The rooting capacity of red tip photinia; *Photinia* × *fraseri* hardwood cuttings under the effects of cutting time and IBA concentration

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Abstract

The experiment was conducted at the lath house in the nursery of Bakrajo Technical Institute campus, Sulaimani Polytechnic University, Bakrajo, Sulaimani city, Iraq, during 2021-2022, in order to study the effect of the date of taking cuttings (October 15th, November 15th, and December 15th) and IBA (Indole-3-butyric acid) concentration (0, 2000, 4000 and 6000 mg. L^{-1}) on rooting, some vegetative and root growth characteristics of red tip photinia, *Photinia x fraseri*. A two-factor experiment was carried out according to a complete randomized design (CRD) with three replications. The results showed that the cuttings taken on November 15th were significantly superior in most of the studied parameters; rooting percentage (10.0%), shoot length (7.00 cm), number of shoots per plant (1.0), number of leaves per plant (5.0), average leaf area (21.07 cm^2), shoot fresh weight (1.32 g), shoot dry weight (0.39 g), shoot diameter (1.95 mm), longest root (7.33 cm), average root number per plant (1.67), root fresh weight (0.55 g) and root dry weight (0.20 g). While, IBA at 6000 mg. L^{-1} caused significant differences in most of the previously mentioned parameters, giving the values 43.33%, 25.67, 1.67, 15.33, 77.28, 13.61, 5.39, 4.31, 27.33, 6.33, 2.48, and 0.71 respectively. Additionally, the interaction between the three cutting times; (October, November and December) and four concentrations of IBA; (0, 2000, 4000, 6000 mg. L^{-1}), the interaction of concentration 6000 mg. L^{-1} of IBA and the date November 15th showed significant superiority in all studied parameters.

Keywords: Rooting, *Photinia* cttings, Cutting time, IBA concentration

Introduction

Red tip photinia (*Photinia x fraseri*) is an evergreen shrub that gets its name from the striking red color of its young leaves, which change to dark green as they mature. the hybrid plant is a cross between *Photinia glabra* (Japanese photinia) and *Photinia*

serratifolia (Chinese Photinia) [1]. Photinia is a genus of about 40-60 species of small trees and large shrubs [2]. Photinia is an important woody landscape plant used for hedging and screening in the USA [3]. The normal propagation technique of photinia is by rooting the apical cuttings with high concentrations of plant growth regulators [4].

Photinia is a woody decorative plant species in which vegetative propagation by traditional strategies is inefficient since cuttings of this species are shown to be troublesome to root [5]. Cutting may be the easiest and least expensive technique for mass propagation and production of plants, in addition, the plants are genetically uniform and almost like their parent. Auxins increase the number of rooted cuttings and reduce the cuttings mortality rate within the nursery [6]. It was found that choosing an appropriate media is a vital step in propagation, and sand is a cheaper and more suitable medium for hardwood cuttings [7]. Auxins will have an effect on the physiological events of plant growth and differentiation such as rooting [4]. In the propagation of photinia by stem cutting, softwood semi-hardwood, and hardwood cuttings are used. Hardwood cuttings are better, because they are simple to prepare, are not promptly perishable whenever growing [8].

Due to some reasons, rooting of photinia cuttings is not perpetually readily (difficult-to root), additionally, biochemical factors might influence the rooting of these cuttings. Also, factors like cultivar, age of container tree, collection date, cuttings length, degree of hardening of the cuttings, wounding, heat treatment and concentration of auxin-like compounds may influence rooting on the cuttings [9,10]. In addition, cultural practices such as time of year, media temperature, light level, air temperature, and misting have been found to promote the extrinsic rooting of stem cuttings [10]. Moreover, rooting on hardwood cuttings improved by applying synthetic auxin, and the most frequently used auxin is IBA [11]. The optimal rooting response of cuttings usually occurs when auxin is supplied immediately after cutting preparation, as even cuttings from plants of the same species can vary depending on their requirements for maximum auxin concentration and method of preparation in order to root successfully [12]. Application of indole-3-butyric acid (IBA) concentration, date of cutting collection, can affect and promote root formation in the cuttings of some genotypes [13].

