# Rooting of hardwood cuttings of quince *Cydonia oblonga* L. as influenced by IBA and rooting substrate

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## Abstract

This research was conducted in the College of Agricultural Engineering Sciences, University of Sulaimani, Kurdistan Region, Iraq, to investigate the effect of different indole-3-butyric acid (IBA) concentrations (0, 1000, 2000 and 3000 mg.L$^{-}$) and rooting media (river-sand, river sand/peat moss, and perlite/peat moss) on rooting success of hardwood cuttings of quince (*Cydonia oblonga* Mill.). The experiment was laid out in a Factorial Randomized Complete Block Design with three replications inside a lath-house. The parameters of rooting%, root number, root length (cm), root dry weight (g), shoot length (cm), shoot diameter (mm), shoot dry weight (g), number of leaves per seedling, leaf area (cm$^2$), and leaf chlorophyll content (SPAD unit) were measured. The effect of individual factors showed that rooting and other traits of rooted cuttings were independent of IBA effect. The highest rooting percentage (62.50%) was achieved in the control cuttings, as well as improved other traits. Also, the best rooting (64.58%) was found in the cuttings planted in river sand medium. Interaction effects of the two factors showed that control cuttings which planted in river-sand gave the highest rooting (70.83%), and the highest other root and shoot traits. River-sand and river sand/peat moss were outstanding for the quince cuttings, but IBA was not needed at the concentrations used in this study.

**Keywords:** IBA, Rooting media, Cutting propagation, Perlite, Peat moss.

## Introduction

The quince (*Cydonia oblonga* Mill.) belongs to the Rosaceae family and the Maloideae (Pomoidae) subfamily which has about 30 genera and 1,000 species, including the genus *Cydonia*, which has only one species, *Cydonia oblonga* Mill., with a large number of varieties (18). The central regions of quince (*Cydonia oblonga* Mill.) are located between Dagestan and Talysh in Trans-Caucasia and north of Iran. Historic documents present evidences of quince domestication in Mesopotamia, between (5000 and 4000) BC that has been pursued to about 500 BC in the ancient Persian and Greek empires (1). Nowadays, mostly, quince is cultivated for two main purposes, the first to obtain quince fruits that is used in the production of jams and jellies, and the second is to use as dwarfing rootstocks for pears and loquats. In addition of pharmaceutical concerns, since phenolics, organic acids, free amino acids, and antioxidants have been determined in quince fruit and jam, which will bring numerous health benefits to humans (34). On the other hand, quince is an outstanding rootstock for pear used through centuries (3). It makes the size of pear trees reduced and tolerates nematodes and aphids (15). In spite of pear, the results of many researches have been emphasized that quince is an excellent rootstock for loquat to reduce tree height which may decrease cost production (4). Furthermore, (21) suggested that for loquat, Anger quince rootstock is a better rootstock than loquat itself.

Quince is propagated by seeds and other vegetative methods, including cuttings and grafting (28), and layering (27). Stem cuttings are widely used, both for its simplicity and its economy in nursery practices (17). From a cutting propagation, quince is known as easy-to-root species. Besides, restrictions were observed in the rooting of quince cuttings of different cultivars, even if they were treated with the auxin; indole-butyric acid (IBA) (30). Auxins are widely applied to cuttings for the sake of improving rooting rate. The effectiveness appears when auxin itself is the only limiting factor in the rooting of the cuttings (36). The rooting response to auxins by the cuttings depends on auxin concentration, species, and time of taking the cuttings. Auxins, particularly IBA, positively influence many aspects of the cuttings, most prominently mobilizations of the food in the cuttings, converting to endogenous auxin, and increasing cell division (19).

Rooting medium is another factor that has a definitive role in rooting the cuttings. Giacobbo *et al*. (13) reported variable rooting ability in grafted cuttings of quince after planting in different media. A satisfactory water content, gas exchange, nutrient supply, and supporting the cuttings should be present in the rooting media to reach optimal results in the cuttings (20). In this regard, this study aims to find out the best rooting media and IBA concentrations for rooting quince cuttings and to find the best method for vegetative propagation of quince through cuttings for rootstock production.

## Materials and Methods

This study was conducted to investigate the effect of rooting substrate and different concentrations of IBA (indole-3-butyric acid) on the rooting of local quince hardwood cuttings in the College of Agricultural Engineering Sciences, University of Sulaimani, Kurdistan Region, Iraq, in 2021.

Collecting the hardwood cuttings:

Plant material of the local variety of quince was taken from 3-year-old quince trees at Kanipanka Nursery Station on February 25, 2021, from the middle part of one-year-old branches with 25±1 cm length and 10±2 mm diameter. The plant wood materials were then brought to the laboratory, where treated with 3 $g.L^-$ Captan (50%) fungicide and put in black plastic bags, then sealed and stored at 4±1 °C (25) for 20 days.

Preparation of IBA solutions:

IBA solution was prepared by dissolving IBA in 50% ethanol (with a purity of 96%) (10). with different concentrations (0, 1000, 2000, and 3000 $mg.L^-$).

Preparation of rooting substrate:

The rooting substrates were prepared from three different rooting media: River-sand, River sand + Peat moss (1:1 v/v), and perlite + peat moss (1:1 v/v).

