International Journal of Agriculture, Environment and Food Sciences

e-ISSN: 2618-5946 https://dergipark.org.tr/jaefs

DOI: https://doi.org/10.31015/2025.1.21 Int. J. Agric. Environ. Food Sci. 2025; 9 (1): 190-198

Two different methods for rooting blackberry cuttings: comparison of aeroponic and perlite media

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Article History
Received: February 4, 2025
Revised: March 8, 2025
Accepted: March 11, 2025
Published Online: March 12, 2025

Article Info
Article Type: Research Article
Article Subject: Horticultural Production

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Available at
https://dergipark.org.tr/jaefs/issue/90253/1633062

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Abstract

This study examines the effects of different IBA concentrations and rooting media on the rooting characteristics of green cuttings from the Jumbo blackberry variety. The cuttings were treated with 0 (control), 500, 1000, and 1500 ppm IBA, then planted in Aeroponic and Perlite rooting systems to compare their performance. Parameters such as rooting rate, root length, development of rootlets, seedling yield, the number of branches per cutting, and disease occurrence were evaluated. In the Perlite medium, the application of 1500 ppm resulted in the most extended root length (7.33 cm), while the highest root number (13.26) was observed at the 500 ppm dose. In the Aeroponic medium, the 1000 ppm application achieved the highest values for root length (10.24 cm) and root number (15.47). However, while the decay rate remained at 0.00% in the Perlite medium, it varied between 16.67% and 20.00% in the Aeroponic medium. The highest rooting rate in the Perlite medium was observed at 500 ppm with 93.33%, whereas in the Aeroponic medium, the rooting rate ranged from 50.00% in the control group to a maximum of 70.00% in the 1500 ppm group. The seedling yield reached 93.33% at 500 ppm in the Perlite medium and peaked at 63.33% in the Aeroponic medium.
In conclusion, the Perlite medium provided healthier root development due to its low decay rate, higher callus formation, and higher rooting rates. In contrast, the Aeroponic medium posed a risk of decay even at higher IBA concentrations.
Keywords: Rooting, IBA, Blackberry, Jumbo, Green cuttings

Cite this article as: Dumlu, F., Karadag, H. (2025). Two different methods for rooting blackberry cuttings: comparison of aeroponic and perlite media. International Journal of Agriculture, Environment and Food Sciences, 9 (1): 190-198. https://doi.org/10.31015/2025.1.21

INTRODUCTION

Historically, the relationship between population and agriculture has been a fundamental element shaping economic and social structures. Agriculture has contributed to societies' development through food production and as the basic building block of an environmental, cultural, and economic network. In particular, the increasing prominence of environmental problems poses a problem in terms of the sustainability of traditional agricultural methods (Eryılmaz & Kılıç, 2018). In this context, alternative agricultural methods offer an important option for solving this problem.

The main factors, such as meeting the increasing food demand and the adverse effects of traditional agricultural methods, have necessitated using alternative agricultural methods (Yavuz et al., 2023). In addition, the infertility of the soil due to the unconscious use of water and chemicals, the rapid increase in urbanization and the restriction of production areas, climate change, and environmental factors are other important factors that necessitate the spread of alternative agricultural methods. In a period when traditional agricultural methods face problems such as limited resources, soil erosion, water shortage, and chemical use, the development of more sustainable and efficient alternatives has become inevitable (FAO, 2017). Alternative agricultural methods go beyond traditional agriculture and offer environmentally friendly, sustainable, less resource-consuming approaches. Considering the increasing demands of the population and environmental pressures, alternative methods have become an important factor in shaping the future of agriculture. Developing technology has enabled the diversification and development of alternative agricultural opportunities and has caused Hydroponics, Aeroponics and Aquaponics to gain importance (Bingöl, 2019).