The objectives of the present study are to evaluate the efficiency of different dates to take the cuttings of *Photinia x fraseri* stem cuttings to develop adventitious roots. Also to study the effect of different concentrations of IBA in combination with IBA substrates in root development.

Material and Methods

Source of cuttings

Cuttings of Fraser's Photinia (*Photinia x fraseri*) were collected with the help of sterilized pruning shears from healthy shrubs in the campus gardens of University of Sulaimani.

Preparing of cuttings

One-year-old cuttings were prepared with 20±2cm in length and 1±0.2cm in diameter with a slanted top of the cuttings, 1 cm from the top node and the lower part was perpendicular, exactly located under the lower node.

Site management and rooting medium

The experiment filed was located at the lath house in the nursery of Bakrajo Technical Institute campus, Sulaimani Polytechnic University, Bakrajo, Sulaimani city, Iraq, with 35° 32' N, 45° 21' E) and 743 meters above sea level. Cuttings were planted in plastic pots, filled with river sand rooting medium. During the rooting period, cuttings were maintained, watering regulated under intermittent mist using an overhead boom irrigation system, and when the cold time began, the lath house was covered tightly by plastic sheets in the form of spending.

Experimental design setup

An experiment was conducted using a completely randomized design (CRD) with three replications. Each treatment included 30 cuttings and each replication contained 10 stem cuttings, and 120 treated cuttings were cultivated directly in a big plastic pot.

Application of the treatments

Cutting collection time

In the middle of every month, 120 stem cuttings were collected from a healthy shrub in October, November and December 2021. Some parameters of the meteorological conditions during the sampling periods were presented in Table 1.

Table (1): Some of the meteorological conditions during the sampling periods 2021 [14].

Measurements	October	November	December
Temperature (ºC)	25.40	14,4	9.30
Relative Humidity (%)	16.31	39.79	58.91
Total Rainfall (mm)	0.00	32.56	81.86

IBA (Indole-3-butyric acid) concentration

Monthly cuttings were prepared. After dissolving IBA powder into (distilled water + ethyl alcohol 95% 1:1 v/v), 2 cm of the cutting bases were quickly dipped for 10 seconds into IBA solutions with various concentrations of 2000, 4000 and 6000 mg. L^{-1}. At the same time, control cuttings were planted after quick dipping in a solution of (distilled water + alcohol) without IBA.
The treatments were denoted as mentioned in Table 2 below:

Table (2): The cuttings of red tip photinia, *Photinia x fraseri* treatments as symbollized in the experiment.

Cutting collection and cultivating time	Symbol		IBA concentration	Symbol		Interaction treatments		
			Control	C0		D1C0	D1C0	D1C0
October 15th	D1		2000 mg. L^{-1}	C1		D1C1	D1C1	D1C1
November 15th	D2		4000 mg. L^{-1}	C2		D1C2	D1C2	D1C2
December 15th	D3		6000 mg. L^{-1}	C3		D1C3	D1C3	D1C3

Data collection:

At the mid of July 2022, all data were collected and three plants (cuttings) were selected randomly from each treatment to record all required data on quantity and quality parameters.

Studied parameters of the cuttings with their abbreviations:

The following parameters were measured for each cutting:

Rooting percentage: calculated by using the equations 1 [15], and 2 [16]:

$$\text{Rooting\%} = \left(\frac{number\ of\ rooting\ cuttings}{total\ number\ of\ cuttings}\right) * 100 \quad [1]$$

Shoot length (SL) (cm): measured with measuring tape in centimeters.

Shoot fresh weight (SFW) (g): the weights of the vegetative system of the cuttings were measured by a digital balance directly after washing off any loose dust, then removing any free surface blot moisture.

Shoot dry weight (SDW) (g): after drying the vegetative shoots in an oven at 70 °C for 48 hrs, their dry weights were recorded in grams.

Number of branches per cutting (NB): recorded by visually counting.

Number of leaves per cutting (NL): recorded by visual counting.

Average leaf area (ALA) (cm^2): measured by using a software program application (Digimizer image analysis) (https://www.digimizer.com/); downloaded on the personal computer, and based on image analysis by determining the dark spot of the leaves images [17].

Shoot diameter (SD) (mm), measured by using a Vernier caliper.