Preparation, IBA treatment and planting of the hardwood cuttings:

The plant wood materials were removed from the cold storage on March 15, 2021. After that, the cuttings were randomly divided into four lots, each lot included 72 cuttings, then every lot was separately and quickly dipped into the control treatment (ethanol with distilled water), and different IBA concentrations for 10 seconds (32). There were 12 treatments with 3 replications. The experiment included a total number of 288 cuttings. The cuttings were distributed among the three rooting substrates in black plastic pots with 43×36 cm. The pots were placed in a lath-house and arranged in a randomized complete block design (RCBD). The weekly averages of temperature and relative humidity were recorded during the whole period of the experiment (Table 1). After 4 months, on July 15, 2021, the experiment was terminated and the cuttings were checked to measure the effect of the treatments.

**Table 1. The weekly average temperature and relative humidity inside the lath-house during the study period.**

| Date | Weeks | Temperature (°C) | Relative Humidity (%) |
|---|---|---|---|
| April 13-19 | Week 1 | 19.11 | 49.42 |
| April 20-26 | Week 2 | 24.31 | 45.23 |
| April27-May 3 | Week 3 | 24.16 | 46.29 |
| May 4-10 | Week 4 | 25.39 | 41.36 |
| May 11-17 | Week 5 | 28.10 | 33.37 |
| May 18-24 | Week 6 | 28.08 | 32.72 |
| May 25-31 | Week 7 | 28.14 | 33.76 |
| June 1-7 | Week 8 | 29.13 | 25.96 |
| June 8-14 | Week 9 | 29.08 | 20.92 |
| June 15-21 | Week 10 | 32.59 | 17.68 |
| June 22-28 | Week 11 | 33.34 | 17.70 |
| June29-July5 | Week 12 | 33.37 | 19.09 |
| July 6-12 | Week 13 | 33.51 | 19.26 |
| July 13-15 | Week 14 | 33.95 | 24.57 |

Studied Parameters:

The experiment was terminated on July 15, 2021, by taking the following parameters:

1. Rooting%.
2. Root length (cm).
3. Root number.
4. Root dry weight (g): the roots were dried at 60 °C for 72 hours in an oven.
5. Shoot length (cm).
6. Shoot diameter (cm).
7. Number of leaves per seedling.
8. Leaf area ($cm^2$), measured by using a software program application (Digimizer image analysis) (https://www.digimizer.com/).
9. Shoot dry weight (g): the shoots were dried at 60 °C for 72 hours in an oven.
10. Total chlorophyll content of leaves (SPAD units), determined using a chlorophyll meter (Model OPTI-SCIENCES

## Results and Discussion

Rooting%

Data shown in Figure (1) demonstrate the effect of IBA concentrations on the rooting Rooting percentage of hardwood cuttings of local quince at any concentration compared to control cuttings. Controversially, the highest rooting percentage (62.50 %) was found in control, while 3000 mg.L$^{-}$ IBA reduced rooting to percentage of quince hardwood cuttings. It was revealed that using IBA was not significantly effective in improving the the lowest percentage (40.97%). Application of exogenous auxins have been used to improve rooting in many species because exogenous auxins increase endogenous auxin, and endogenous auxin which is essential for root formation in cuttings should be at an optimal level to reach the best rooting rate (15). Whereas, the ineffectiveness of IBA in this study could be attributed to that endogenous auxin might not be the only limiting factor for root formation. These results coincided with the results of Nogueira *et al*. (24) and Sousa *et al*. (36) indicating that IBA was not needed to root formation in fig cuttings, and they backed to that endogenous auxin may not be a sole factor to induce rooting in the fig cuttings. They further discussed that the factors that were crucial for rooting occurred in the cuttings before treating with exogenous auxin. Besides, the tissue of the quince cuttings, at the time of collection, might not be responsive or sensitive to the applied IBA. The taking time of cuttings is related to the sensitivity of the cutting tissues to the applied exogenous auxins (23). Figure (2) shows the effect of rooting media on the rooting percentage of local quince hardwood cuttings. The highest value of rooting (64.58%) was observed from cuttings stuck in river sand, which was significantly not different with rooting (50.08%) of the cuttings stuck in river sand/peat moss medium, both of them were significantly higher than those of perlite/peat moss substrate with the lowest value (38.02%) of rooting. The growing or rooting medium is one of the major factors affecting the rooting of stem cuttings. The rooting success of any cutting is affected by the interaction of some factors like water, oxygen, and nutrient availability in the growing media (5)

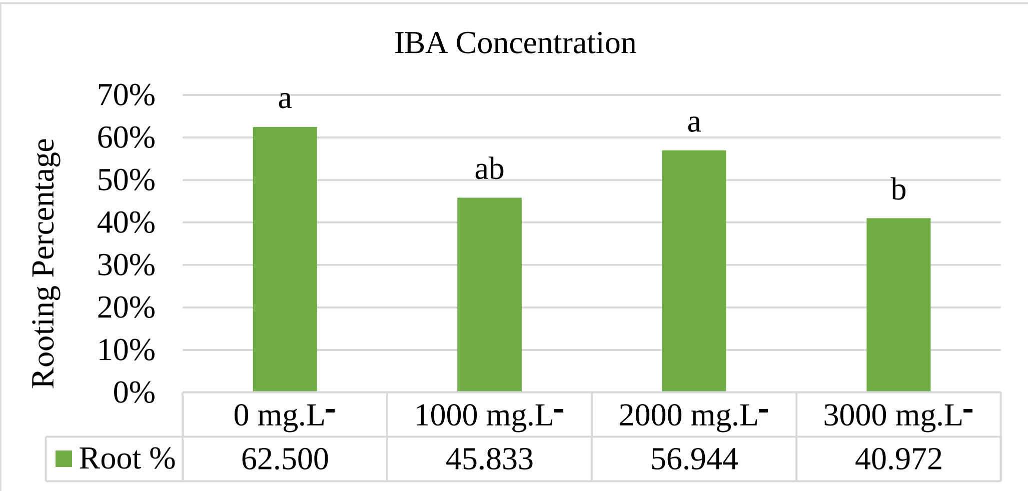


**Figure 1. Effect of IBA concentrations (mg.L$^{-}$) on rooting percentage of hardwood cuttings of local quince. Values that are not sharing the same superscripts (a, b) differ significantly (*P*≤0.05).**

