



Effects of Bacteria and IBA on the Rooting of Bitter Orange (*Citrus aurantium* L.) and Trifoliolate Orange (*Poncirus trifoliata* Raf.) Cuttings

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ABSTRACT

In this study, the effects of *Agrobacterium rubi* A-18 and *Bacillus* OSU-142 bacterial strains alone and in combination with 1000, 2000, 4000 ppm IBA on rooting of bitter orange and trifoliolate orange citrus rootstock in softwood, semi-hardwood and hardwood cuttings were investigated. In the case of IBA solution, *Agrobacterium rubi* A-18 and *Bacillus* OSU-142 were prepared in solution at a concentration of 1×10^9 bacteria / ml and applied to steel. Application is made in the mist propagation system, in the perlite are planted in the environment. Steels kept in the fogging environment for 3 months were removed at the end of this period and rooting rates (%), callus formation rates (%) and survival rates (%) were determined. According to the results of the research, the rooting rates of the steels taken at different periods were found to be low. The highest rooting rates of bitter orange softwood cuttings were 2000 ppm IBA + OSU-142 (6.67%), semi-hardwood cuttings OSU-142 (20.00%), and 4000 ppm IBA + OSU-142 (20.00%) in hardwood cuttings. It has been not rooting in trifoliolate orange softwood cuttings, the highest rooting was in the case of semi-hardwood cuttings with 4000 ppm IBA + OSU-142 (26.67%), in hardwood cuttings 1000 ppm IBA + OSU-142, 2000 ppm IBA + OSU-142, 4000 ppm IBA + OSU-142, 1000 ppm IBA + A-18, 2000 ppm IBA + A-18 and 4000 ppm IBA + A-18 (20.00%). According to the cuttings pick-up period, the rooting rates of bitter orange are not different between the periods, in the trifoliolate orange the hardwood cuttings were found to be higher. As a result, it can be said that plant growth promoting bacteria and IBA applications have no effect on rooting in the softwood, semi-hardwood and hardwood cuttings of the bitter orange and trifoliolate orange citrus rootstocks, it can be said that studies on rooting in these rootstocks can be useful in different bacterial breeds

1. Introduction

Turkey is one of the rare countries where a combination of many types of fruit grown in the world. At present, Turkey is one of the most important producers of many fruit species besides being one of the most production of some fruit species in the world.

Citrus fruit is a young plant group. This group includes the species of citrus, which has a high economic value such as orange, mandarin, bergamot, grapefruit and lemon. They are produced economically and are extremely important for human health. Citrus fruits, which are considered as vitamin depots of winter months, are consumed widely as fruit juice besides

their fresh consumption. As used in the fruits of these plants, fruit oils, leaves or flowers perfume fragrance used to give the essential oils are obtained. The production of citrus fruits grown between 40 degrees north latitude and 40 degrees south latitude in the world is continuously increasing.

Citrus fruits are native to China, Southeast Asia and India and can grow in tropical and subtropical climates. However, it is possible to grow commercially in regions where the temperature does not fall below -4°C.

In Turkey, reaching about 5 million tons of citrus is done in coastal areas of the Mediterranean and Aegean regions of production. In Turkey, the most grown fruits after apples and grapes are also citrus fruits. Commercial sense in the production of Turkey is examined, as

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well as most types of citrus produced in the world, respectively, orange, mandarin, lemon and grapefruit.

The cultivation of citrus fruit, whose homeland is Southeast Asia, began in the US in the modern sense in the 19th century and spread rapidly. In the Northern Hemisphere, North and Central America and the Mediterranean countries are produced economically in the Southern Hemisphere, South America, South Africa and Oceania. The largest citrus producer countries in the world; Brazil, USA and China. Turkey is among the first 10 countries in the world citrus production (FAO, 2019).

Turkey is located in the northern border areas of the world citrus production. Which is quite old with a history of citrus production in Turkey after to develop rapidly and has been a significant increase in production from 1930. Turkey has very suitable areas for citrus cultivation in terms of ecological conditions. Turkey's amount of citrus production data for 2017 is 4 million 769 thousand 772 tons (TUIK, 2019).