Longest root (LR) (cm): in any rooted cutting, the longest root was taken and measured in centimeters using a measuring tape.

Number of roots per cutting (NR): in the rooted cuttings, the overall roots were counted.

Root fresh weight (RFW) (g): weighted by a digital balance directly after the roots were removed from the soil and washed off any loose soil, then removed face blot moisture.

Root dry weight (RDW) (g): after an overnight drying of the roots in an oven set at 70 °C, their dry weights were taken.

Seedling Quality Index (SQI): was calculated as follows:

$$\text{The seedling quality index (SQI)} = \frac{Total\ seedling\ dry\ weight}{\left(\frac{height(cm)}{diameter(mm)}+\frac{shoot\ dry\ weight(g)}{root\ dry\ weight(g)}\right.} \quad [2]$$

Statistical analysis:

The effects of the treatments on the measured parameters, which were obtained and expressed as averages were evaluated by Analysis of Variance (ANOVA), significance difference was analyzed by Duncan's multiple comparison tests ($P \leq 0.05$). The whole data processing was completed via XLSTAT 2016 data analysis program for Windows software (https://www.xlstat.com) [18].

Results and Discussion

Rooting%

At the end of the study, according to the values of the rooting percentage stated in Figure 1, the cuttings of red tip photinia *Photinia x fraseri* which collected on November 15th (D2) gave higher significant values than that collected on October 15th (D1) and December 15th (D3), rooting percentages on October 15th (D1), November 15th (D2) and December 15th (D3), were 6.33, 10.00 and 3.33%, respectively.

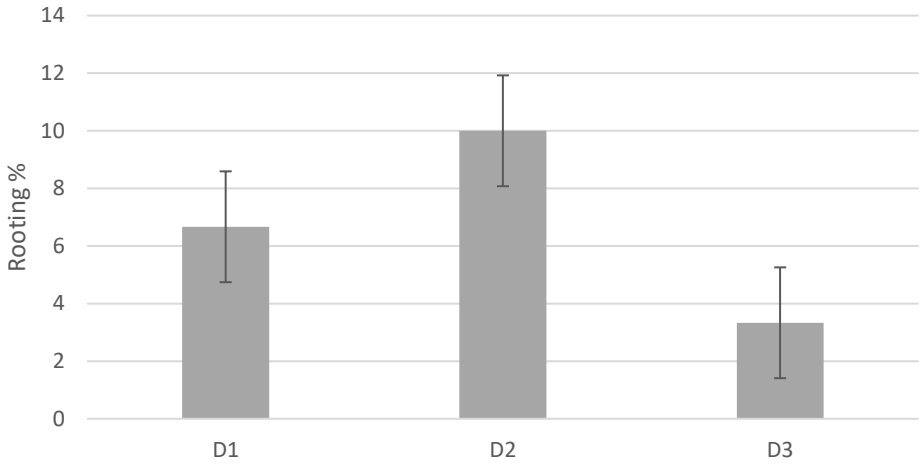

Figure (1): Effect of cutting collection time on rooting percentage of red tip photinia *Photinia x fraseri*.

Based on statistical evaluation, the IBA concentration in the different collection times of the cuttings had important effects on the rooting rates of red tip photinia *Photinia x fraseri* cuttings. The data shown in Figure 2a indicated that the cuttings collected on October 15th (C3) and immersed in 6000 mg. L^{-1} concentration of IBA for 10 seconds; the rooting% was significantly increased to 26.67% as compared to control (C0) with 6.67%, IBA 2000 (C1) with 10.00% and IBA 4000 mg. L^{-1} (C2) with 13.33%.

Also on November 15th (Figure 2b); the following values were resulted: C0 10.00%, C1 (13.33%), C2 (33.33%) and C3 (43.33%), while on December 15th (Figure 2c), the results were 3.33, 10.00, 20.00 and 33.33%, respectively for control (C0), 2000 (C1), 4000 (C2) and 6000 mg. L^{-1} IBA (C3).