Indoor farming has expanded quickly within the horticultural sector due to yield consistency and environmental control capabilities (Benke & Tomkins, 2017). Aeroponic systems, which stand out among alternative agricultural methods, are among the modern approaches that minimize water use, prioritize sustainability, and allow production in controlled environments. Aeroponic systems allow the producer to precisely control root zone nutrient and water regimes and environmental conditions, as well as have complete access to the roots throughout the life of the crop (Hayden et. al., 2004; Cai et. al., 2023). Aeroponic systems are used in plant production areas for cutting rooting, seedling, and cultivation. Aeroponic rooting is an economical method, especially in terms of rapid reproduction and protection of plants (Mehandru et al., 2014). Aeroponics allows artificial elevation of root zone O_2 to enhance yield (Eldridge et al., 2020).

Perlite is a light and fine-grained rock of volcanic origin and is widely used as a rooting medium, especially in agriculture. In addition to having a high water retention capacity, perlite, which has good air permeability, provides an ideal environment for plant root development. Perlite accelerates the rooting process of cuttings, enabling the growth of strong and healthy new plants (Kalyoncu, 1996). It was noted that perlite can be used alone or mixed with similar products to successfully root wood cuttings (Gregory, 1999; Sengel et. al 2012; Kir, 2025). For this reason, perlite is an effective rooting medium, especially preferred in applications such as propagation by cuttings and plant production (Grillas, 2001).

Propagation by cuttings is widely used in many plant species, especially fruit trees, ornamental plants, shrubs, some vegetables, and field crops (Preece, 2003; Chen & Stamps 2006; Kroin, 2009; Megersa, 2017). One of the most important factors in propagation by cuttings is the selection of a suitable rooting medium (Schimilewski, 2008; Barreett et. al., 2016). These mediums generally consist of materials that can retain water but have good aeration, such as peat, perlite, and cocopeat.

This study aimed to compare the rooting performances of green cuttings of the Jumbo blackberry variety in an aeroponics rooting system and perlite medium. In recent years, the aeroponics rooting system has emerged as a new technique for producing seedling cuttings. It provides advantages such as more efficient use of water and nutrients during the rooting process. This study aims to compare the aeroponics system with traditional rooting media such as perlite and to contribute to the literature on the advantages and disadvantages of the system. It aims to evaluate the potential of aeroponics systems for use in rooting processes.

MATERIALS AND METHODS

Material

This study used green cuttings of the Jumbo Blackberry (*Rubus spp*.) variety as plant material. Jumbo Blackberry is widely grown in Turkiye due to its increasing importance in supplying raw materials to industry and other consumption areas (Akbulut et al., 2003). Cuttings used in the study were obtained from the blackberry parcel belonging to Tokat Gaziosmanpaşa University Agricultural Research and Application Center. Cuttings cut to approximately 20 cm in length were kept in a damp cloth before planting to prevent moisture loss. Plantings were made on the same day.

Method

The study compared the rooting performances of blackberry green cuttings in an aeroponic rooting system and perlite rooting medium. IBA (Indole-3-butyric acid Merck) was applied to the cuttings to promote rooting (Gerçekcioğlu, 2009; Kalyoncu et al., 2016). IBA was applied to blackberry cuttings at doses of 0 (control), 500, 1000 and 1500 ppm. Each cutting was kept for 10 seconds in the recording records and randomly placed in aeroponic and perlite media. The study was set up according to the randomized plot design. 10 cuttings were used for each application. A total of 240 cuttings are used in aeroponic medium (4 applications x 3 replicates x 10 cuttings = 120 cuttings) and perlite medium (4 applications x 3 replicates x 10 cuttings = 120 cuttings). Cuttings were planted in both rooting systems simultaneously on August 17, 2023. The results obtained; Data analysis was performed using the SPSS package program. The data obtained from both media were compared, and the most appropriate IBA dose and rooting media were determined.

Aeroponic Rooting System

The aeroponic system in which the study was conducted was designed in an industrial size, consisting of a three-story structure, and each floor has three boxes with 2 m² of growing area. This system has a total planting area of 18 m² and is equipped with misting nozzles and circulation fans that provide optimum humidity and air circulation. The system is automated by PLC (Programmable Logic Controller) control, and each cabinet can be operated independently (Figure 1). The nozzles have a hole diameter of 0.30 µm.