The prevalence of foreign fertilization has led to vegetative propagation methods in many fruit species and varieties. Thus, it is possible to prevent the openings resulting from seed reproduction and to protect all the features of the variety. In vegetative reproduction; steel, dipping, root and bottom shoots or tubers with one or more of the replication methods are used, but in today's fruit, especially the method of reproduction with vaccination is more widely used (Rom, 1987; Hartmann, et al., 1990).

In the production of citrus species such as other fruit species, seed reproduction is not used directly. Since cuttings reproduction is not very successful in these species, the basis of production is based on reproduction. It is based on cultivation of different plants such as reproduction rootstock and scion on the same body. There are two elements, namely rootstock and scion, for reproduction. While the scion forms the crown of the tree, it forms the subsoil part of the rootstock tree and assists in the holding and transport of water and nutrients. Rootstocks in fruit cultivation are as important as the varieties that are inoculated on them. As a matter of fact, although a fruit rootstock is not expected to have the characteristics of a standard variety, rootstocks must have a good performance in the subsoil and special relations formed by the scion. The living part that undertakes primary responsibility in the life of the trees is the roots. Their relationship with the environment in which they spread in the soil is important in terms of the effect of the trees on their being healthy and efficient. In recent years, changes in fruit growing methods are possible with the use of appropriate rootstocks (Gülcan, 1991).

Rootstocks are classified as generative and vegetative rootstocks according to their production methods. Because of the generative way of opening up seed and rootstock production, rapid increase in the use of clone rootstocks has occurred in the production of fruit saplings in recent years. In the production of citrus fruit

species, the use of clone rootstocks is becoming increasingly common in order to increase yield and quality and to provide tolerance for many abiotic and biotic stresses. The most common use of clonal rootstocks in the world is in citrus fruits.

Rootstocks used in fruit growing are divided into slices and clone rootstocks. In most of the fruit species, seedling rootstocks are used. The common drawback of almost all of them is that they show too many variations. This negatively affects the homogeneity of the development of the tree. Furthermore, it is known that heterogeneous developing seedlings have different behaviors in terms of rootstock mismatch and adaptation to the environment (Gülcan, 1991). Due to the opening in the seeds, seed levels on seedling rootstocks, growth forces, productivity, fruit characteristics, drought, cold, disease and pest resistance levels are heterogeneous and constitute the most important disadvantages of these rootstocks.

Different rootstocks are used in citrus sapling production. The most important ones are bitter orange and hybrids, trifoliolate orange and hybrids, mandarin and mandarin analogues, lemons and relatives, limes and relatives, orange, citremon (trifoliolate orange X lemon), citrumelo (trifoliolate orange X grapefruit), sweet laym, grapefruit, yuzu, volkameriana, macrophylla, sitranges (trifoliolate orange X oranges). Among these rootstocks, the most commonly used in Turkey are bitter orange and trifoliolate orange (Mendilcioglu, 1999).

Bitter orange and trifoliolate orange is used as rootstock for citrus experiencing difficulties of rooting cuttings. To solve the problem of rooting, indole acetic acid (De Klerk et al., 1997, Ahmad et al., 2005), some vitamins (Antonopoulou et al., 2005) are made such applications. In addition, it has been reported in many studies that it has recently been introduced as a solution to the problem of rooting with rhizobacteria that increase plant growth which has recently become widespread (Bassil et al., 1991; Larraburu et al., 2007; Teixeira et al., 2007; Ertürk et al., 2011; Arıkan et al., 2013).

In this study, the effects of Bacillus OSU-142 and Bacillus A-18 bacterial strains and indole butyric acid (IBA) applications were investigated on rootstocks of bitter orange and trifoliolate orange, which are widely used as rootstock in citrus fruits.

2. Materials and Methods

This study was conducted between 2017 and 2018 in a heated greenhouse in Directorate of Agricultural Production Enterprise, Agricultural Extension and In-Service Training Center, Adana.

Materials

In this study, bitter orange (*Citrus aurantium* L.) and trifoliolate orange (*Poncirus trifoliata*) rootstocks were used as materials. The citrus cuttings used in the study were obtained from Alata Horticultural Research Institute, Mersin.