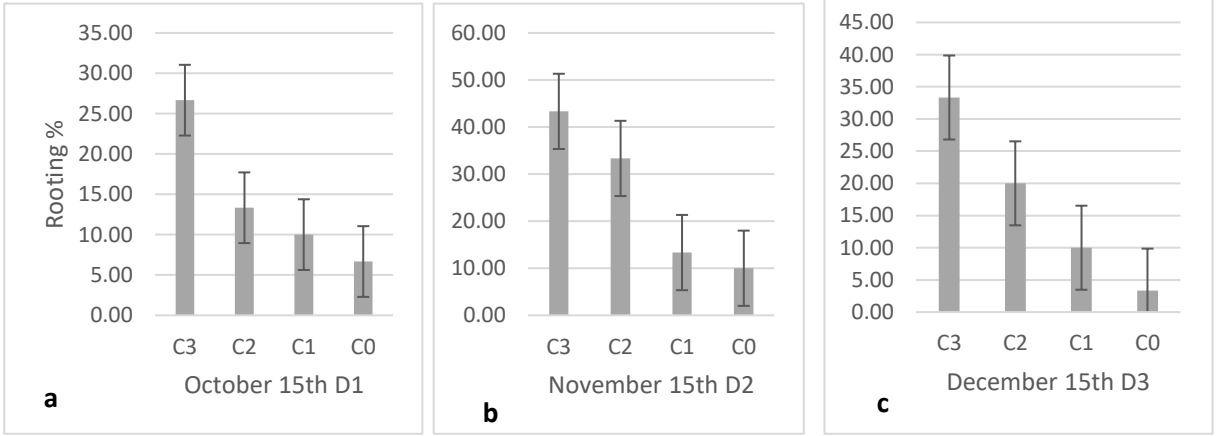

Figure (2): Effect of IBA concentration and cutting collection time on rooting percentage of red tip photinia *Photinia x fraseri*.

The data presented in (Figure 3) for red tip photinia, show that the average of rooting percentage was affected by combination of cutting collection time and IBA concentration ranged from 3.33 to 43.33%. The highest percentage occurred with interaction of

cuttings collected on November 15th and quickly dipped into IBA solution with concentration 6000 mg. L^{-1} (D2C3) and the lowest percentage was resulted from cuttings collected on December 15th control (D3C0).

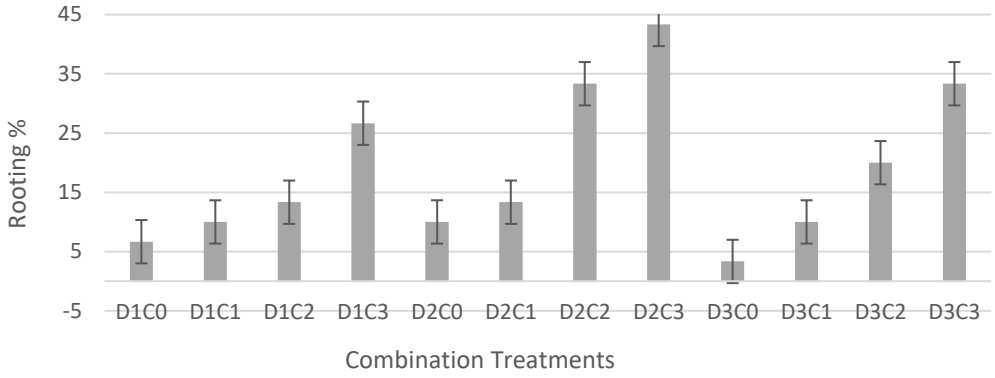

Figure (3): Combination effect of cutting collection time and IBA concentration on rooting percentage of red tip photinia *Photinia x fraseri* cuttings.

Vegetative growth parameters:

Table (3) denotes that mong all collection times; differences in all parameters were significant, in which the values were increased significantly in cuttings collected on November 15th (D2), in which the following results were obtained: SL (7.00 cm), NB (1.0), NL (5.0), ALA (21.07 cm^2), SFW (1.32 g), SDW (0.39 g) and SD (1.95 mm). However, the lowest values of SL (1.33 cm), NB (0.33), NL (1.33), ALA (5.08 cm^2), SFW (0.21 g), SDW (0.07 g) and SD (0.79 mm) were resulted in cuttings collected on December 15th (D3).