The results of the current study are contrary to those of Al-Saqri and Alderson (2) who reported that using perlite with peat moss highly significantly affected the rooting percentage more than vermiculite in *Rosa centifolia* cuttings. (7) also reported that using coco peat + perlite medium resulted in a higher root percentage of cuttings. Whereas, the rooting percentage of the quince cuttings in this study agreed with Hakeem (14) who reported that sand/fiber mixture gave a higher percentage of rooting and produced stronger and more fibrous roots than sand, fiber, or peat moss alone. Also, (29) reported that silt media had recorded a significantly higher survival percentage (83.33±16.33%). Decreasing rooting in perlite/peat moss medium may be related to that this medium could not provide the cuttings with a suitable environment to form roots, such as lacking essential nutrients, ion exchange, beneficial microorganisms, and proper pH (33).

It can be shown that the interaction of different IBA concentrations and rooting media had no significant connection for enhancing the rooting rate of hardwood cuttings of local quince. The highest rooting percentage (70.83%) was obtained from the combination of river sand and 0 $mg.L^{-}$ IBA. Besides, the lowest rooting percentage (62.5%) was recorded from the interaction of 3000 $mg.L^{-}$ IBA and perlite/peat moss medium (Figure 3). This might be due to the fact that quince cuttings are easy to root and

do not respond to IBA concentration, and river sand medium afford the cuttings the necessities for better rooting. These results are contrary to those of Sardoei (31) who reported that a higher rooting percentage (85%) was achieved in perlite/silt (1:1 v/v) medium in guava. Also, Exadaktylou *et al*. (11) found that a combination of perlite with peat moss is suitable for rooting in hardwood cuttings of the cherry cultivar ‘Gisela 5’.

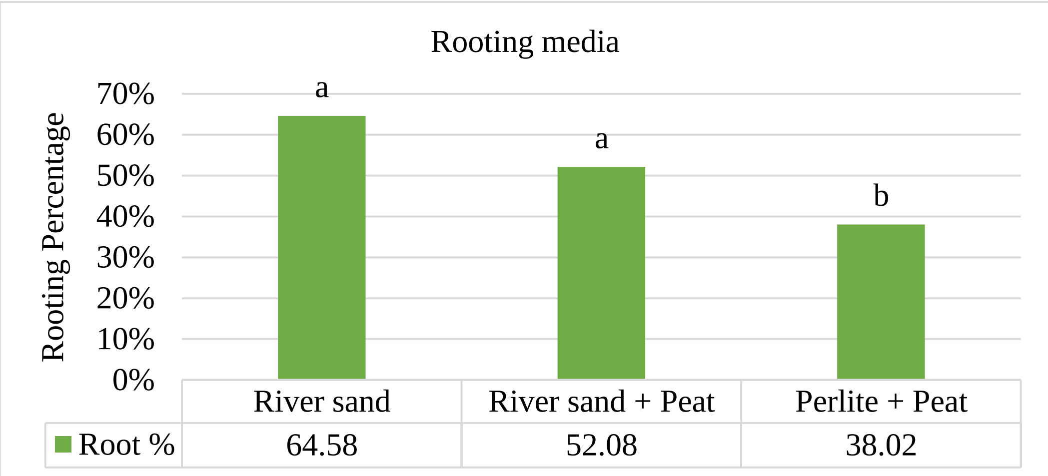


**Figure 2. Effect of rooting media on rooting percentage of hardwood cuttings of local quince. Values that are not sharing the same superscripts (a, b) differ significantly (*P*≤0.05).**