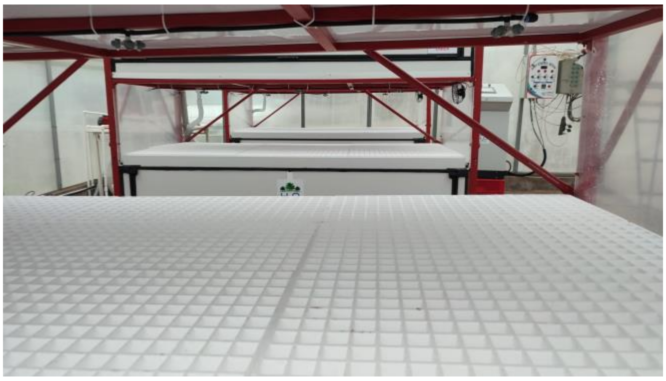

Figure 1. Aeroponic rooting system

Perlite Rooting System

This system used iron-equipped pool-type benches, and the cuttings were planted in a 30 cm deep perlite medium. Irrigation was done with a misting system from above, controlled with a timer (Figure 2). It has been stated that the perlite rooting unit prevents root rot by providing a light, sterile, and air-permeable medium (Gül et al., 2010) and increases rooting success in woody plant cuttings (Mamatha et al., 2024).

The most suitable rooting medium and IBA dose were determined using these methods, and the aim of the study was achieved.

Figure 2. Perlite Rooting System

RESULTS AND DISCUSSION

The trial was started simultaneously on August 17, 2023, using the Aeroponic and Perlite rooting systems. Ten cuttings were used in each replication, and a total of 240 cuttings were used. The placement of the cuttings in these two different environments was carried out with a random distribution. The SPSS statistical package program was used to evaluate the obtained data. Statistical analyses aimed to reveal the significance levels of the effects of doses and different rooting environments on the development of cuttings.

Table 1. Statistical analysis results (Root development)

Media	Application	Root Length (cm)	Root Diameter (mm)	Cutting Diameter (mm)	Root Number (Number)
Perlite	Control	6.34 a	0.76 a	8.33 a	11.90 ab
	500 ppm	5.91 a	0.70 a	7.71 a	13.26 ab
	1000 ppm	5.09 a	0.52 a	8.08 a	10.43 abc
	1500 ppm	7.33 a	0.60 a	7.63 a	12.07 ab
Aeroponic	Control	5.47 a	0.36 a	7.87 a	3.53 c
	500 ppm	6.29 a	0.58 a	7.56 a	7.33 abc
	1000 ppm	10.24 a	0.59 a	7.80 a	15.47 a
	1500 ppm	5.44 a	0.88 a	8.27 a	6.74 bc

The statistical analysis results of root development in perlite and aeroponic media are shown in Table 1. Different applications were made in each medium, and their effects on root length, root diameter, cutting diameter, and root number were evaluated. Statistically, no significant difference was found between root length, root diameter and cutting diameter.

However, it is understood from the root lengths that the aeroponic environment promotes root development. 1500 ppm application in perlite medium gave the highest value regarding root length (7.33 cm). However, the 500 ppm application stands out in terms of root number. 1000 ppm application in aeroponic medium provided the highest results in terms of root length (10.24 cm) and root number (15.47 pieces) (Table 1). No significant differences were observed between both medium and application factors regarding root length. This situation reveals that root development varies more in response to genetic and environmental factors. However, it is stated in the literature that root length shows a constant trend regardless of a specific medium and that the composition of the nutrient solution and the oxygen level in the root zone are more effective (Mamatha et al., 2024). In a study, it was reported that the average root storage increase in aeroponically grown crops was more than 20 g dry weight compared to cassava grown under drip irrigation (Selvaraj et al., 2019). It was also reported that burdock grown under aeroponics accumulated 49% more aerial biomass compared to conventional cultivation (Hayden et al., 2004). Root growth in aeroponics has been observed to be relatively high at certain nutrient levels (especially 1000 ppm). However, it should be noted that aeroponics generally results in lower root diameter and number. This indicates that roots grow more densely and rapidly but have smaller diameters.