Table (3)*: Effect of cutting collection time on studied seedling growth parameters of red tip photinia *Photinia x fraseri.*

Treatments	SL	NB	NL	ALA	SFW	SDW	SD
D1	5.00 a	0.67 a	3.33 a	14.03 b	0.65 ab	0.21 ab	1.95 a
D2	7.00 a	1.00 a	5.00 a	21.07 a	1.32 a	0.39 a	2.84 a
D3	1.33 b	0.33 a	1.33 b	5.08 c	0.21 b	0.07 b	0.79 a
SE**	1.337	0.385	1.805	6.112	0.273	0.209	0.367

* Values followed by the same letter within each column did not differ significantly (P≤0.05) according to Duncan's multiple range tests.

** Standard error of the means.

It is clear from Table (4) that in different collection times of cuttings, treatments of IBA concentration were effective significantly in a positive manner and increased all vegetative and root growth parameters, which differed according to the concentration of IBA solution as compared to controls. It is clear that on October 15th (D1), the highest values were obtained from C3 with (11.333 cm, 1.000, 8.00, 38.08 cm^2, 3.20 g, 1.24 g and 3.770 mm) for SL, NB, NL, ALA, SFW, SDW and SD, respectively, while the lowest values (5.000 cm, 0.667, 3.33, 14.03 cm^2, 0.65 g, 0.21 g and 1.953 mm) were recorded from control (C0).

On November 15th (D2), Table 4 denotes to the advanced values 25.67, 1.67, 15.33, 77.28, 13.61, 5.39, and 4.310 were back to (C3), as compared to control values (C0) giving 7.000, 1.00, 5.000, 21.07, 1.32, 0.39, and 2.84. While on December 15th (D3), the greatest values were back to C3 as (16.33, 1.00, 10.67, 43.20, 5.751, 2.237, and 4.47) compared to the smallest values for C0 with (1.333, 0.333, 1.333, 5.080, 0.209, 0.067 and 0.793) for each of SL (cm), NB, NL, ALA (cm^2), SFW (g), SDW (g), and SD, respectively.

Table (4)*: Effects of IBA concentration on studied cuttings vegetative growth parameters of red tip photinia *Photinia x fraseri* taken in different cutting collection times

Treatments		SL	NB	NL	ALA	SFW	SDW	SD
D1	C3	11.33a	1.00a	8.00a	38.08a	3.20a	1.24a	3.77a
	C2	8.17ab	1.00a	6.0ab	27.15a	1.65b	0.66b	2.97ab
	C1	7.67ab	1.00a	6.00ab	26.46a	1.59b	0.50b	3.77a
	C0	5.00 b	0.67a	3.33b	14.03b	0.65c	0.21c	1.95b
	SE**	1.893	0.369	1.247	5.199	0.289	0.111	0.720
D2	C3	25.67a	1.67a	15.33a	77.28a	13.61a	5.39a	4.31b
	C2	15.50b	1.33a	9.67b	48.37b	5.21b	2.21b	6.28a
	C1	6.830c	1.00a	5.67c	24.31c	1.41c	0.43c	3.01c
	C0	7.000c	1.00a	5.00c	21.07c	1.32c	0.39c	2.84c
	SE**	1.074	0.333	0.811	2.380	0.649	0.259	0.224
D3	C3	16.33a	1.00a	10.67a	43.20a	5.75a	2.24a	4.47a
	C2	13.67a	1.00a	9.00a	35.64a	4.14b	1.69b	3.99ab
	C1	4.83b	1.00a	4.67b	17.93b	0.83c	0.26c	2.68b
	C0	1.33b	0.33b	1.33c	5.08c	0.21c	0.07c	0.79c
	SE**	1.624	0.234	1.354	4.707	0.346	0.140	0.591

* Values followed by the same letter within each column did not differ significantly (P≤0.05) according to Duncan's multiple range tests.

** Standard error of the means.

It is evident from data presented in Table (5) that the vegetative growth parameters of red tip photinia; SL (cm), NB, NL, ALA (cm^2), SFW (g), SDW (g) and SD were affected by the combination of cutting collection times with IBA rooting hormone concentrations, in which D2C3 gave the superior values in all vegetative growth parameters; SL (cm), NB, NL, ALA (cm^2), SFW (g) and SDW (g), giving the values 25.67, 1.67, 15.33, 77.28, 13.61, and 5.39, respectively, while the greatest SD value (4.31 mm) was noticed from D2C2, as compared to the remainder combinations.