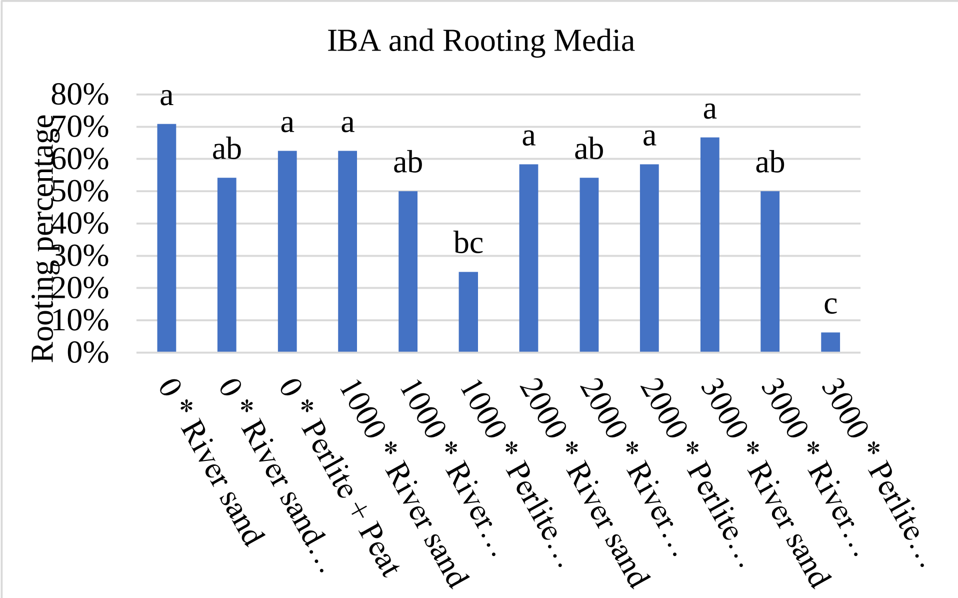


**Figure 3. Interaction between IBA concentrations (mg.L⁻) and rooting media on rooting percentage of local quince. Values that are not sharing the same superscripts (a, b, c) differ significantly (*P*≤0.05).**

Root characteristics

Data presented in table (2) show that no significant differences were detected in the root length of local quince hardwood cuttings as a result of the application of IBA at different concentrations. In contrast, root length was reduced in the cuttings treated with IBA concentrations. So, the longest root (40.85 cm) was observed in control cuttings, but root length was decreased to about half of the control cuttings (22.75 cm) in the ones dipped in 3000 mg.L⁻ IBA, in the same manner. This result disagrees with (35). The impact of IBA concentrations on root number was not effecting, root number was the same in the treated and untreated, which gave the highest value of root number (13.17) in 2000 mg.L⁻ of IBA concentration, this might be due to hormonal effect leading to accumulation of internal substances and their downward movement and these growth regulators also stimulate cambial activity involved in root initiation in many species. The results of dry weight proved that IBA concentrations were not significantly sufficient to achieve better root dry weight than control cuttings. So, root dry weight was superior (1.41 g) in control cuttings. On the contrary, 3000 mg.L⁻ IBA decreased root dry weight to the lowest value (0.58 g). Moreover, IBA concentrations did not effect on root length, root number and root dry weight. Previous results Erez and Yablowits (9) showed that the adverse influence of IBA was found when higher concentrations were applied, Also, da Costa *et al.* (6) reported that a comparatively higher auxin concentration is required for adventitious root induction, but its formation was adversely suboptimal auxin concentration. This result disagrees with Galavi *et al*, (12) who reported that IBA enhanced the maximum number of roots, root length and root dry weight in grape cuttings.

**Table 2. Effect of IBA concentration (mg.L$^{-}$) on root traits of hardwood cuttings of local quince.**

| IBA concentration (mg.L$^{-}$) | Root length (cm) | Root number | Root dry weight (g) |
|---|---|---|---|
| 0 | 40.85 a | 13.17 a | 1.41 a |
| 1000 | 34.18 ab | 11.93 a | 1.11 a |
| 2000 | 35.19 ab | 13.20 a | 1.09 a |
| 3000 | 22.75 b | 10.59 a | 0.58 b |

* The values in each column with the same letter do not differ significantly (P≤0.05) according to Duncan's Multiple Range Test.

The results of the effects of rooting substrate on hardwood cuttings of local quince are shown in table (3) demonstrating that rooting substrates were not effective on root traits, but the maximum value was observed in root length (35.71cm) for using rooting substrate perlite with peat moss. This may be due to the fact that perlite has a slow degradation rate, low bulk density, high porosity, and high-water holding capacity that make particularly suitable as growing substrate. Or may be due to the easy translocation of water and minerals to the above-ground parts of the cuttings. Many researchers studied the influence of perlite as growing substrate. One of the studies found that the highest number of primary roots per plant, length of the most developed roots, and the number of crowns per runner were obtained from perlite (8). While the minimum value of root length (31.92 cm) was recorded when rooting substrate, river sand, was used alone. Then the highest values of root number (15.81) and root dry weight (1.11 g) were recorded in river sand. The increase in root weight was due to the greater number of roots, highest root girth, and length of the roots. Whereas, the lowest values of root number (8.90) and root dry weight (1.09 g) were recorded when perlite plus peat moss rooting substrate was used.

**Table 3. Effect of rooting substrate on root traits of hardwood cuttings of local quince.**

| Rooting substrate | Root length (cm) | Root number | Root dry weight (g) |
|---|---|---|---|
| River sand | 31.92 a | 15.81 a | 1.11 a |
| River sand + Peat moss | 32.11 a | 11.96 ab | 0.95 a |
| Perlite + Peat moss | 35.71 a | 8.90 b | 1.09 a |

* The values in each column with the same letter do not differ significantly ($P \leq 0.05$) according to Duncan's Multiple Range Test.

