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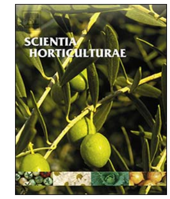

Research Paper

The effect that indolebutyric acid (IBA) and position of cane segment have on the rooting of cuttings from grapevine rootstocks and from Cabernet franc (*Vitis vinifera* L.) under conditions of a hydroponic culture system

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ABSTRACT

The present study aimed at determining the effect of indolebutyric acid (IBA) and of the part of cane from which the cuttings were taken on the rooting ability of three rootstocks and of a grapevine variety using a hydroponic system employing water as the culture medium. Under hydroponic conditions, three different auxin treatments (control water, 120 and 250 ppm IBA) were applied on the three rootstocks, namely 1103 Paulsen, SO4, Dog Ridge and cv Cabernet franc (*Vitis vinifera* L.). The treatments were applied annually for a period of two (2) years and, more specifically, in 2014 and 2015, using a completely randomized design. The cuttings were collected from the Experimental Vineyard, Laboratory of Viticulture, Agricultural University of Athens. The study continued by evaluating the effect of that three factors, rootstock/variety, cane part donating the cuttings, and IBA concentration had on the following: percentage of callogenesis, percentage of rhizogenesis, average diameter of roots, average number of roots per cutting, total surface of roots, and total length of roots. The results of the experiment revealed that treatment with 250 ppm IBA and cuttings coming from the middle part of the cane yielded the highest rhizogenesis percentages. At the same time, the highest callogenesis percentage was observed in the basal cuttings of rootstock 1103 P that underwent the same treatment. Following the 120 ppm IBA treatment, the basal cuttings of rootstock Dog Ridge presented the highest average number of roots. Under the 250 ppm IBA treatment, the basal, middle and middle cuttings of the Dog Ridge rootstock respectively presented the highest average diameter, surface, and length of roots. The experiment led to the conclusion that, under hydroponic conditions and when treated in low IBA concentrations, the grapevine variety and the rootstocks under study can give rooting results which are quite satisfactory. Based on those results, a hydroponic system employing water as its culture medium may prove practical and economical when it comes to vine propagation.

1. Introduction

Grapevine (*Vitis vinifera* L.) is considered one of the world's most vital crops and its cultivation is of great significance to the economy of many countries, Greece included. Traditional viticulture once decreed that grapevine varieties be grown on their own roots due to their sound rooting ability. However, the Phylloxera (*Dactulosphaira vitifoliae*, Fitch, 1855) crisis resulted in the development of a new method of asexual propagation which entailed grafting grapevine varieties on rootstocks.

After the 1898 invasion of phylloxera to the Greek vineyards, Greek viticulturists used a number of rootstocks such as 41B, 110R, 99R, 3306 C, 3309 C, 140 Ru, 1103 P, and SO4 as vine propagation material (Stavrakakis, 2010).

Due to the difference in their properties such as resistance to phylloxera and various pathogens, tolerance to abiotic stresses such as drought, lime, salt, frost, high salinity, and Fe2+ deficiency, rootstocks affect the growth of a *Vitis vinifera* scion in terms of vigor, yield, fruit development, and wine quality (Arrigo and Arnold, 2007; Corso and Bonghi, 2014). Moreover, as the capacity of rootstocks to induce rooting varies, it is crucial to take into consideration each rootstock's actual rooting ability.

Heeding that consideration has given rise to a number of practices aiming at obtaining a rooting success percentage by employing not only various culture media, storage conditions, and ways of handling cuttings but also, treatments involving various facilitators such as growth regulators and more. (Alley and Peterson, 1977; Satisha and Adsule, 2008; Wample, 1997). To that purpose and on the basis of the study's experiment, the present article will be discussing auxins, IBA and hydroponic systems using water as a culture medium towards encouraging rhizogenesis.

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In terms of accelerating the formation of adventitious roots on stem cuttings, auxins play a pivotal role (Hartmann et al., 1997). The rooting property of auxins and their importance in plant propagation has been widely hailed and acknowledged for a long time (Thiman and Went, 1934). Auxin is a hormone whose contribution to rooting induction and root formation has been repeatedly documented as essential. Be it directly or indirectly, auxin triggers the formation of adventitious roots in cuttings since it is an indispensable requisite for the initiation of the root primordia, presumably as early as the time of the induction of the mother cells' cellular division competence (Haissig, 1970). As such it is instrumental in increasing the cuttings' percentage of rooting. Despite the fact that plants produce natural auxin in shoots and young leaves, it is advisable to use synthetic auxin in order to ensure successful rooting and prevent the cuttings from dying (Hartmann et al., 1997; Kasim and Rayya, 2009; Stefanic et al., 2006).

At present, indole-3-butyric acid (IBA) is the auxin most widely used in stimulating the rooting process in cuttings because of its high ability to promote root initiation and its weak toxicity. What is more it is also exceptionally stable when compared to 1-Naphthaleneacetic acid (NAA) (Al-Sheikh, 1987; Moretti et al., 2001); indole-3-acetic acid (IAA) (Blazich, 1988); and 2,4-Dichlorophenoxyacetic acid (2,4-D) (Tofanelli et al., 2014). Among its various attributes, IBA boasts the advantage of being photostable in a number of its concentrations when applied in cuttings (Simon and Petrasek, 2011).

Depending on the species and the variety, and according to Mohammad et al. (2013), an auxin treatment is known to have a positive effect on rhizogenesis at specific concentrations. Nevertheless, as it was also shown by McGuire et al. (1998), in higher concentrations, an auxin treatment may result in inhibiting rhizogenesis.