Table (5)*: Effect of cutting collection time and IBA concentration on studied seedling vegetative growth parameters of red tip photinia *Photinia x fraseri*

Treatments	SL	NB	NL	ALA	VFW	VDW	SD
D1C0	5.00e	0.67cd	3.33fg	14.03f	0.65de	0.21fg	1.95e
D1C1	7.67e	1.00bc	6.00de	26.46de	1.59d	0.50ef	3.77bcd
D1C2	8.17de	1.00bc	6.00def	27.15de	1.65d	0.66e	2.10cde
D1C3	11.33cd	1.00bc	8.00cd	38.08c	3.20c	1.24d	3.77bcd
D2C0	7.00e	1.00bc	5.00ef	21.07ef	1.32d	0.39efg	2.84cde
D2C1	6.83e	1.00bc	5.67def	24.31e	1.41d	0.43efg	3.01cde
D2C2	15.50b	1.33ab	9.67bc	48.37b	5.21b	2.21b	6.28a
D2C3	25.67a	1.67a	15.33a	77.28a	13.61a	5.39a	4.31b
D3C0	1.33f	0.33d	1.33g	5.08g	0.21e	0.07g	0.79f
D3C1	4.83e	1.00bc	4.67ef	17.93ef	0.83de	0.26efg	2.68de
D3C2	13.67bc	1.00bc	9.00bc	35.64cd	4.14c	1.69c	3.99bc
D3C3	16.33b	1.00bc	10.67b	43.20bc	5.75b	2.24b	4.47b
SE**	1.568	0.272	1.163	4.276	0.456	0.179	0.553

* Values followed by the same letter within each column did not differ significantly (P≤0.05) according to Duncan's multiple range tests.
** Standard error of the means.

Root growth parameters

Statistical significances of the effect of collection times are shown in (Table 6). The results differ among October 15th (D1), November 15th (D2), and December 15th (D3), significantly resulting in the most measured parameters of roots. While the highest values in cuttings collected on November 15th (D2) were LR (7.33 cm), NR (1.67), RDW (0.20 g). Whereas the lowest values of LR (2.5 cm), NR (0.67), RFW (0.22 g) and RDW (0.10 g) were observed from cuttings collected on Decembe 15th (D3).

Table (6)*: Effect of cutting collection time on studied roots growth parameters of red tip photinia *Photinia x fraseri*

Treatments	LR	NR	RFW	RDW
D1	4.83 ab	1.00 b	1.03 a	0.14 a
D2	7.33 a	1.67 a	0.55 b	0.20 a
D3	2.50 b	0.67 b	0.22 b	0.10 a
SE**	2.884	0.415	0.381	0.106

* Values followed by the same letter within each column did not differ significantly (P≤0.05) according to Duncan's multiple range tests.
** Standard error of the means.

It is clear from Table (7) that on different collection times of cuttings, treatments of IBA concentration were effective significantly in positive manners and increased all

vegetative and root growth parameters, which differed according to the concentration of IBA solution as compared to controls, mostly on October 15th (D1), in which the highest values were recorded in C3 (21.67, 3.00, 1.77 and 0.50) for LR (cm), NR, RFW (g), and RDW (g), respectively, while the lowest values 4.83, 1.00, 3.33, 1.03 and 0.142 were observed from control (C0).

On November 15th (D2), table (7) also shows that the advanced values (27.33, 6.33, 2.48, and 0.71) were noticed from (C3), as compared to control (C0) values (7.333, 1.67, 0.55 and 0.20). While on December 15th (D3), the greatest values were recorded from C3 as (11.83, 1.00, 1.15 and 0.35) as compared to the smallest values (2.50, 0.33, 0.22 and 0.10) which were recorded from control (C0) for each LR (cm), NR, RFW (g), and RDW(g), respectively.