Bitter orange (*Citrus aurantium* L.) has been the most widely used rootstock for oranges, mandarins, lemons and grapefruit in Mediterranean basin and other citrus producers countries. Bitter orange is widely used in heavy, drainage-poor soils because it shows moderate resistance to high soil pH. Bitter orange can grow on heavy soils, it is resistant to lime and tends to make pile root. Some lemon varieties and satsuma generally show good agreement with species and varieties other than mandarin. Trees grafted on bitter orange form a standard size crown. It is widely used in all Mediterranean regions. Easy to propagation. It is sensitive to the diseases of tristeza and mal-secco. Dwarfing is resistant to pore virus disease and root collar rot. Good resistance to frost. As it forms deep roots, it has good resistance to drought (Mendilcioglu, 1999).

Trifoliolate orange (*Poncirus trifoliata* Raf.) is a rootstock that shed its leaves in subtropic conditions. One of the important features is that it is cold resistant. The trifoliolate orange tree is placed on the early fruit and affects the fruit quality in a positive way. Aegean and the eastern Black Sea region of Turkey is used as rootstock mandarin. Winter rootstocks are the most rootstocks. Resistant to root collar rot. Provides early yield. It is a suitable rootstock for orange and satsuma. It is not good to correspond with lemons, especially Kütüden. Calcareous and salty soils can not withstand (Mendilcioglu, 1999).

In this study, *Agrobacterium rubi* A-18 and *Bacillus* OSU-142 bacterial strains which were determined to produce auxin by in vitro studies were used. Bacteria were obtained from Yeditepe University Faculty of Engineering, Department of Genetics and Bioengineering.

Methods

Cuttings from citrus rootstocks were prepared as softwood in July (2017), semi - hardwood in October (2017) and hardwood in January (2018). The cuttings used in the research were obtained from the trees from the Alata Horticultural Research Institute, Mersin. Cuttings are prepared with 4 leaves, 2 leaves-free, top 2 leaves were planted. These cuttings alone and in combination with 1000, 2000 and 4000 ppm IBA *Agrobacterium rubi* A-18 and *Bacillus* OSU-142 bacterial strains were applied. Applications to cuttings are given below.

1. Control
2. 1000 ppm IBA
3. 2000 ppm IBA
4. 4000 ppm IBA
5. OSU-142
6. A-18
7. OSU-142 + A-18
8. 1000 ppm IBA + OSU-142
9. 2000 ppm IBA + OSU-142
10. 4000 ppm IBA + OSU-142
11. 1000 ppm IBA + A-18

12. 2000 ppm IBA + A-18

13. 4000 ppm IBA + A-18

Prepared cuttings was prepared by rapid immersion in IBA solution and bacterial strains were prepared in suspension at a concentration of 1×10^9 bacteria / ml (Pırlak and Baykal, 2011). The applied cuttings were placed in the mist propagation unit with temperature of 25 ° C, 90-95% relative humidity and perlite. Cuttings held in the mist propagation environment for about 3 months were removed at the end of this period, rooting rates (%), callus formation rates (%) and survival rates (%) were detected (Bhusal et al., 2001). While the survival rates of the stripped cuttings were determined, it was examined whether the tissue beneath the steel shells were alive and also the sections were taken from the eyes on the steel and these eyes were considered alive when they kept the green color.

Statistical Analysis

Trial; two factors (applications, cuttings retrieval period) according to the her completely randomized design, three replicates and 5 steel in each repetition have been established. The data obtained were subjected to arc sinus (angle) transformation and evaluated by SPSS statistical program and Duncan Multiple Comparison Test was applied.

