2.58 b	0.06 b
Apple	3.89 c	2.89 e	5.78 d	0.50 ef	0.50 de	0.00 d	0.00 d
Sour cherry	1.33 ef	3.89 e	2.22 ef	0.86 e	1.17 de	0.00 d	0.00 d
Cherry	0.22 g	0.11 e	0.22 f	0.11 f	0.11 e	0.00 d	0.00 d
Garlic extract concentration (g·L)							
Control (0 g.L)	3.41 b	23.80 b	7.23 b	1.71 b	4.17 b	0.77 b	0.09 a
25 g·L	4.26 a	34.98 a	9.46 a	2.88 a	6.35 a	1.01 a	0.06 b
50 g·L	3.67 b	20.44 b	7.88 b	1.11 c	4.17 b	0.70 b	0.02 c
Plant × garlic extract concentration (g·L)							
Rose × 0	0.00 j	0.00 g	0.00 i	0.00 j	h00.0	g00.0	f00.0
Rose × 25	0.67 hij	0.67 g	1.00 hi	0.50 ghij	0.50 fgh	g00.0	00.0 f
Rose × 50	1.00 ghij	2.00 g	1.00 hi	1.50 efghi	1,83 fgh	g08.0	ef 01.0
Wild privet × 0	5.00 cd	128.17 c	29.00 bc	5.47 c	17.00 c	b82.5	a72.0
Wild privet × 25	7.67 b	224.75 b	37.50 a	5.37 c	17.50 c	a47.7	b63.0
Wild privet × 50	9.67 a	255.00 a	32.67 b	6.89 b	26.75 a	d00.4	c10.0
Poplar × 0	1.00 ghij	4.67 g	1.00 hi	1.33 efghij	1-33 fgh	g05.0	f00.0
Poplar × 25	3.67 def	59.50 d	4.67 gh	13.55 a	22.67 b	e42.1	cd07.0
Poplar × 50	0.67 hij	0.00 g	2.67 ghi	0.00 j	0.50 fgh	g38.0	ef02.0
Sycamore × 0	2.67 efg	5.17 g	3.00 ghi	1.57 defgh	2.67 fg	g00.0	f00.0
Sycamore × 25	2.33 fgh	3.00 g	2.33 ghi	1.02 fghij	2.00 fgh	g00.0	f00.0
Sycamore × 50	2.00 fghi	0.17 g	3.00 ghi	0.37 hij	0.50 fgh	g05.0	def03.0
Berry × 0	8.33 ab	36.67 ef	19.67 d	1.38 defg	5.67 e	g17.0	ef02.0
Berry × 25	9.67 a	47.47 de	27.00 c	1.67 defgh	5.33 e	g00.0	f00.0
Berry × 50	9.33 ab	45.00 e	26.00 c	1.58 defg	5.33 e	g00.0	f00.0
Grape × 0	7.67 b	27.00 f	11.00 e	2.61 de	7.50 de	f91.0	cde06.0
Grape × 25	8.67 ab	38.33 ef	13.33 e	2.84 d	8.17 d	c49.4	cd08.0
Grape × 50	5.67 c	34.33 ef	10.33 ef	2.42 de	9.17 d	e78.1	cde06.0
Apple × 0	3.67 def	2.33 g	4.67 gh	0.50 ghij	0.50 fgh	0.00 g	0.00 f
Apple × 25	4.33 cde	3.17 g	6.33 fg	0.50 ghij	0.50 fgh	0.00 g	0.00 f
Apple × 50	3.67 def	3.17 g	6.33 fg	0.50 ghij	0.50 fgh	0.00 g	0.00 f
Sour cherry × 0	2.33 fgh	10.17 g	4.00 ghi	2.08 def	2.83 f	0.00 g	0.00 f
Sour cherry × 25	1.00 ghij	1.00 g	3.00 ghi	0.33 hij	0.33 fgh	0.00 g	0.00 f
Sour cherry × 50	67.0 hij	0.50 g	0.67 hi	0.17 ij	0.33 fgh	0.00 g	0.00 f
Cherry × 0	0.00 j	0.00 g	0.00 i	0.00 j	0.00 h	0.00 g	0.00 f
Cherry × 25	0.33 ij	0.17 g	0.33 hi	0.17 ij	0.17 gh	0.00 g	0.00 f
Cherry × 50	0.33 ij	0.17 g	0.33 hi	0.17 ij	0.17 gh	0.00 g	0.00 f
P-value							
Plant	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Garlic extract conc.	0.0072	<0.0001	0.0001	<0.0001	<0.0001	0.0215	<0.0001
Plant × garlic extract concentration (g·L)	<0.0001	<0.0001	0.0072	<0.0001	<0.0001	<0.0001	<0.0001

Mean values followed by the similar letters within a column are not significantly different from each other at $P \le 0.05$ (Duncan's multiple range test).