Shoot characteristics

Table (4) demonstrates the effect of growth regulators on vegetative traits of local quince hardwood cuttings. It is clear that IBA concentrations were not effective on vegetative traits compared to control cuttings. The maximum values of shoot length (54.52 cm), shoot diameter (3.19 mm), shoot dry weight (11.27 g), number of leaves (29.76), and leaf area (26.34 cm²) were recorded in control of IBA concentrations. Whereas, the minimum values of shoot length (32.47 cm), shoot diameter (1.96 mm), shoot dry weight (4.91 g), number of leaves per seedling (18.02), and leave area (19.28 cm²) were recorded in (3000 mg.L$^{-}$) of IBA concentration. This may be caused by hardwood cuttings which contain stored nutrients such as hydrocarbons, nucleic acids, proteins, and natural hormones that can be used for shoot growth and development. Hence, they absorbed more water and nutrients needed for better growth and vase versa. In this regard, Mohammed (22) referred that superior root traits are necessary for the best shoot growth because of absorbing high water and nutrients. Moreover, as was seen in the cuttings treated with 3000 mg.L$^{-}$ IBA in the current study, it has been recorded that high auxin dosage retarded bud sprout and finally vegetative traits, particularly in dormant hardwood cuttings (15). On the other hand, the maximum value of chlorophyll (21.88 ccl) was recorded in control of IBA concentration. While the lowest value of chlorophyll (13.68 ccl) was also found in (3000 mg.L$^{-}$) of IBA concentration. Similarly, Omar and Khudhur (26) reported that different concentrations and application levels of auxin and their interaction significantly affected chlorophyll, while showing a non-significant effect on chlorophyll-B, total chlorophyll, and total carotenoid content of the leaf. On the contrary, Kaur *et al.* (16) reported that total chlorophyll content in leaves of grapevine stem cuttings was enhanced after IBA treatment.

**Table 4. Effect of IBA concentration (mg.L$^{-}$) on vegetative traits of hardwood cuttings of local quince.**

| IBA concentration (mg.L$^{-}$) | Shoot length (cm) | Shoot diameter (mm) | Shoot dry weight (g) | Number of leaves | Leaf area (cm²) | Chlorophyll (ccl) |
|---|---|---|---|---|---|---|
| 0 | 54.52 a | 3.19 a | 11.27 a | 29.67 a | 26.34 a | 21.88 a |
| 1000 | 48.04 a | 2.83 a | 8.79 a | 25.04 a | 23.61 a | 20.65 a |
| 2000 | 46.78 a | 2.92 a | 9.93 a | 26.56 a | 26.08 a | 20.60 a |
| 3000 | 32.47 b | 1.96 b | 4.91 b | 18.02 b | 19.28 a | 13.68 b |

* The values in each column with the same letter do not differ significantly (*P*≤0.05) according to Duncan's Multiple Range Test.

It can be seen from the data in table (5), regarding the effect of rooting substrate on vegetative traits of hardwood cuttings of local quince, that these traits were significantly affected by rooting substrate (River sand and River sand with Peat moss) above rooting substrate (perlite with peat moss), this could be due to the difference in the level of organic matter content and/or water-holding capacity. While the maximum values of shoot length (55.35 cm), shoot diameter (3.11 mm), shoot dry weight (10.25 g), number of leaves per seedling (28.00), and leaf area (27.41 cm²) were recorded in rooting substrate (River sand with Peat moss), but the minimum values of shoot length (32.28cm), shoot diameter (2.18 mm), shoot dry weight (7.19 g), number of leaves per seedling (19.07) and leaf area (18.27cm²) were recorded in perlite/peat moss substrate. Similar results were recorded by Qadri *et al.* (29) who reported that silt substrate had recorded significantly higher shoot length, shoot diameter, and number of leaves. Furthermore, the maximum value of chlorophyll (25.76 ccl) was recorded in (River sand) which had significantly above rooting substrate (Perlite with Peat moss) as (9.85 ccl) in chlorophyll which observed as the minimum value. This could be related to the impact of river sand which contains more organic matter than perlite. Analyzed data of interaction of the IBA concentration and rooting substrate in table (6) explains that there was an important role in enhancing root measurement, in terms of root length, root number and root dry weight. Root length was not significantly different in the cuttings which were treated with different IBA concentrations and planted in the different rooting substrates with exception of the ones that were treated with 3000 mg.L⁻ IBA and planted in a mixture of perlite with peat moss substrate. The longest root (51.50 cm) was observed in the control cuttings which were planted in the perlite with peat moss substrate followed by (50.56 cm) in those treated with 2000 mg.L⁻ IBA and planted in a mixture of perlite with peat moss substrate. However, root length was decreased to the

**Table 5. Effect of rooting substrate on vegetative traits of hardwood cuttings of local quince.**

| Rooting Substrate | Shoot length (cm) | Shoot Diameter (mm) | Shoot dry weight (g) | Number of leaves | Leaf area (cm²) | Chlorophyll (ccl) |
|---|---|---|---|---|---|---|
| River sand | 48.72 a | 2.88 a | 8.73 ab | 27.39 a | 25.81 a | 25.76 a |
| River sand + Peat moss | 55.35 a | 3.11 a | 10.25 a | 28.00 a | 27.41 a | 22.00 a |
| Perlite + Peat moss | 32.28 b | 2.18 b | 7.19 b | 19.07 b | 18.27 b | 9.85 b |

* The values in each column with the same letter do not differ significantly (P≤0.05) according to Duncan's Multiple Range Test.

minimum (7.43 cm) in the cuttings dipped in the highest IBA dose of 3000 mg.L$^{-}$ and planted in a mixture of perlite with peat moss substrate. Besides, the river sand medium and its interaction with IBA concentrations, or a mixture of river sand with peat moss in combination with IBA concentrations (1000, 2000, and 3000 mg.L$^{-}$) was rised to the maximum root number. The highest (19.72) root number was obtained in the control cuttings and planted in the river sand, but the lowest (2.22, 6.50, and 7.78) root numbers were found in the cuttings planted in a mixture of river sand with peat moss, perlite, and peat moss substrate after dipping in 3000, 0, and 1000 mg.L$^{-}$ IBA, respectively. Meanwhile, the same cuttings had the highest root dry weight (1.77 g) from the control cuttings which were planted in river sand, followed by (1.55 g) from the control cuttings which were planted in a mixture of perlite with peat moss substrate.