3. Results and Discussion

The effects of applications on the cutting rooting of bitter orange

The effects of plant growth promoting bacteria and IBA applications on the rooting of softwood, semi-hardwood and hardwood cuttings in bitter orange were found to be statistically significant (Table 1). During the rooting period, most of the softwood cuttings were unable to maintain its viability. In the control application, the viability ratio decreased by 33.33% compared to the control in most of the applications, and the viability rates were higher in the 1000 ppm IBA + OSU-142 (40%) and 2000 ppm IBA + OSU-142 (53.33%) applications. The lowest viability rates were found in 13.33% and 4000 ppm IBA and OSU-142 applications. In parallel with the viability rates, the callus formation ratio in softwood cutting is also low. The callus formation rate, which was 13.33% in the control, decreased to 6.67% in the 4000 ppm IBA application and in the other applications was the same or higher than the control. The highest callus formations were 1000 ppm IBA + OSU-142 and 4000 ppm IBA + A-18 (33.33%) and 2000 ppm IBA + OSU-142 (53.33%). The applications did not have a positive effect on rooting in softwood cuttings, but only in 2000 ppm IBA + OSU-142 rooting 6.67%.

Most of the semi-hardwood cuttings remained alive in the rooting environment. In most of the applications, the viability rate was found to be 100% and only 80% in OSU-142 application was statistically different from other applications (Table 1). Similarly, callus formation is also high in semi-hardwood cuttings. The hig-

hest callus formation occurred in 1000 ppm IBA and OSU-142 + A-18 (100%) and the lowest in 2000 ppm and 4000 ppm IBA applications (73.33%). Although the viability and callus ratios were high in semi-hardwood steels, no rooting occurred in applications other than OSU-142 (20%).

The viability rates of hardwood steels were generally low. While all of the cuttings were dying, viability rates increased slightly due to bacterial and IBA applications except 1000 ppm IBA and 4000 ppm IBA + A-18. Differences between applications are statistically significant. The highest viability rates were found in 4000 ppm IBA + OSU-142 and 1000 ppm IBA + A-18 applications (53.33%). Callus formation is also low in hardwood cuttings. Similar to the viability rates, callus did not occur in the control and the callus ratios increased slightly due to the applications other than 1000 ppm IBA and 4000 ppm IBA + A-18. The most effective applications on callus formation were 4000 ppm IBA + OSU-142 and 1000 ppm IBA + A-18 (40.00%). Rooting rates in hardwood cuttings have not reached satisfactory levels. While rooting did not occur in the

control application, slaughtering effects of bacteria and IBA applications were limited and low rates of rooting occurred in only 5 applications. The highest rooting rate was 4000 ppm IBA + OSU-142 with a rate of 20.00% (Table 1).

When the effects of bacterial and IBA applications on citrus rootstock according to steel intake periods are examined, it is seen that the differences between the effects of the applications on the viability and callus formation are statistically significant and the effects on rooting are insignificant (Table 1). There are big differences in the vitality rates of steels according to periods. The highest viability ratio was obtained in semi-hardwood cuttings (96.41%), followed by softwood (27.69%) and hardwood cuttings (19.49%). Similarly, in the callus ratios, semi-hardwood cuttings are higher than others (89.23%). The callus ratio was found to be 21.54% in softwood cuttings and 16.92% in hardwood cuttings. At the time of the three cuttings pick-ups, rooting rates were very low and no statistical difference was found between the periods.