Table 2 - Effects of different concentration of garlic extract (the culture substrate) on root-related traits

Treatments	Total length of roots	Number of roots	Root length mean (cm)	The highest root length (cm)	Fresh weight (gr)	Dry weight (gr)
Plant						
Rose	2.61 d	0.55 d	0.36 c	0.33 d	0.2 d	0.00 d
Wild privet	318.75 a	42.57 a	8.43 a	21.22 a	5.27 a	0.58 a
Poplar	29.61 c	3.33 c	4.14 b	7.12 c	0.62 c	0.03 c
Sycamore	0.83 d	0.33 d	0.17 c	0.33 d	0.01 d	0.01 cd
Berry	2.61 d	0.78 d	0.18 c	1.00 d	0.05 d	0.01 cd
Grape	73.06 b	10.12 b	4.84 b	11.00 b	2.58 b	0.06 b
Apple	0.00 d	0.00 g	0.00 c	0.00 d	0.00 d	0.00 d
Sour cherry	0.00 d	0.00 g	0.00 c	0.00 d	0.00 d	0.00 d
Cherry	0.00 d	0.00 g	0.00 c	0.00 d	0.00 d	0.00 d
Garlic extract concentration (g·L)						
Control (0 g·L)	28.67 b	3.44 c	1.92 b	3.48 b	0.77 b	0.09 a
25 g·L	52.83 a	8.27 a	2.43 a	6.00 a	1.01 a	0.06 b
50 g·L	29.74 b	4.64 b	1.41 c	3.48 b	0.70 b	0.02 c
Plant × garlic extract concentration (g·L)						
Rose × 0	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Rose × 25	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Rose × 50	7.83 g	1.67 f	1.07 f	1.00 e	0.08 g	0.01 ef
Wild privet × 0	202.67 c	21.00 c	9.91 a	19.00 b	5.82 b	0.72 a
Wild privet × 25	418.25 b	56.00 b	8.68 b	28.00 a	7.47 a	0.63 b
Wild privet × 50	462.00 a	a00.67	6.71 c	16.67 b	4.00 d	0.10 c
Poplar × 0	4.33 g	f67.0	0.87 f	1.67 e	0.05 g	0.00 f
Poplar × 25	82.50 e	e33.7	10.18 a	17.33 b	1.42 e	0.07 cd
Poplar × 50	2.00 g	f00.2	0.00 f	0.00 e	0.38 g	0.02 ef
Sycamore × 0	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Sycamore × 25	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Sycamore × 50	1.00 g	f00.1	0.50 f	1.00 e	0.05 g	0.03 def
Berry × 0	6.50 g	f33.1	25.0 f	2.50 e	0.17 g	0.02 ef
Berry × 25	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Berry × 50	0.00 g	1.00 f	0.31 f	0.50 e	0.00 g	0.00 f
Grape × 0	42.50 f	8.00 e	5.72 cd	9.50 d	0.91 f	0.06 cde
Grape × 25	96.50 d	12.50 d	3.06 e	14.00 c	4.49 c	0.08 cd
Grape × 50	80.17 e	10.67 d	4.75 d	11.00 d	1.78 e	0.05 cde
Apple × 0	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Apple × 25	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Apple × 50	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Sour cherry × 0	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Sour cherry × 25	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Sour cherry × 50	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Cherry × 0	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Cherry × 25	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
Cherry × 50	0.00 g	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f
P-value						
Plant	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Garlic extract conc.	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Plant × garlic extract concentration (g·L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Mean values followed by the similar letters within a column are not significantly different from each other at $P \leq 0.05$ (Duncan's multiple range test).

application in grape cuttings had significant impacts on all rooting traits. Root growing was not observed in the cuttings of apple, sour cherry, and cherry. In this experiment, the highest total root length and number of roots were observed in wild privet cuttings at a high concentration and the highest mean root length was recorded in poplar cuttings at a moderate concentration. The root length and fresh weight were uppermost in wild privet cuttings with a moderate concentration of garlic extract, and the highest root dry weight was measured in the cuttings of this plant in the control treatment (Table 2).

The effects of different concentrations of garlic extract on the cuttings

Shoot-related characteristics. The interaction of plant type and extract concentration resulted in significant impacts on the number of green cuttings, total shoot length, number of shoots, mean shoot length, longest shoot length, and fresh and dry weights of shoots. The application of garlic extract did not have positive effects on all the traits in rose cuttings. In wild privet cuttings, moderate concentration (25 g/L) could further elevate the number of green cuttings, total shoot length, number of shoots, and shoot fresh weight. The longest shoot length and shoot dry weight were observed in wild privet cuttings at high concentration treatment (50 g/L) (Table 3).