In contrast, the cuttings dipped in 3000 mg.L$^{-}$ IBA and planted in a mixture of perlite with peat moss showed the lowest (0.23 g) root dry weight. Data presented in Table (7) illustrate that the combination of the two factors, rooting substrate, and IBA concentration effectively resulted in different shoot characteristics of hardwood cuttings of local quince. The interaction of 1000 mg.L$^{-}$ IBA with a mixture of river sand plus peat moss substrate differently produced shoot length, shoot diameter, leave number, and leave area when compared to the combination of 3000 mg.L$^{-}$ IBA with a mixture of perlite with peat moss. The cuttings were dipped in 1000 mg.L$^{-}$ IBA and planted in a mixture of river sand with peat moss substrate had the highest values of shoot length (65.78 cm), shoot diameter (3.34 mm), number of leaves per seedling (31.11), and leave area (29.03 cm$^{2}$). Whereas, the combination of 3000 mg.L$^{-}$ IBA with a mixture of perlite with peat moss substrate sharply reduced shoot length (7.24 cm), shoot diameter (0.44 mm), number of leaves (5.18), and leaf area (4.10 cm$^{2}$). Furthermore, shoot dry weight,

**Table 6. The interaction effect between IBA concentration (mg.L$^{-}$)and rooting substrate on root traits of hardwood cuttings of local quince.**

| IBA (mg.L$^{-}$) | Rooting substrate | Root length (cm) | Root number | Root dry weight (g) |
|---|---|---|---|---|
| 0 | River sand | 35.89 a | 19.72 a | 1.77 a |
| | River sand / Peat moss | 35.17 a | 6.50 cd | 0.90 bc |
| | Perlite / Peat moss | 51.50 a | 13.28 abc | 1.55 ab |
| 1000 | River sand | 36.61 a | 15.17 abc | 1.13 abc |
| | River sand / Peat moss | 32.61 a | 12.83 abc | 0.98 abc |
| | Perlite / Peat moss | 33.33 a | 7.78 bcd | 1.22 abc |
| 2000 | River sand | 25.56 a | 11.72 abc | 0.68 cd |
| | River sand / Peat moss | 29.44 a | 15.56 abc | 1.24 abc |
| | Perlite / Peat moss | 50.56 a | 12.33 abc | 1.36 abc |
| 3000 | River sand | 29.61 a | 16.61 ab | 0.83 bcd |

| | | | | |
|---|---|---|---|---|
| | River sand / Peat moss | 31.22 a | 12.94 abc | 0.67 cd |
| | Perlite / Peat moss | 7.43 b | 2.22 d | 0.23 d |

* The values in each column with the same letter(s) do not differ significantly ($P \leq 0.05$) according to Duncan's Multiple Range Test.

, and leaf area were differently affected by the combinations of the different IBA concentrations and growing substrate. Moreover, the best shoot dry weight (14.17 g) was observed in the cuttings treated with 2000 mg.L- IBA and planted in a mixture of river sand with peat moss substrate, followed by (12.64 g) from the control cuttings which were planted in river sand substrate. Additionally, there were significant differences in leaf chlorophyll content of the quince hardwood cuttings as they were dipped in the various doses of IBA and planted in the different rooting substrates. The control cuttings planted in river sand exhibited the greatest chlorophyll content (30.31 ccl), while chlorophyll content was severely diminished to the lowest level (0.92 ccl) in the leaves of the cuttings dipped in 3000 mg.L- IBA and planted in a mixture of perlite with peat moss substrate.

**Table 7. The interaction effect between IBA concentration (mg.L-) and rooting substrate on vegetative traits of hardwood cuttings of local quince.**

| IBA (mg.L-) | Rooting Substrate | Shoot length (cm) | Shoot Diameter (mm) | Shoot dry weight (g) | Number of leaves | Leaf area (cm²) | Chlorophyll (ccl) |
|---|---|---|---|---|---|---|---|
| 0 | River sand | 56.11 a | 3.03 a | 12.64 Ab | 30.89 A | 27.70 a | 30.31 a |
| | River sand/ Peat moss | 52.89 a | 3.20 a | 9.91 a-d | 28.78 A | 28.14 a | 25.31 ab |
| | Perlite/ Peat moss | 54.56 a | 3.33 a | 11.24 Abc | 29.33 A | 23.17 a | 10.02 d |
| 1000 | River sand | 55.33 a | 3.23 a | 8.89 Bcd | 30.33 A | 24.16 a | 24.10 ab |
| | River sand/ Peat moss | 65.78 a | 3.34 a | 11.04 Abc | 31.11 A | 29.03 a | 23.78 ab |
| | Perlite/ Peat moss | 23.00 bc | 1.91 a | 6.45 Cd | 13.67 bc | 17.64 a | 14.06 cd |
| 2000 | River sand | 40.00 ab | 2.56 a | 6.07 D | 23.22 Ab | 24.33 a | 26.22 ab |
| | River sand/ Peat moss | 56.00 a | 3.19 a | 14.17 A | 28.33 A | 25.76 a | 21.18 abc |
| | Perlite/ Peat moss | 44.33 ab | 3.02 a | 9.55 a-d | 28.11 A | 28.15 a | 14.40 cd |
| 3000 | River | 43.44 | 2.72 | 7.33 | 25.11 | 27.03 | 22.39 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | sand | ab | a | Cd | ab | a | abc |
| | River sand/ Peat moss | 46.72 ab | 2.73 a | 5.88 D | 23.78 ab | 26.71 a | 17.74 bcd |
| | Perlite/ Peat moss | 7.24 c | 0.44 b | 1.53 E | 5.18 C | 4.10 b | 0.92 e |

* The values in each column with the same letter do not differ significantly (P≤0.05) according to Duncan's Multiple Range Test.