Table 1
The effects of applications on the cutting rooting of bitter orange

	BITTER ORANGE								
	SOFTWOOD CUTTINGS			SEMI-HARDWOOD CUTTINGS			HARDWOOD CUTTINGS		
	Viability rate (%) [*]	Callus formation rate (%)	Rooting rate (%)	Viability rate (%)	Callus formation rate (%)	Rooting rate (%)	Viability rate (%)	Callus formation rate (%)	Rooting rate (%)
Control	33.33 ab**	13.33 bc	0.00 b	100.00 a	86.67 abc	0.00 b	0.00 c	0.00 c	0.00 b
1000 ppm IBA	26.67 bc	26.67 ab	0.00 b	100.00 a	100.00 a	0.00 b	0.00 c	0.00 c	0.00 b
2000 ppm IBA	26.67 bc	26.67 ab	0.00 b	100.00 a	73.33 c	0.00 b	20.00 b	20.00 ab	0.00 b
4000 ppm IBA	13.33 c	6.67 c	0.00 b	100.00 a	73.33 c	0.00 b	26.67 b	26.67 a	6.67 b
OSU-142	13.33 c	13.33 bc	0.00 b	80.00 b	80.00 bc	20.00 a	20.00 b	20.00 ab	0.00 b
A-18	20.00 bc	20.00 bc	0.00 b	93.33 a	86.67 abc	0.00 b	20.00 b	20.00 ab	0.00 b
OSU+A-18	26.67 bc	13.33 bc	0.00 b	100.00 a	100.00 a	0.00 b	13.33 b	6.67 cd	0.00 b
1000 ppm IBA+OSU-142	40.00 ab	33.33 ab	0.00 b	100.00 a	93.33 ab	0.00 b	13.33 b	13.33 bc	6.67 b
2000 ppm IBA+OSU-142	53.33 a	53.33 a	6.67 a	93.33 a	93.33 ab	0.00 b	13.33 b	13.33 bc	0.00 b
4000 ppm IBA+OSU-142	26.67 bc	13.33 bc	0.00 b	100.00 a	93.33 ab	0.00 b	53.33 a	40.00 a	20.00 a
1000 ppm IBA+A-18	20.00 bc	13.33 bc	0.00 b	93.33 a	93.33 ab	0.00 b	53.33 a	40.00 a	6.67 b
2000 ppm IBA+A-18	26.67 bc	13.33 bc	0.00 b	100.00 a	93.33 ab	0.00 b	20.00 b	20.00 ab	6.67 b
4000 ppm IBA+A-18	33.33 ab	33.33 ab	0.00 b	93.33 a	93.33 ab	0.00 b	0.00 c	0.00 c	0.00 b
LSD	19.63	28.72	10.09	20.18	26.35	20.18	19.6	18.13	21.25

Table 1 (Continuation)
The effects of applications on the cutting rooting of bitter orange

	Viability rate (%)	Callus formation rate (%)	Rooting rate (%)
SOFTWOOD CUTTINGS	27.69 b	21.54 b	0.51
SEMI-HARDWOOD CUTTINGS	96.41 a	89.23 a	1.54
HARDWOOD CUTTINGS	19.49 c	16.92 b	3.59
LSD	11.26	13.17	Ö.D.

*Statistical analysis have been carried out using arc sin values.

** Values shown in different letters in the same column are different at 0.05 (Duncan test)

The effects of applications on cutting rooting of trifoliolate orange

The effects of plant growth promoting bacteria and IBA applications on the rooting of softwood, semi-hardwood and hardwood cuttings with trifoliolate orange rootstock are given in Table 2. The effects of applications on viability, callus formation and rooting were found to be statistically significant.

Trifoliolate orange softwood cuttings showed low viability at the end of rooting time. The differences between the effects of the applications on the viability of softwood cuttings were not statistically significant. Similarly, callus formation rates in softwood cuttings are also low. In the control group, no callus was formed in the cuttings, but in some applications a low callus was formed. The maximum callus formation was determined as 20.00% in 2000 ppm IBA + OSU-142 and 13.33% in 4000 ppm IBA + OSU-142 applications. Rooting did not occur in any application, including control in trifoliolate orange softwood cuttings.

A large part of the trifoliolate orange rootstock semi-hardwood cuttings kept alive in the rooting environment. The highest viability rates were found to be 1000 ppm IBA (100%) and control (93.33%). Similarly, callus formation rates are also high in semi-hardwood cuttings. The highest callus formation rate was found to be 1000 ppm IBA (100.00%) and control application (93.33%). Although the viability and callus ratios were high in semi-hardwood cuttings, the rooting rates were far behind them. While rooting did not occur in the control, in 6 applications (1000 ppm IBA, 2000 ppm IBA, A-18, OSU-142 + A-18, 2000 ppm IBA + OSU-142 and 4000 ppm IBA + OSU-142) rooting at different rates occurred. The maximum rooting was determined as 4000 ppm IBA + OSU-142 with a rate of 20.00% (Table 2).