The application of garlic extract in poplar cuttings had positive effects on average shoot length and longest shoot length, with no positive impacts on the other traits. Garlic extract at moderate concentration significantly affected all shooting traits in sycamore cuttings. In berry cuttings, the use of this extract at both concentrations led to fairly positive influences on the longest shoot length and fresh and dry weights of the shoots, but no positive effects were observed on the other traits. In grape cuttings, no positive effects were observed on the traits except for the number of green cuttings at 25 g/L and dry weight of shoots at 50 g/L. There was no positive effects on the traits in garlic extract treatments of apple cuttings. Moreover, in sour cherry cuttings, only the mean shoot length was positively influenced by the moderate concentration (Table 3).

In cherry, cuttings treated with a moderate concentration had positive effects on the number of green cuttings, total shoot length, number of shoots, mean shoot length, longest shoot length, and shoot fresh weight. The highest number of green cuttings was found in berry cuttings at all concentrations. Total shoot length and number of shoots were uppermost in wild privet cuttings at moderate-level treatment. In wild privet cuttings, maximum mean shoot length occurred at a concentration of 50 g/l and the longest shoot length was obtained at both moderate and high concentrations. Also, the highest fresh and dry weight of shoots was measured in sycamore cuttings in the control (Table 3).

Root-related traits. Analysis of the experimental data showed that garlic extract yielded significant effects on total length of roots, number of root, mean root length, root length, and root fresh and dry weights of different cuttings. Rose plant cuttings were not rooted in any of the treatments. In wild privet cuttings, an extract concentration of 25 mg/L increased the total root length and both high and moderate concentrations produced the highest roots (Table 4).

Garlic extract treatments had no positive effects on all root traits in poplar cuttings. The application of different extract concentrations in sycamore cuttings led to no significant differences with the control. The berry, apple, sour cherry, and cherry cuttings were not rooted in this experiment. In grape cuttings, the use of garlic extract at both moderate and high concentrations produced positive impacts on the total root length, number of roots, the longest root length, and root fresh and dry weights (Table 4).

Using different concentrations of garlic extract in the callus stage

Shoot-related characteristics. According to the results of ANOVA, the interaction of plant type and garlic extract concentrations led to significant differences in all shoot-related traits at 1% level. The highest number of green cuttings was found in wild privet, berry, and grape cuttings, but there were no significant differences between the control and treatments. A high concentration of garlic extract had a negative effect on the number of green cuttings in poplar, while it had positive effects on rose and sycamore cuttings at both garlic extract concentrations. In apple cuttings, a high concentration of garlic extract positively affected the number of green cuttings. Garlic extract had no effects on sour cherry cuttings and produced negative consequences in cherry cuttings. The highest shoot length was obtained in poplar cuttings treated with 50 g/L of garlic extract. The highest shoots were measured in poplar cuttings treated with garlic extract. There were no significant differences in the shoot length and the longest shoots in wild privet and rose cuttings with garlic extract treatments. The moderate concentration in sycamore cuttings, both concentrations in berry cut-

Table 3 - Effects of different concentration of garlic extract (on the cuttings) on shoot-related characteristics