When we examine the effects of medium applications on root development based on the content of the table, the average root length in the control group in perlite medium is 6.34 cm, which is relatively high compared to the other groups. Aeroponically grown roots may have more capillary roots compared to hydroponically grown roots (Kratsch et al., 2006), which will affect the aerosol capture of the roots. However, at 1500 ppm, the root length increases again, reaching 7.33 cm. Here, it is seen that high ppm levels (1500 ppm) can increase root length. Root diameter and root number also increased in parallel with the high root length at 1500 ppm (Table 1). While the root length was relatively low in the control group in the aeroponics application (5.47 cm), a significant increase was observed with the 1000 ppm application (10.24 cm). While the cutting diameter in the aeroponics medium was generally lower than in the perlite medium, the diameters in the 500 ppm and 1500 ppm applications were at similar levels. A study determined that aeroponics increased potato mini tuber yield by 70% compared to hydroponics, but the average tuber weight was 33% lower (Ritter et al., 2001). In the root number, 15.47 observed in the 1000 ppm group was relatively high compared to the other groups and showed that this medium supported root development (Table 1).

Table 2. Statistical analysis results (rooting status)

Media	Applıcatıon	Decay rate (%)	Callus rate (%)	Rooting rate (%)	Seedling yield (%)
Perlite	Control	0.00 b	100.00 a	86.67 ab	83.33 ab
	500 ppm	0.00 b	100.00 a	93.33 a	93.33 a
	1000 ppm	0.00 b	96.67 a	80.00 ab	80.00 ab
	1500 ppm	0.00 b	96.67 a	90.00 a	76.67 bc
Aeroponic	Control	16.67 a	66.67 b	50.00 d	43.33 e
	500 ppm	20.00 a	80.00 ab	60.00 cd	53.33 de
	1000 ppm	16.67 a	83.33 ab	70.00 bc	63.33 cd
	1500 ppm	10.00 b	86.67 ab	70.00 bc	63.33 cd

The statistical analysis results of parameters such as decay rate, callus rate, rooting rate, and seedling yield measured in Perlite and Aeroponic media are in Table 2.

The decay rate remained constant at 0.00% in all applications of Perlite media. This shows that Perlite media is not affected by the risk of decay. However, the decay rate in Aeroponic media is at the highest rate of 20.00% at 500 ppm dose. While the rate decreases to 16.67% in control and 1000 ppm applications, it decreases to 10.00% in 1500 ppm. This situation reveals that the risk of decay is higher in Aeroponic media (Table 2). In light of the findings, it can be said that 1000 ppm is the most effective nutrient level for root development in both perlite and aeroponics. The low decay rate and high callus rate in perlite indicate that plant development is healthy in this environment. Even at high nutrient levels, there is no risk of decay, and rooting rates remain pretty satisfactory.

The high decay rate in aeroponics is due to the higher humidity levels and limited air circulation in these systems. It is also reported in the literature that high humidity levels encourage the development of pathogenic organisms, and therefore, the decay rate increases in aeroponics systems (Eldridge et al., 2020). On the other hand, the low decay rate in perlite media can be explained by the physical structure of the perlite, which provides better drainage and prevents water accumulation (Gislerod & Mortenson, 1990). For example, while the decay rate in perlite media was 15%, this rate reached 30% in aeroponics media. The low rate of decay supports healthy root development in this environment. Research indicates that inorganic growth media such as perlite increase the ability to reduce decay (Hendrick & Black, 2002). In aeroponics, it was observed that decay rates were higher

(16.67-20.00%), and seedling yields were low (43.33-63.33%). Although aeroponics systems allow roots to develop freely in the air, theoretically providing healthy root development, the risk of decay increases with high nutrient levels (Lakhiar et al., 2018). The data obtained supports this thesis.

The callus rate in Perlite media has the highest value, with 100% in the control group, and other ppm levels vary between 96.67% and 100%. This shows that Perlite media is effective in healing root wounds. While the callus rate was as low as 66.67% in the control group in the aeroponic system, it increased to 80.00% at 500 ppm, 83.33% at 1000 ppm, and 86.67% at 1500 ppm. High-dose application levels may positively affect callus formation (Figure 3, Figure 4). Perlite medium and 500 ppm application provided high callus and seedling yield by eliminating the risk of decay. This combination is the most effective option.