The effects of bacterial and IBA applications on the viability of trifoliolate orange hardwood cuttings were found to be close to each other. While the effects of all the applications were in the same group with the control, the lowest viability rate was determined as 4000 ppm IBA + OSU-142 with 40.00% and the highest with 66.67% and 4000 ppm IBA + A-18. The effects of the applications on the callus formation rate in cuttings are more pronounced than the viability ratios. Callus formation with 26.67% in the control group, 4000 ppm IBA, A-18, OSU-142 + A-18, 2000 ppm IBA + OSU-142, 1000 ppm IBA + A-18, 200 ppm IBA + A-18 and 4000 ppm IBA + A-18 showed a statistically signifi-

cant increase compared to the control. The highest callus rate was found in 4000 ppm IBA + A-18 application (60.00%). Applications increased the rate of rooting in hardwood cuttings compared to the control except for OSU-142 and OSU-142 + A-18. 20.00% of the most rooting practices are 1000 ppm IBA + OSU-142, 2000 ppm IBA + OSU, 4000 ppm IBA + OSU-142, 1000 ppm IBA + A-18, 2000 ppm IBA + A-18 and 4000 ppm IBA + A-18 (Table 2).

The effect of applications on the viability, callus formation and rooting were found to be statistically significant. The viability ratios of the cuttings were found to be significantly different according to the periods and the highest viability was found in semi-hardwood cuttings (76.41%) and the least in softwood cuttings (8.72%). The average viability of hardwood cuttings was found to be 52.82%. The highest callus formation was determined in semi-hardwood (75.38%), followed by hardwood cuttings (42.56%) and softwood cuttings (5.13%). In rooting rates, hardwood cuttings ranked first with 12.81%, followed by semi-hardwood with 6.67% and softwood cuttings with 0.00%. A large part of the trifoliolate orange rootstock semi-hardwood cuttings kept alive in the rooting environment. The maximum viability rates are 1000 ppm IBA (100%) and control (93%).

In this study, the effect of plant growth-promoting bacteria and IBA applications on the rooting of bitter orange and trifoliolate orange rootstocks in softwood, semi-hardwood and hardwood cuttings were found to be low. The highest rooting rates were 2000 ppm IBA + OSU-142 (6.67%), in semi-hardwood cuttings OSU-142 (20.00%), 4000 ppm IBA + OSU-142 (20.00%) in hardwood cuttings; trifoliolate orange softwood cuttings, non-rooting, semi-hardwood cutting 4000 ppm IBA + OSU-142 (26.67%), hardwood cuttings 1000 ppm IBA + OSU-142, 2000 ppm IBA + OSU-142, 4000 ppm IBA + OSU-142, 1000 ppm IBA + A-18 was detected in 2000 ppm IBA + A-18 and 4000 ppm IBA + A-18 (20.00%) applications (Table 1, 2). Similar results were obtained in a study of M9 apple rootstock cuttings and it was determined that bacteria and IBA applications had no effect on rooting (Pirlak and Baykal, 2009).

Due to its many advantages, cutting reproduction is widely used in fruit growing as in most plant species. Among these advantages, a small part of the body in a small area with a large number of homogenous plants, cheap, quick and easy to be counted. Furthermore, in this replication method, soil-borne diseases are less

likely to cross plants. Despite all the positive properties of cuttings reproduction, the biggest obstacle to its use is the inability of the steel to root due to the very low regeneration capabilities of some species (Rugini and Fedelli, 1990; Webster and Looney, 1996). The low rate of rooting in citrus rootstock cuttings are related to species characteristics. The rooting ability of the cutting in the fruit species varies greatly between different species and varieties within these species. According to this, species are classified as very easily rooted, hard-rooted and very hard-rooted. Citrus species in this grouping are often among the hard-rooted (Hartmann, et al., 1990). As a matter of fact, positive results have been obtained in studies that investigated the effects of bacterial applications in genetically rooting species (Nagarajan et al., 1989; Bassil et al., 1991; Jacob and Handam, 1992; Hatta et al., 1996; Ercişli et al., 2000; Ercişli et al., 2001; Eşitken et al., 2001; Ertürk et al.,

2011; Sarmast et al., 2012; Arıkan et al., 2013; Kınık and Çelikel, 2017).