Treatments	Number of green cuttings	Total length of shoots	Number of shoots	Shoot length mean (cm)	The highest shoot length (cm)	Fresh weight (gr)	Dry weight (gr)
Plant							
Rose	0.33 f	0.50 e	0.44 e	0.50 d	0.44 f	0.15 d	0.01 f
Wild privet	7.78 b	111.00 a	33.25 a	3.46 b	12.78 b	8.34 b	2.23 b
Poplar	6.67 c	71.50 b	9.44 c	8.99 a	18.00 a	11.50 a	2.92 a
Sycamore	1.50 c	3.72 de	2.00 e	1.19 c	1.83 e	1.08 d	0.10 ef
Berry	10.00 a	27.11 c	20.89 b	1.34 c	3.22 d	3.77 c	1.02 d
Grape	6.55 c	30.00 c	9.78 c	3.11 b	7.05 c	8.61 b	1.19 c
Apple	1.78 e	0.69 e	1.78 e	0.28 d	0.33 f	0.16 d	0.03 ef
Sour cherry	2.89 d	6.61 d	4.67 d	1.61 c	3.31 d	0.89 d	0.20 e
Cherry	0.67 ef	0.33 e	0.67 e	0.22 d	0.22 f	0.07 d	0.01 f
Garlic extract concentration (g·L)							
Control (0 g·L)	4.46	29.61 a	8.63	2.31 a	5.04	3.72	0.84 a
25 g·L	4.41	25.37 b	9.78	2.25 a	4.56	3.44	0.64 b
50 g·L	3.96	16.37 c	8.31	1.46 b	5.21	3.15	0.91 a
Plant × garlic extract concentration (g·L)							
Rose × 0	1.00 efg	1.50 g	1.33 i	1.50 gh	1.33 gfh	0.45 f	0.04 h
Rose × 25	0.00 g	0.00 g	0.00 i	0.00 j	0.00 h	0.00 f	0.00 h
Rose × 50	0.00 g	0.00 g	0.00 i	0.00 j	0.00 h	0.00 f	0.00 h
Wild privet × 0	7.33 bc	95.50 bc	23.67 c	3.81 d	11.00 c	6.77 c	1.83 d
Wild privet × 25	8.67 ab	127.83 a	41.33 a	3.08 de	13.33 bc	10.07 b	2.36 c
Wild privet × 50	7.33 bc	104.00 b	35.50 b	3.52 d	14.00 b	8.18 bc	2.49 bc
Poplar × 0	7.67 bc	92.00 c	12.67 d	7.52 c	15.56 b	13.87 a	3.53 a
Poplar × 25	5.67 c	35.50 e	8.00 def	10.10 b	19.00 a	6.93 c	1.53 de
Poplar × 50	6.67 bc	58.75 d	7.67 efg	21.10 a	20.00 a	8.95 b	2.77 b
Sycamore × 0	0.50 efg	0.67 g	2.00 hi	10.1 ghi	1.50 gfh	1.22 ef	0.04 h
Sycamore × 25	2.67 de	7.33 g	3.00 ghi	1.96 fg	3.50 ef	1.08 ef	0.24 h
Sycamore × 50	1.00 efg	0.17 g	1.00 i	0.50ij	0.50 gh	0.23 f	0.03 h
Berry × 0	10.00 a	28.67 ef	20.00 c	1.44 gh	3.00 gf	3.03 de	0.84 g
Berry × 25	10.00 a	30.17 ef	19.00 c	1.70 fgh	3.67 ef	4.31 d	1.01 fg
Berry × 50	10.00 a	22.50 f	23.67 c	0.87 hij	3.00 gf	3.98 d	1.20 f
Grape × 0	6.33 c	33.00 e	8.68 de	3.49 d	6.33 d	6.85 c	1.13 fg
Grape × 25	7.00 bc	29.33 ef	9.39 de	3.40 d	8.38 d	9.17 b	1.08 fg
Grape × 50	6.33 c	34.33 ef	11.33 de	2.42 ef	6.50 d	9.80 b	1.35 ef
Apple × 0	2.33 def	1.17 g	2.33 hi	0.33 ij	0.33 gh	0.10 f	0.01 h
Apple × 25	2.33 def	0.57 g	2.33 hi	0.35 i	0.50 gh	0.37 f	0.08 h
Apple × 50	0.67 efg	0.33 g	0.67 i	0.17 j	17.0 gh	0.02 f	0.01 h
Sour cherry × 0	3.33 d	10.33 g	7.67 efg	1.44 gh	6.00 de	1.14 ef	0.26 h
Sour cherry × 25	2.00 defg	3.67 g	3.67 fghi	1.92 fg	2.00 fgh	0.49 f	0.04 h
Sour cherry × 50	3.33 d	5.83 g	3.67 fghi	1.47 gh	1.25 fgh	1.04 ef	0.32 h
Cherry × 0	0.33 fg	0.17 g	0.33 i	0.17 j	17.0 gh	0.04 f	0.00 h
Cherry × 25	1.33 def	0.67 g	1.33 i	0.33 ij	0.33 gh	0.17 f	0.01 h
Cherry × 50	0.33 fg	0.17 g	0.33 i	0.17 j	17.0 gh	0.01 f	0.01 h
P-value							
Plant	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Garlic extract concentration	0.3226	0.0032	0.2786	0.0819	0.2726	0.8816	0.0007
Plant × garlic extract concentration (g·L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Mean values followed by the similar letters within a column are not significantly different from each other at $P \leq 0.05$ (Duncan's multiple range test).

Table 4 - Effects of different concentration of garlic extract (on the cuttings) on root-related traits