In aeroponics, it is recommended to prefer high doses (1000 ppm and 1500 ppm) to reduce decay and increase callus/rooting rates. Considering that high doses reduce yield in perlite medium but improve in aeroponics, medium and dose selection should be made carefully in line with the purpose of the experiments.

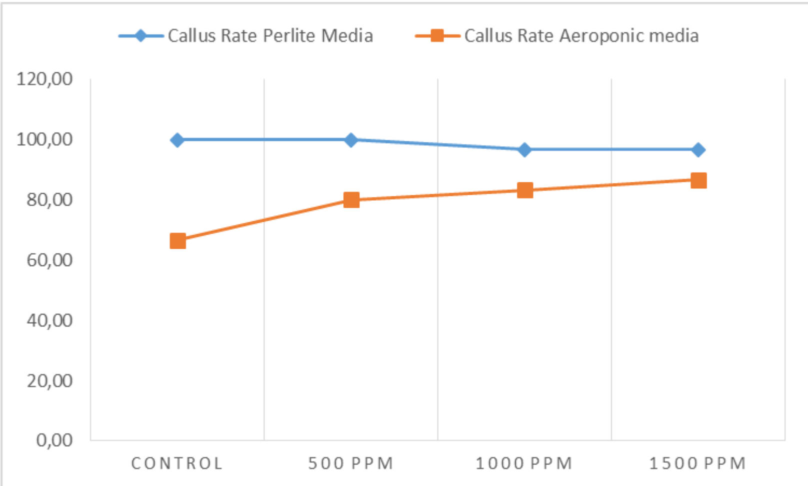

Figure 3. Callus formation rate

Figure 4. Callus formation

Figure 5. Rooting cuttings

While the highest rooting rate in perlite medium was 93.33% with 500 ppm, it decreased to 80.00% and 90.00% in 1000 ppm and 1500 ppm groups. The lowest rooting rate in aeroponic medium was 50.00% in the control group, while this rate varied between 60.00% and 70.00% in other groups. This shows that rooting in aeroponic medium can be increased with better applications (Figure 5, Figure 6). Sharma et al. (2018) in *Tamarix aphylla*, found root development (rooting%, roots/cutting and root length) generally higher in cuttings treated with IBA, they also noted that the highest rooting values (87 %) were performed in cuttings treated with a mixture of IBA and NAA. It was stated in his study that 1 g L^{-1} Indole-3-butyric acid combined with a 10-minute spraying interval increased root biomass yield (Scaltrito et. al 2024).