The study showed that treatments of cuttings with indole-3-butyric acid (IBA) at the concentration levels of 200 and 2000 mg L^{-1} inhibited rooting (Castro et al., 1994). It also focused on the effect of exogenous IBA. According to Harmon (1943), exogenous IBA was not effective in inducing rooting in muscadine grape cuttings, whereas according to Gaspar and Hofinger (1988), high concentrations of endogenous auxin did promote adventitious root formation.

Applications of indole-3-butyric acid (IBA) standing at 2500–4000 mg L^{-1} were tried out in the process involving the rooting of semi – hardwood cuttings taken from apple, plum and olive trees (Hartmann et al., 1997). The results were impressive. Al-Sagri and Alderson (1996) also confirm that application of auxin at the level of 3000–4000 mg L^{-1} contributed positively to increasing the rooting of cuttings from woody ornamental shrubs such as rose bushes and Chinese hollyhock. According to San José et al. (2012), the use of growth regulators on black alder increases the rate of rooting, the percentage of rooted cuttings, the number and quality of roots per cuttings, and the uniformity of rooting. Babashpour-Asl et al. (2012) evaluated the effect of indole-3-butyric acid on the rooting ability of semi-hardwood cuttings of bougainvillea and produced results which indicated that the highest number of roots was observed in treatments of 2000 mg L^{-1}.

Equally important is the selection of the part of the cane from which cuttings are taken. Research data indicate that, in principle, cuttings coming from the middle part of the cane record a higher rooting percentage when compared to cuttings coming from the base part of the cane. Cuttings originating from the top part of the cane represent the lowest rooting percentage (Keeley et al., 2004; Weaver et al., 1975). However, viticultural practice and national legislation (Stavrakakis, 2013) decree that, for the production of rooted cuttings-simple and grafted respectively, the cane segments that should be used are the top and base ones.

All culture media employed towards promoting the rhizogenesis of the vine are required to have traits which, apart from furthering the root system's continuous development, allow for moisture retention and satisfactory oxygen and heating levels. A study by Gornik et al. (2008) investigating the propagation of grapevine rootstocks showed how the culture media's low moisture state and high temperature may impact negatively on rhizogenesis. Studies on propagation of cuttings in a variety of culture media (Davtyan and Bznuni, 1974; Galavi et al., 2013; Sabir et al., 2004) showed the significant effect of that type of culture medium on the rhizogenesis percentage and on the weight and length of roots. Moreover, according to Sabir et al. (2004), perlite, when used as a culture medium, yields better results when compared to other culture media such as sand or sawdust, thanks to the high oxygen levels it provides. Other studies have further shown that better and higher callogenesis percentages are closely and positively associated with oxygen supply (Hartmann and Kester, 1975; Shippy, 1930): the higher the callogenesis percentages, the higher the rhizogenesis percentages and number of roots (Hartmann and Kester, 1975).

The behavior of cuttings after water treatments have also been the subject of many studies. In 1986, one such study by Bartolini et al. revealed that immersing cuttings of 140 Ru and 5BB in water for twelve hours reduced the GA concentration, which inhibits the creation of roots, and led to the vigorous increase in the cuttings' rooting ability (Bartolini et al., 1986). Decades later, Waite and May (2005) immersed cuttings of the cv Chardonnay first for four (4) seconds and then for fifteen (15) hours. Their study reported that only the 15-h immersion led to the creation of roots.

Throughout the years, nurseries have viewed fog or high humidity systems as a way of promoting the rooting of cuttings (Al-Sagri and Alderson, 1996; Hartmann et al., 1997) but such systems have always entailed a rather steep equipment cost. In order to improve the rooting percentage of stem cuttings of *Vitis thunbergeii*, Peng et al. (2008) investigated another possibility: a floating culture system which, using water as its culture medium, gave satisfactory results.

Given that, at present, nurseries have to change soil every three years and are forced to use large surface areas resulting in higher input and higher cost, research in this field aims at developing rapid, practical and economical propagation methods that can be used by nurseries worldwide.

The aim of this study was to examine under hydroponic conditions the effect that different concentrations of indolebutyric acid (IBA), together with the part of cane from which the cuttings were taken, had on the propagation ability of three rootstocks (1103 Paulsen, SO4, Dog Ridge), and of cv Cabernet franc (*Vitis vinifera* L.) during two consecutive years. IBA is not always readily available to producers, nor is it dispensed at affordable prices, especially when it entails higher concentrations. Given those restrictive factors, the study made use of lower IBA concentrations in order to evaluate IBA performance in the presence of water as a culture medium; and in order to assess the potential effectiveness and practicality that a hydroponic system may have in vine propagation when water is that system's culture medium.

2. Material and methods

2.1. Plant material and experimental design

The plant material (canes) came from vines of the grapevine variety Cabernet franc (*Vitis vinifera* L.) and rootstocks 1103 P (*Vitis berlandieri* cv. Rességuier n°2 x *Vitis rupestris* cv. Lot), SO4 (*Vitis berlandieri* x *Vitis riparia*), Dog Ridge (*Vitis champinii* Planchon). All rootstocks selected are preserved in the Ampelographic Collection, Laboratory of Viticulture, Agricultural University of Athens. The position of all selected canes was horizontal since the experimental vineyard they came from is trained on a multi-wired horizontal trellis system. Canes were collected from vines of normal vigor during two consecutive years, 2014 and 2015. By the term "normal", it is meant that the vines present the typical length and diameter of the internodes, and more specifically from the 6th to 7th node, depending on the variety. Due to the fact that the 2014 results bore a striking similarity to those for 2015, the data for both years were integrated and are presented here as one set of data.

The canes were initially 1.8 m in length. Next, they were cut into three segments: base, middle and top (basal, middle, and apical cuttings