Treatments	Total length of roots	Number of roots	Root length mean (cm)	The highest root length (cm)	Fresh weight (gr)	Dry weight (gr)
Plant						
Rose	0.00 d	0.00 c	0.00 c	0.00 d	0.00 d	0.00 d
Wild privet	292.70 a	42.40 a	6.53 b	18.83 b	4.91 a	0.48 a
Poplar	171.61 b	13.87 b	11.83 a	20.87 a	1.95 c	0.16 b
Sycamore	0.33 d	0.22 c	0.15 c	0.22 d	0.03 d	0.00 d
Berry	0.00 d	0.00 c	0.00 c	0.00 d	0.00 d	0.00 d
Grape	98.39 c	13.11 b	7.17 b	17.00 c	3.77 b	0.12 c
Apple	0.00 d	0.00 c	0.00 c	0.00 d	0.00 d	0.00 d
Sour cherry	0.00 d	0.00 c	0.00 c	0.00 d	0.00 d	0.00 d
Cherry	0.00 d	0.00 c	0.00 c	0.00 d	0.00 d	0.00 d
Garlic extract concentration (g·L)						
Control (0 g·L)	46.68 b	4.40 c	3.30 a	5.54 b	1.18 a	0.08 a
25 g·L	63.30 a	7.42 a	2.60 ab	5.00 b	1.25 a	0.06 b
50 g·L	41.18 b	5.60 b	2.28 ab	6.54 a	0.83 b	0.07 b
Plant × garlic extract concentration (g·L)						
Rose × 0	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Rose × 25	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Rose × 50	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Wild privet× 0	265.50 b	42.00 a	6.33 e	16.00 d	6.99 a	0.57 a
Wild privet× 25	331.50 a	44.33 a	6.25 e	21.00 b	5.34 b	0.45 b
Wild privet× 50	203.50 c	37.00 b	6.92 e	19.50 bc	2.19 cd	0.41 c
Poplar× 0	241.00 b	15.33 c	14.24 a	24.00 a	3.15 c	0.29 d
Poplar × 25	117.67 e	4.50 d	9.82 c	18.00 cd	1.27 d	0.03 g
Poplar × 50	159.17 d	18.67 c	11.23 b	19.67 bc	1.43 d	0.18 e
Sycamore× 0	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Sycamore × 25	1.00 g	0.00 e	0.44 f	0.67 f	0.00 e	0.00 g
Sycamore × 50	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Berry × 0	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Berry × 25	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Berry × 50	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Grape × 0	59.50 f	7.33 d	8.33 d	12.00 e	2.45 c	0.03 g
Grape × 25	119.50 e	16.33 c	6.23 e	19.00 bc	4.51 b	0.06 f
Grape × 50	116.17 e	15.67 c	7.34 de	19.67 bc	4.34 b	0.26 d
Apple × 0	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Apple × 25	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Apple × 50	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Sour cherry × 0	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Sour cherry × 25	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Sour cherry × 50	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Cherry × 0	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Cherry × 25	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
Cherry × 50	0.00 g	0.00 e	0.00 f	0.00 f	0.00 e	0.00 g
P-value						
Plant	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Garlic extract concentration	0.0658	0.3573	0.0213	0.1200	0.0068	<0.0001
Plant × garlic extract concentration (g·L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Mean values followed by the similar letters within a column are not significantly different from each other at $P \leq 0.05$ (Duncan's multiple range test).

tings, and a high concentration in apple cuttings resulted in desirable effects on this trait. The effect of this extract was positive in sour cherry cuttings, and there was a negative effect on the length of shoots produced in cherry cuttings (Table 5).

The fresh weight of shoots was uppermost in wild privet cuttings treated with 25 g/L of garlic extract, which was not significantly different from that of grape cuttings at 50 g/L. Dry weight of wild privet cuttings was the highest in all treatments. The use of garlic extract increased fresh and dry weights of shoots in poplar, sycamore, and berry cuttings. In grape and apple cuttings, a high concentration of garlic extract yielded useful impacts on the fresh and dry weights of shoots while it led to negative consequences in sour cherry and cherry cuttings (Table 5). Overall, the use of garlic extract at the time of callus formation was evaluated to be positive on the shoot-related traits of sycamore, berry, and apple cuttings.

Root-related traits. Analysis of experimental data showed that different concentrations of garlic extract significantly influenced rooting characteristics of different cuttings in the callus stage at 1% level. The use of garlic extract could significantly affect the root number and length at moderate concentration and root dry weight at both concentrations in the callus stage of rose cuttings. The use of moderate concentration had a significant effect on the increase of all root traits in wild privet cuttings in the callus stage. The high concentration caused a decrease in the number of roots and an increase in root length, and the moderate concentration increased the longest root length of poplar cuttings. The use of garlic extract at this stage caused a significant decrease in fresh and dry weights of roots in poplar cuttings. Sycamore cuttings showed some increases in the root traits at the moderate concentration. Berry cuttings increased the number of roots to some extent at both concentrations. In the cuttings of this plant, the length of roots was the greatest at the moderate concentration of garlic extract and the longest root length, and root fresh and dry weights were greater at the concentration of 50 g/L. In grape cuttings, the moderate concentration increased the number of roots and the high concentration elevated root length. In the cuttings of this plant, both concentrations increased the length of the longest root and reduced root fresh and dry weights. Root growing did not occur in apple, sour cherry, and cherry cuttings (Table 6).

The highest number of rooted cuttings was observed in wild privet cuttings treated with the moderate concentration of garlic extract, which did not differ significantly with the grape and control wild privet cuttings at the same concentration. The highest root length was obtained in wild privet cuttings treated with moderate concentration, which did not show significant differences with the cuttings treated with the high concentration. The longest roots and highest root dry weight were recorded in wild privet cuttings at moderate concentration. Poplar control cuttings gained the highest fresh weight (Table 6).