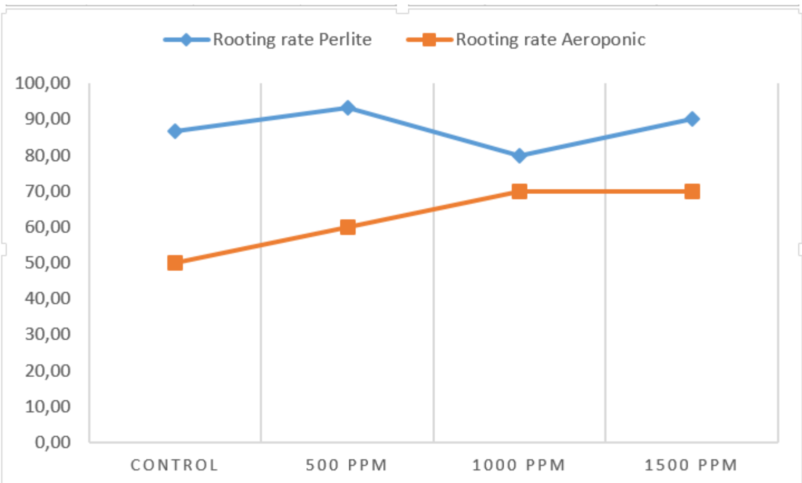

Figure 6. Rooting rate

In perlite medium, seedling yield was the highest, with 93.33% in the 500 ppm group, while it decreased to 76.67% in the 1500 ppm group. In aeroponics, seedling yield varied between 43.33% and 63.33% in all applications. These values indicate that seedling yield in aeroponics was low and could have problems in terms of development. In aeroponics, a low yield (43.33%) was observed in the control group, while this value increased with applications (53.33-63.33%). However, it still lagged behind the perlite medium. 500 ppm application in perlite medium gives the most effective results in seedling yield and rooting, while 1500 ppm in aeroponics medium offers the highest value in callus rate. However, aeroponics applications show lower performance in total. Experiments conducted in perlite medium show that parameters such as root length, diameter, and number give the best results, especially at 500 ppm. Perlite is a frequently used medium for plant development thanks to its lightness, water-holding capacity, and aeration properties (Marschner, 2012). Similarly, there are findings in the literature that perlite media positively affect root development and increase root number and diameter (Baiyin et al., 2021). In addition, the low decay rate (0.00%), high callus rate (100%), and rooting rates (93.33%) observed in the perlite medium show that this medium is quite suitable for healthy plant development.

Rooting experiments were conducted in aeroponics and perlite media using green cuttings in the Jumbo blackberry variety. The analysis results revealed that neither the media nor the application factors showed a significant effect in terms of root length. However, the decay rate varied depending on the media type and was higher in the aeroponics medium. These findings support some aspects of the existing studies in the literature, while they differ in some aspects.

The fact that no significant difference was observed in terms of root length suggests that root development is mainly driven by genetic factors or other environmental factors other than media and applications. In the literature, it is stated that the effect of different media on root length is generally minimal. Instead, the nutrient solution composition and the root zone's oxygen level are more critical (Pineda et al., 202015). In this context, the results of our study underline this view by showing a constant trend in root length regardless of a particular medium or application.

The fact that the application did not significantly affect root length and decay rate suggests that these applications did not create a critical difference in terms of the parameters examined. Although similar findings are found in the literature, it has been stated that increasing the variety of applications may produce more significant results in some cases (Balliu et al., 2021). For example, a study reported that different application types caused changes of up to 10% in root length. Therefore, it is recommended that the application types be diversified and tested with different plant species in future studies.

Our study observed that different application types did not create a significant difference in root length and decay rate. However, the literature has stated that more significant results can be obtained as the variety of applications increases (Balliu et al., 2021).

As a result, this study emphasizes the critical effects of the environmental factor, especially on the decay rate, while revealing that some parameters, such as root length, are less affected by environmental factors. Future studies should be conducted with a broader range of environments and applications to assess the generalizability of these results. Additionally, strategies to reduce the impact of pathogenic microorganisms may be critical for more effective use of aeroponic systems.

CONCLUSION

This study highlights the critical effects of environmental factors on root length and decay rate. Although the effect of the environment on the decay rate is significant, parameters such as root length are less affected by environmental factors and practices. This shows that optimizing the medium and environmental conditions is important, especially in reducing decay rates. Aeroponic systems may negatively affect productivity when the decay rate is high, while media such as perlite have lower decay rates and can provide healthier root development.

High decay rates in aeroponic systems negatively affect the productivity of such systems. In future studies, various strategies should be developed to reduce decay rates in aeroponic systems. These strategies may include factors such as regulating humidity levels, improving airflow, and optimizing the microclimate of the environment. In addition, using biological or chemical control methods that prevent the proliferation of pathogenic microorganisms may contribute to aeroponic systems being more efficient and sustainable.

It has been stated in the literature that oxygen levels play a critical role in root development (Smith et al., 2015). Therefore, improving oxygen levels in the root zone can be an important strategy to accelerate root development. Increasing oxygen levels, especially in aeroponic systems, can provide healthier root development.

Future studies should be conducted with different media and application types to test the generalizability of these results. Developing strategies to reduce decay rates in rooting studies on green cuttings in aeroponic systems will allow these systems to be used more efficiently and sustainably.

This study was conducted only on green cuttings of the Jumbo blackberry variety. Studies on different plant species can reveal how media types and application diversity differ according to plant species.

In conclusion, this study provides important information by investigating the effects of different rooting media and application types on plant rooting. However, more comprehensive studies in the future can reinforce these results and allow rooting processes to be made more efficient.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Declaration of Interests

The authors declare that they have no conflict of interest.

Author contribution

All the authors verify that the text, figures, and tables are original and that they have not been published before. This study was produced from the Fatma DUMLU's master thesis.

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