Table (7)*: Effect of IBA concentration on studied cuttings root growth parameters of red tip photinia *Photinia x fraseri*, cuttings collected on different times

Treatments		LR	NR	RFW	RDW
D1	**C3**	21.67 a	3.00 a	1.77a	0.50 a
	C2	14.17 b	2.67 a	1.35a	0.42 ab
	C1	8.83 c	2.67 a	1.59a	0.32 b
	C0	4.83 c	1.00 b	1.03a	0.142 c
	SE**	2.312	0.527	0.382	0.071
D2	**C3**	27.33 a	6.33a	2.48a	0.71a
	C2	17.33 b	4.33b	1.73b	0.52b
	C1	10.33 c	2.33c	1.09c	0.36c
	C0	7.33 c	1.67c	0.55d	0.20d
	SE**	1.983	0.471	0.060	0.050
D3	**C3**	11.83 a	1.00 a	0.93 a	0.27 ab
	C2	11.83 a	1.00 a	1.15 a	0.35 a
	C1	9.00 a	1.00 a	1.13 a	0.38 a
	C0	2.50 b	0.33 b	0.22 b	0.10 b
	SE**	1.986	0.624	0.160	0.083

* Values followed by the same letter within each column did not differ significantly (P≤0.05) according to Duncan's multiple range tests.

** Standard error of the means.

It is evident from data presented in Table (8) that the root growth parameters of red tip photinia; Longest Root (LR) (cm), Number of Roots per plant (NR), Root Fresh Weight (RFW) (g) and Root Dry Weight (RDW) (g) were affected by combination of cutting collection times with IBA rooting hormone concentrations. Results indicate that (D2C3) had superior values in all of the vegetative growth parameters; Longest Root (LR) (cm), Number of Roots per plant (NR), Root Fresh Weight (RFW) (g) and Root Dry Weight (RDW) (g) giving the values (27.33, 6.33, 2.48 and 0.71), respectively, as compared to all of the other combination factors between cutting collection times and IBA solution concentrations.

Table (8)*: Effect of cutting collection time and IBA concentration on studied seedling's root growth parameters of red tip photinia *Photinia x fraseri.*

Treatments	LR	NR	RFW	RDW
D1C0	4.83fg	1.00 e	1.03de	0.14 fg
D1C1	8.83ef	2.67 cd	1.59bc	0.32 de
D1C2	14.17cd	2.67 cd	1.35bcd	0.42 bcd
D1C3	21.67 b	3.00 c	1.77 b	0.50 bc
D2C0	7.33 ef	1.67 de	0.55 ef	0.20 efg
D2C1	10.33 de	2.33 cd	1.09 cd	0.36 bcd
D2C2	17.33 c	4.33 b	1.73 b	0.52 b
D2C3	27.33 a	6.33 a	2.48 a	0.71 a
D3C0	2.50 g	0.67 e	0.22f	0.10 g
D3C1	9.00 ef	2.67 cd	1.13 cd	0.38bcd
D3C2	11.83 de	2.67 cd	1.15 cd	0.35cde
D3C3	11.83 de	2.33 cd	0.93 de	0.27def
SE**	2.099	0.544	0.242	0.108

* Values followed by the same letter within each column did not differ significantly (P≤0.05) according to Duncan's multiple range tests.
** Standard error of the means.

Seedling Quality Index (SQI)

Seedlings quality index was calculated, and the results shown in (Figure 4) which shows that seedlings of red tip photinia *Photinia x fraseri* grown from cuttings obtained on November 15th and treated with 6000 and 4000 mg. L^{-1} IBA (D2C3 and D2C2) have significant differences with (0.40, 0.45), respectively compared to all other treatments. While the lowest values (0.09 and 0.07) were observed from the treatment combinations D1C0 and D3C0, respectively.