4. Discussion and Conclusions

According to the results of three experimental sections, it seems that the effects of garlic extract on the traits related to shoots and roots of different cuttings depend on the time of use, species type, and the extract concentration. In the first section, the use of high garlic extract concentration (50 g/l) in rose cuttings and moderate concentration (25 g/l) in wild privet, poplar, berry, grape, apple, and cherry cuttings had positive impacts. Garlic extract had no positive effects on shoot traits in sycamore and sour cherry culture substrates. In *Schefflera arboricola*, garlic extract application increased plant height, leaf number, and fresh and dry weights of leaves (Hanafy *et al.,* 2012). In leguminous plants, the extract especially at high concentrations caused negative effects on growth and decreased plant height (Adeleke, 2015). Also, using a high concentration of garlic extract in the culture substrates of rose and wild privet, and moderate concentration in poplar and grape substrates had positive effects on their rooting traits. However, a high concentration of garlic extract was not effective in the rooting of sycamore, berry, apple, sour cherry, and cherry cuttings. Considering the evaluated shoot and root traits, the use of 50 g/L and 25 g/L of garlic extract was useful in rose cuttings and poplar and grape cuttings, respectively.

Garlic extract contains many allelopathic chemicals (Wang *et al.,* 2015) with a known antimicrobial and antibacterial agent (Harris *et al.,* 2001). Garlic planting in vegetable hydroponic substrates has been shown to prevent them from many diseases and to reduce the microbial population in the substrate (Liu *et al.,* 2014). The positive effects of garlic extract are more evident at low and moderate concentrations. High concentrations of garlic extract led to decreased growth of shoots and roots due to increased allelo-

Table 5 - Effects of different concentration of garlic extract (in the callus stage) on shoot-related characteristics

Treatments	Number of green cuttings	Shoot length mean (cm)	The highest shoot length (cm)	Fresh weight (gr)	Dry weight (gr)
Plant					
Rose	1.22 cd	5.46 c	10.44 d	2.27 d	0.70 e
Wild privet	9.67 a	8.54 b	29.78 b	23.08 a	7.09 a
Poplar	4.89 b	18.14 a	35.14 a	13.08 b	4.76 b
Sycamore	0.78 d	2.14 de	2.44 e	0.40 de	0.08 ef
Berry	8.78 a	3.66 cd	10.33 d	5.26 c	1.43 d
Grape	8.67 a	8.41 b	15.39 c	21.81 a	2.98 c
Apple	1.22 cd	1.45 e	1.61 e	0.17 e	0.03 ef
Sour cherry	2.33 c	2.46 de	3.83 e	0.53 de	0.09 ef
Cherry	0.33 d	0.78 e	0.50 e	0.03 e	0.01 f
Garlic extract concentration (g·L)					
Control (0 g·L)	4.00	5.08	9.94 b	6.47 b	1.65 b
25 g·L	4.59	5.36	12.50 a	7.82 a	2.08 a
50 g·L	4.04	6.10	12.27 a	6.06 b	1.88 a
Plant × garlic extract concentration (g·L)					
Rose × 0	0.67 def	5.73 cdef	11.67 cdef	1.84 fgh	0.33 hi
Rose × 25	2.00 cdef	4.98 defg	9.00 efgh	3.19 efgh	0.92 ghi
Rose × 50	1.00 cdef	5.66 def	10.67 defg	1.79 fgh	0.84 ghi
Wild privet × 0	9.67 a	8.54 cd	30.17 b	21.34 b	6.95 a
Wild privet × 25	10.00 a	8.81 c	27.83 b	26.27 a	7.41 a
Wild privet × 50	9.33 a	8.26 cd	31.33 b	20.89 b	6.92 a
Poplar × 0	5.33 b	17.27 b	26.50 b	10.19 d	3.78 cd
Poplar × 25	6.33 b	15.03 b	37.67 a	14.92 c	5.51 b
Poplar × 50	3.00 c	21.09 a	40.00 a	13.79 c	4.66 bc
Sycamore × 0	0.00 f	0.00 i	0.00 j	0.00 h	0.00 i
Sycamore × 25	1.33 cdef	5.00 defg	5.67 ghij	0.48 gh	0.15 hi
Sycamore × 50	1.00 cdef	1.43 ghi	1.67 ji	0.73 gh	0.00 i
Berry × 0	8.33 a	3.08 efghi	5.00 fghi	3.03 de	1.14 ghi
Berry × 25	9.00 a	4.08 efgh	11.83 cdef	5.10 ef	1.35 fgh
Berry × 50	9.00 a	3.82 fghi	12.17 cdef	6.66 e	1.81 fg
Grape × 0	8.67 a	8.45 cd	17.00 c	21.71 b	3.31 de
Grape × 25	9.00 a	7.66 cde	13.67 cde	21.88 b	3.18 de
Grape × 50	8.33 a	9.13 c	15.50 cd	25.87 a	2.46 ef
Apple × 0	0.67 def	1.00 hi	0.83 ji	0.03 h	0.03 i
Apple × 25	0.67 def	1.00 hi	0.83 ji	0.06 h	0.01 i
Apple × 50	2.33 cde	3.42 fghi	3.17 hij	0.41 gh	0.06 i
Sour cherry × 0	2.00 cdef	0.67 hi	1.00 ji	0.28 gh	0.06 i
Sour cherry × 25	2.67 cd	3.54 fghi	5.33 ghij	0.49 f	0.17 hi
Sour cherry × 50	2.33 cde	3.17 fghi	5.17 ghij	0.48 gh	0.05 i
Cherry × 0	0.67 def	1.00 hi	0.83 ji	0.07 h	0.01 i
Cherry × 25	0.33 ef	1.33 ghi	0.67 j	0.03 h	0.01 i
Cherry × 50	0.00 f	0.00 i	0.00 j	0.00 h	0.01 i
P-value					
Plant	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Garlic extract concentration	0.1060	0.1614	0.1060	0.0159	0.1672
Plant × garlic extract concentration (g·L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Mean values followed by the similar letters within a column are not significantly different from each other at $P \leq 0.05$ (Duncan's multiple range test).