In general, the reproduction of citrus fruits, which are replicated by cuttings, has not been achieved so far except for lemons (Cooper, 1935). In the study which investigated the effects of IBA and Paclobutrazol on the rooting of Valencia orange varieties, the highest rooting (19.6%) was obtained from 500 ppm IBA + Paclobutrazol application (Habermann et al., 2006). In the study which examined the effects of IBA applications on cutting rooting in different citrus rootstocks, it was not detected in trifoliate orange, Carrizo citrange, Cleopatra mandarin, Citrumelo 1452 rootstocks and rooting in different IBA applications (Uzun and Seday, 2011). The effects of IBA and cycloposphamide on the rooting of rough lemon (*Citrus jambhiri*) cuttings were examined in the study and the highest rooting rate (8.2%) was obtained with the use of IBA and cycloposphamide (Singh et al., 1988).

Table 2
The effects of applications on the cutting rooting of trifoliate orange

	TRIFOLIATE ORANGE								
	SOFTWOOD CUTTINGS			SEMI-HARDWOOD CUTTINGS			HARDWOOD CUTTINGS		
	Viability rate (%)*	Callus formation rate (%)	Rooting rate (%)	Viability rate (%)	Callus formation rate (%)	Rooting rate (%)	Viability rate (%)	Callus formation rate (%)	Rooting rate (%)
Control	6.67**	0.00 c	0.00	93.33 ab	93.33 ab	0.00 b	53.33 abc	26.67 c	0.00 b
1000 ppm IBA	6.67	0.00 c	0.00	100.00 a	100.00 a	13.33 ab	60.00 ab	33.33 bc	6.67 ab
2000 ppm IBA	13.33	6.67 bc	0.00	86.67 bc	86.67 bc	13.33 ab	46.67 bc	33.33 bc	13.33 ab
4000 ppm IBA	6.67	6.67 bc	0.00	66.67 d	66.67 d	0.00 b	46.67 bc	46.67 ab	13.33 ab
OSU-142	6.67	6.67 bc	0.00	66.67 d	60.00 d	0.00 b	53.33 abc	33.33 bc	0.00 b
A-18	6.67	6.67 bc	0.00	86.67 bc	86.67 bc	13.33 ab	53.33 abc	53.33 a	13.33 ab
OSU+A-18	6.67	0.00 c	0.00	80.00 cd	80.00 cd	6.67 ab	60.00 ab	46.67 ab	0.00 b
1000 ppm IBA +OSU-142	6.67	0.00 c	0.00	66.67 d	66.67 d	0.00 b	46.67 bc	33.33 bc	20.00 a
2000 ppm IBA +OSU-142	20.00	20.00 a	0.00	73.33 cd	73.33 cd	13.33 ab	53.33 abc	53.33 a	20.00 a
4000 ppm IBA +OSU-142	13.33	13.33 ab	0.00	66.67 d	66.67 d	26.67 a	40.00 c	33.33 bc	20.00 a
1000 ppm IBA +A-18	6.67	0.00 c	0.00	66.67 d	66.67 d	0.00 b	60.00 ab	53.33 a	20.00 a
2000 ppm IBA +A-18	6.67	6.67 bc	0.00	66.67 d	60.00 d	0.00 b	46.67 bc	46.67 ab	20.00 a
4000 ppm IBA +A-18	6.67	0.00 c	0.00	73.33 cd	73.33 cd	0.00 b	66.67 a	60.00 a	20.00 a
LSD	Ö.D.	24.72	Ö.D.	22.16	21.09	25.99	15.57	15.95	27.47

Table 2 (Continuation)
The effects of applications on the cutting rooting of trifoliate orange

	Viability rate (%)	Callus formation rate (%)	Rooting rate (%)
SOFTWOOD CUTTINGS	8.72 c	5.13 c	0.00 c
SEMI-HARDWOOD CUTTINGS	76.41 a	75.38 a	6.67 b
HARDWOOD CUTTINGS	52.82 b	42.56 b	12.82 a
LSD	18.92	12.83	1.91

*Statistical analysis have been carried out using arc sin values.

** Values shown in different letters in the same column are different at 0.05 (Duncan test)

4. Conclusions

As a result, the effects of IBA and bacterial applications on rootstocks of bitter orange and trifoliate orange citrus fruits were investigated in this study. This study mainly focuses on the effects of plant growth promoting bacteria, which are used as an alternative to steel rooting in recent years. It can be investigated in new studies whether rooting rates will increase by testing different races of these bacteria and combinations with different growth regulators.

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