## Conclusion

It could be concluded from the results of this study that the application of IBA is not required to elevate rooting rate, or other characteristics of the rooted cuttings in the hardwood cuttings of quince taken in late February and planted in river sand, river sand/peatmoss, and perlite/peatmoss substrates. On the other hand, the three substrates had apparent roles in rooting of the hardwood cuttings of quince, river sand and river sand/peat moss were comparable significant substrates, whereas perlite/peat moss declined most studied parameters. The interaction of the two factors declared that IBA concentrations were also not good options to improve rooting and related traits in the hardwood cuttings of quince, but the substrate was effective. Further studies are needed to reveal whether quince hardwood cuttings respond positively to low concentrations of IBA less than 1000 mg.L$^{-}$, prolonged soaking and powder methods, or taking the cuttings in different dates.

## Conflict of interest

The authors have no conflict of interest.

## References


1- **Abdollahi, H. 2019**. A review on history, domestication and germplasm collections of quince (*Cydonia oblonga* Mill.) in the world. Genetic Resources and Crop Evolution, 66(5): 1041–1058. doi: 10.1007/s10722-019-00769-7.

2- **Al-Saqri, F. and P. G. Alderson. 1996**.Effects of IBA, cutting type and rooting media on rooting of Rosa centifolia. Journal of Horticultural Science, 71(5):729–737. doi: 10.1080/14620316.1996.11515453.

3- **Aygun, A.; B. San; H. Dumanoglu and Celik, M. 2006**. Propagation by mound layering of some selected "SO" quince genotypes (*Cydonia oblonga*) as compatible rootstocks for pears (*Pyrus communis*). New Zealand Journal of Crop and Horticultural Science, 34(3):191-193.

4- **Bermede, A. O. and A. A. Polat. 2010.** Budding and rooting success of loquat on quince-A and BA-29 quince rootstocks. In III International Symposium on Loquat, 887: 333-336.

5- **Bhardwaj, R. L. 2013.** Effect of growth media on seed germination and seedling growth of papaya cv.

'Red Lady. Indian Journal for Agricultural Research, 47(2): 163-168.

6- **da Costa, C. T.: M. R. de Almeida; C. M. Ruedell; J. Schwambach; F. S. Maraschin and Fett-Neto, A. G. 2013.** When stress and development go hand in hand: main hormonal controls of adventitious rooting in cuttings. Frontiers in Plant Science, 4:133-152.https://doi.org/10.3389/fpls.2013.00133

7- **Dvin, S. R.; E. G. Moghadam and Kiani, M. 2011.** Rooting response of hardwood cuttings of MM111 apple clonal rootstock to indolebutyric acid and rooting media. Asian Journal of Applied Sciences, 4 (4): 453-458. DOI: 10.3923/ajaps.2011.453.458.

8- **Ercisli, S.; O. Anapali; A. Esitken and Sahin, Ü. 2002.** The effects of IBA, rooting media and cutting collection time on rooting of kiwifruit. Gartenbauwissenschaft, 67(1): 34-38.

9- **Erez, A. and Z. Yablowitz. 1981.** Rooting of peach hardwood cuttings for the meadow orchard. Scientia Horticulturae, 15 (2): 137–144. doi: 10.1016/0304-4238(81)90101-1.

10- **Evert, D. R. and Smittle, D. A. 1990.** Limb girdling influences rooting, survival, total sugar, and starch of dormant hardwood peach cuttings. HortScience, 25(10): 1224–1226. doi: 10.21273/hortsci.25.10.1224.

11- **Exadaktylou, E.; T. Thomidis; B. Grout; G. Zakynthinos and Tsipouridis, C. 2009.** Methods to improve the rooting of hardwood cuttings of the 'Gisela 5' cherry rootstock. HortTechnology, 19(2): 254-259. DOI: 10.21273/HORTSCI.19.2.254

12- **Galavi, M.; M. A. Karimian and Mousavi, S. R.2013.**Effects of different auxin (IBA) concentrations and planting-beds on rooting grape cuttings (*Vitis vinifera*). Annual Review and Research in Biology, 3(4): 517-523.

13- **Giacobbo, C. L.; J. C. Fachinello and Bianchi, V. J. 2007.** Effect of substrate, indolebutyric acid and root grafting on the propagation of quince (*Cydonia oblonga* Mill.) cultivar EMC by cuttings. Ciência e Agrotecnologia, 31(1): 64-70.

14- **Hakeem Kontoh, I. 2008.** Propagation of voacanga Africana cuttings for the protection of water bodies in the transitional zone of Ghana (Doctoral dissertation).Ghana.

15- **Hartmann, H. T.; D. E. Kester; Jr. F. T. Davies and Geneve, R. L. 2011.** Plant Propagation: Principles and Practices. 8th Edition. Pearson Education, Inc., Prentice Hall, Upper Saddle River, NJ 07458. USA.

16- **Kaur, S.; S. S. Cheema; B. R. Chhabra and Talwar, K. K. 2002.** Chemical induction of physiological changes during adventitious root formation and bud break in grapevine cuttings. Plant Growth Regulation, 37(1): 63-68.