Table 6 - Effects of different concentration of garlic extract (in the callus stage) on root-related traits

Treatments	Number of roots	Root length mean (cm)	The highest root length (cm)	Fresh weight (gr)	Dry weight (gr)
Plant					
Rose	1.22 d	5.60 c	7.83 c	0.40 d	0.04 d
Wild privet	9.00 a	16.59 a	32.79 a	13.04 b	4.40 a
Poplar	3.87 c	14.91 a	24.74 b	6.31 c	0.80 c
Sycamore	0.44 ef	1.28 d	2.28 d	0.04 d	0.01 d
Berry	1.00 de	8.82 b	8.07 c	0.35 d	0.06 d
Grape	b14.8	10.09 b	26.78 b	14.65 a	2.59 b
Apple	0.00 f	0.00 d	0.00 d	0.00 d	0.00 d
Sour cherry	0.00 f	0.00 d	0.00 d	0.00 d	0.00 d
Cherry	0.00 f	0.00 d	0.00 d	0.00 d	0.00 d
Garlic extract concentration (g·L)					
Control (0 g·L)	2.08 b	4.22 b	7.19 b	4.45 a	0.64 b
25 g·L	3.08 a	7.09 a	12.86 a	3.57 b	0.87 a
50 g·L	2.26 b	7.01 a	12.35 a	2.27 c	0.64 b
Plant × garlic extract concentration (g·L)					
Rose × 0	0.67 fg	4.78 g	7.33 e	0.25 e	0.00 g
Rose × 25	2.33 e	6.62 fg	8.33 e	0.30 e	0.03 f
Rose × 50	0.67 fg	5.39 g	7.83 e	0.65 e	0.09 f
Wild privet× 0	9.00 ab	14.33 bc	26.50 bc	12.89 bc	3.63 b
Wild privet× 25	10.00 a	19.26 a	35.67 a	13.96 b	5.06 a
Wild privet× 50	8.00 bc	16.31 ab	32.00 ab	11.89 bc	3.80 b
Poplar× 0	5.00 d	11.24 cde	17.07 d	17.24 a	1.18 d
Poplar × 25	4.50 d	14.80 b	30.67 ab	3.05 d	0.50 ef
Poplar × 50	2.33 e	18.68 a	26.50 bc	2.29 de	0.73 de
Sycamore× 0	0.00 g	0.00 f	0.00 f	0.00 e	0.00 f
Sycamore × 25	1.00 fg	3.42 gh	3.83 ef	0.09 e	0.01 f
Sycamore × 50	0.33 fg	0.00 h	3.00 ef	0.02 e	0.00 g
Berry × 0	0.33 fg	0.00 h	0.00 f	0.03 e	0.03 f
Berry × 25	1.33 ef	13.90 bcd	7.50 e	0.24 e	0.03 f
Berry × 50	1.33 ef	9.62 ef	13.83 d	0.78 e	0.13 f
Grape × 0	7.00 c	9.64 ef	24.33 c	18.68 a	3.99 b
Grape × 25	9.00 ab	9.84 ef	28.00 bc	14.47 b	2.18 c
Grape × 50	7.67 c	10.80 de	28.00 bc	10.89 c	2.06 c
Apple × 0	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Apple × 25	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Apple × 50	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Sour cherry × 0	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Sour cherry × 25	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Sour cherry × 50	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Cherry × 0	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Cherry × 25	0.00 g	0.00 h	0.00 f	0.00 e	0.00 f
Cherry × 50	0.00 g	h00.0	0.00 f	0.00 e	0.00 f
P-value					
Plant	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Garlic extract concentration	<0.0001	<0.0001	<0.0001	<0.0001	0.0474
Plant × garlic extract concentration (g·L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Mean values followed by the similar letters within a column are not significantly different from each other at *P*≤0.05 (Duncan's multiple range test).

pathic properties (Adeleke, 2015). One of the reasons for the failure of rooting in the cuttings is the substrate contamination to pathogenic agents and their entry into the stem, and as a result, the contamination of cuttings and failure in rooting (Hartmann *et al.,* 2002). Garlic extract is a strong disinfectant that resulted in increased rooting and improved shooting.

In the second part of the experiment, using the moderate concentration of garlic extract had positive impacts on the shoot and root traits of wild privet cuttings. Garlic extract contains auxin hormone, and immersing the tips of olive cuttings in garlic extract in combination with other natural auxins-containing substances (e.g., algae) produced the longest roots and increased the number of shoots, leaf number, mean shoot length, and dry weight of shoots (Gad and Ibrahim, 2018). The same authors reported that the compound was able to compete with IBA and no significant differences were found in these traits with those of IBA-treated olive cuttings.

In the third part of the experiment, the use of moderate-level garlic extract in the callus stage of rose and sycamore cuttings and the high concentration in the callus stage of the berry cuttings had positive effects on the shoot and root traits. There is ample evidence that garlic extract has an allelochemical property that affects cell division, absorption of water and minerals, phytohormone metabolism, respiration and photosynthesis, enzyme function, and expression of genes (Portales-Reyes *et al.,* 2015; Sadaqa *et al.,* 2016).

Biostimulators are a group of naturally occurring substances that can be applied either as spraying or at the tips of cuttings, and some of these substances increase water absorption and nutrient transfer, and stimulate growth processes, with possible hormonal properties (Dobranszki and Teixeira da Silva, 2010); a few of them had positive effects on ornamental pine propagation and rooting of ornamental plant cuttings (Shevchenko, 2008; Szabó and Hrotkó, 2009; Pacholczak *et al.,* 2016). These substances stimulate the processes occurring in plants to increase growth. Khan *et al*. (2009) and Borowski (2009) reported that natural substances alter the growth and development of cells in the root system and the concentration of many substances in the plant. The mechanism of the physiological and biochemical processes of these substances remains unknown, and their information and application in horticulture and plant propagation are very limited and require further study and attention (Du Jardin, 2015; Ertani *et al.,* 2015).

Many plant extracts such as coconut juice, banana pulp, potato puree, date sap, corn extract, papaya extract, and beef extract have been used in micropropagation to enhance plant growth (Islam *et al.,* 2003; Murdad *et al.,* 2010; Nambiar *et al.,* 2012; Sudipta *et al.,* 2013). The accumulation of carbohydrates, particularly simple ones (monomers), in the rooting zone is essential for rooting onset at early stages, and carbohydrate concentrations of applied natural substances had high influences on the rooting (Costa *et al.,* 2007).

Active oxygen species (ROSs) are oxygen species that destruct cells and destroy membranes and nucleic acids during such tensions as cutting and mechanical damage to cuttings. ROSs, therefore, is always present at rooting event. Biostimulators and natural substances used to increase the growth of different plants reduce the effects of various stresses on plants (Dobranszki and Teixeira da Silva, 2010). Phenolic compounds are classified into simple phenols, phenolic acids, hydroxycinnamic derivatives, and flavonoids. Researchers have reported that many phenolic compounds and flavonoids function as strong antioxidant compounds that are found abundantly in many plant extracts, including medicinal plants. The active ingredients of medicinal plants include complex chemical compounds produced and stored in the organs of medicinal plants and protect cells from oxidative damage (Lin and Harnly, 2010). The extracts of medicinal plants have many antimicrobial properties and can prevent the release of microorganisms in the culture medium and plant growth media (Radwan *et al.,* 2015).

Considering the shoot and root traits evaluated in the three experiments, the use of 50 g/L and 25 g/L of garlic extract was useful in rose cuttings and poplar and grape cuttings, respectively. Moderate concentration (25 g/L) of garlic extract revealed positive effects on shoot and root traits of wild privet cuttings. Also, the use of moderate garlic extract had positive effects on rose, and at a high concentration (50 g/L) on sycamore cuttings and on berry cuttings in the callus stage. As a result, to improve the quantity and quality of shooting and rooting in rose cuttings, garlic extract can be used at a concentration of 50 g/L in the substrate or 25 50 g/L in the callus formation stage. A comparison of data from these two experiments indicated that the use of 25 g/L was more effective in the callous formation stage. Also, to improve the quality and quantity of shoots and roots in wild privet cuttings, garlic extract can be used at 25 g/L on the cuttings. The quality and quantity of poplar and berry cuttings can be improved by concentrations of 50 g/L and 25 g/L of garlic extract in the callus stage. No positive impacts were noticed on the other plants, or positive effects were seen only on shooting or rooting traits.

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