17- **Kesari, V. and L. Rangan. 2010.** Development of Pongamia pinnata as an alternative biofuel crop — current status and scope of plantations in India. Journal of Crop Science and Biotechnology, 13(3): 127–137. DOI: 10.1007/s12892-010-0064-1

18- **Kole, C.2011.** Wild Crop Relatives: Genomic and Breeding Resources: Temperate Fruits. Springer-Verlag, Berlin, Heidelberg, Germany. pp.264.

19- **Krajnc, A. U.; M. Turinek and Ivančič, A. 2013.** Morphological and physiological changes during adventitious root formation as affected by auxin metabolism: Stimulatory effect of auxin containing seaweed extract treatment. Agricultura, 10(1-2): 17-27.

20- **Kumar, S.; A. Malik; R. Yadav and Yadav, G. 2019.** Role of different rooting media and auxins for rooting in floricultural crops: A review. International Journal of Chemical Studies, 7(2): 1778-1783.

21- **López-Gómez, E.; M. A. San Juan; P. Diaz-Vivancos; J. M. Beneyto; M. F. García-Legaz and Hernández, J. A. 2007.** Effect of rootstock grafting and boron on the antioxidant systems and salinity tolerance of loquat plants (Eriobotrya japonica Lindl.). Environmental and Experimental Botany, 60(2): 151-158.

22- **Mohammed, A. A. 2021.** Application of different concentrations of licorice and willow extracts as rooting stimulator in hardwood cuttings of olive (*Olea europaea* L.). International Journal of Environment, Agriculture and Biotechnology, 6(6): 58–63.

23- **Mohammed, A. A. 2022.** Rooting hardwood cuttings of plum (*Prunus domestica* L.) according to taking time of the cuttings. Research Journal of Agriculture and Forestry Sciences, 10(1): 1–4.

24- **Nogueira, Â. M.; N. N. J. Chalfun; L. F. Dutra and Villa, F. 2007.** Propagação de figueira (*Ficus carica* L.) por meio de estacas retiradas durante o período vegetativo. Ciência e Agrotecnologia, 31: 914-920.

25- **Noori, I. M. and A. A. Muhammad. 2020.** Rooting of peach (*Prunus persica* L.) Batsch] hardwood cuttings as affected by IBA concentration and substrate pH', Journal of Applied Horticulture, 22(1): 33–37. doi: 10.37855/jah.2020.v22i01.07.

26- **Omar, T. J. and S. A. Khudhur. 2015.** Effect of NAA and IAA on stem cuttings of Dalbergia Sissoo (Roxb). Journal of Biology and Life Science, 6(2): ISSN 2157-6076 doi: 10.5296/jbls.v6i2.7445.

27- **Pawar, Y. D. and P. Singh. 2020.** Advances in propagation techniques of pomegranate. International Journal of Current Microbiology and Applied Sciences, 9(6): 2122–2137.DOI: 10.20546/ijcmas.2020.906.260

28- **Postman, J. 2009.** Cydonia

oblonga: The Unappreciated Quince. Arnoldia, 67(1): 2–9.

29- **Qadri, R.; M. Azam; S. B. Khan; I. Khan; L. Ul Haq; Y. Yang; J. M. Muzammil; M. A. Ghani and Moazzam, M. 2018.** Growth performance of guava cutting under different growing media and plant cutting taking height. Bulgarian Journal of Agricultural Science, 24 (2): 236-243.

30- **Rufato, L.; A. De Rossi; C. L. Giacobbo and Fachinello, J. C. 2002.** Vegetative propagation of seven quince cultivars for utilization as pear rootstocks in Brazil. In: I International Symposium on Rootstocks for Deciduous Fruit Tree Species, 658: 667-671.

31- **Sardoei, A. S.2014.**Effect of different media of cuttings on rooting of guava (*Psidium guajava* L.). European Journal of Experimental Biology, 4 (2): 88–92.

32- **Sebastiani, L. and R. Tognetti. 2004.** Growing season and hydrogen peroxide effects on root induction and development in *Olea europaea* L. (cvs "Frantoio" and 'Gentile di Larino') cuttings. Scientia Horticulturae, 100(1–4): 75–82. doi: 10.1016/j.scienta.2003.08.008.

33- **Shaukat, S.; A. S. Khan; M. Hussain; M. Kashif and Ahmad, N. 2018.** Evaluation of spring wheat genotypes for heat tolerance using cell membrane thermostability. International Journal of Biosciences, 12 (5): 291-296. DOI: 10.12692/ijb/12.5.291-296

34- **Silva, B. M.; P. B. Andrade; P. Valentão; F. Ferreres; R. M. Seabra and Ferreira, M. A. 2004.** Quince (*Cydonia oblonga* Miller) fruit (pulp, peel, and seed) and jam: antioxidant activity. Journal of Agricultural and Food Chemistry, 52(15): 4705-4712. DOI: 10.1021/jf040057v

35- **Singh, K. K.; J. M. S. Rawat and Tomar, Y. K. 2011.** Influence of IBA on rooting potential of torch glory Bougainvillea glabra during winter season. Journal of Horticultural Science and Ornamental Plants, 3(2): 162-165.

36- **Sousa, C. M.; R. N. Busquet; M. A. D. S. Vasconcellos and Miranda, R. M. 2013.** Effects of auxin and misting on the rooting of herbaceous and hardwood cuttings from the fig tree. Revista Ciência Agronômica, 44(2): 334-338. DOI: 10.1590/S1806-66902013000200016