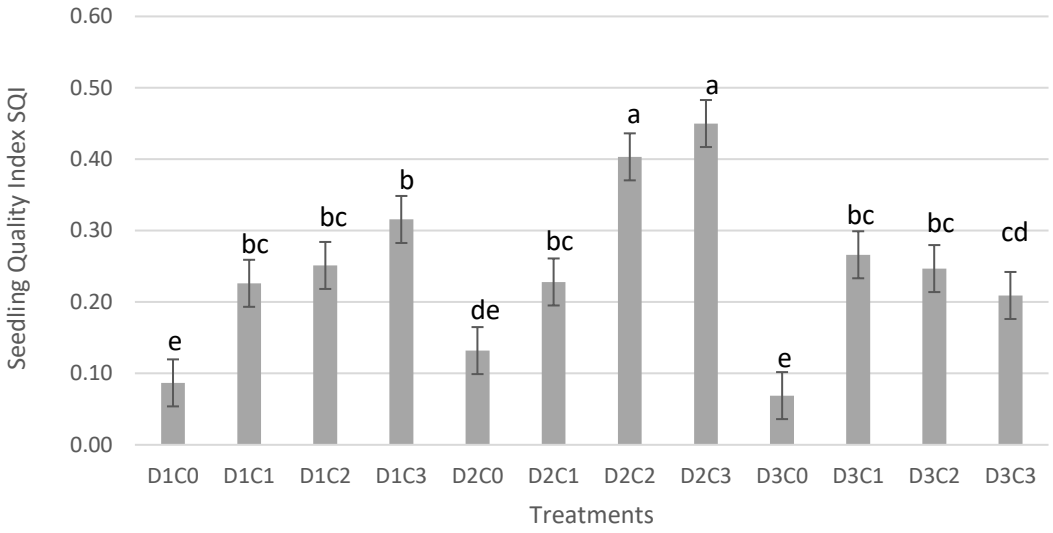

Figure (4): Effect of cutting collection time and IBA concentration on Seedlings Quality Index in red tip photinia *Photinia x fraseri*

In the present study, rooting response varied with cuttings' collection date, Fig. 1 showed that cuttings collected on November had the highest level and significantly increased rooting percentage by 10.00% compared to cuttings collected on October 6.67% and December 3.33%, these results agreed with the results reported by [6,19]. Cutting collection time is one of the most important factors that have a great effect on rooting stem cuttings, as well as has an effect on characters of both the shoot system and root system of cuttings [20].

Seasonal variation in rooting efficiency has been reported previously for cuttings of several other plants and is attributed to cuttings' initial physiological characteristics [21, 22, 23].

Several studies had reported that the effective action in the process of adventitious root formation can be influenced by a series of internal and external factors. Among internal factors, the most important role goes to phytohormones, especially the auxins, is attributed [12, 24, 25, 26, 27]. It is generally believed that auxin have a particular role in root initiation [28].

The results of root formation percentage (Figure 2) in this study, it was revealed a high impact of IBA concentrations on rooting rate, with positive effects in the high concentration of 6000 mg. L^{-1} in all different times, however, the rooting percentage reached the highest values 26.67, 43.33, 33.33% for October, November and December, respectively, while the smallest rate 6.67, 10.00, 3.33% in the same order of time. The results in Figures 2, and 3 were in line with the results reported [29, 30].

The results agree with the explanation given by [23] that there are possibly other simulating factors affecting rooting activities. Furthermore, it can be conjecturable that exogenously applied auxin possibly alter the concentration of endogenous hormones and thus the original balance among endogenous hormones is replaced by the new balance beneficial to root formation.

The increase in percent rooting upon IBA treatment can be attributed to the fact that IBA helps in the elongation of meristematic cells and root differentiation [31]. Although, there are conflicting reports on the comparison of the effects of IBA on rooting.

An increase in the number and length of roots of treated cuttings enhanced shoot development, as it improved nutrition and water utilization [32]. The relationship between the rate of root formation or the number of adventitious roots and the onset of axillary bud growth indicated that some factors were transported to the stem and axillary buds by adventitious roots [33]. The role of growth regulators in the production of plants via cuttings was previously reported on many plant species [34]. Rooting response varied with cuttings' collection date (Tables 3, and 6). Among the detected vegetative and rooting characters, number of branches per plant, shoots diameter and roots dry weight did not differ significantly among the three collection periods, but the differences in all characters of leaf area, number of roots and root fresh weight for rooted cutting were significant. IBA efficiently enhanced the growth parameters, and the Seedling Quality Index of red tip photinia *Photinia x fraseri*, (Tables 4, 7 and Fig. 4). Most of seedlings and plants profit from the relations with auxins ratio contents in the plant and the nature of this relationship, i.e., positive to negative, greatly depends on the environmental conditions. It also stimulates the vegetative growth of plants, namely increasing height, and diameter, stimulating the formation of leaf seedlings and can make plants greener because it is a constituent of chlorophyll.

Cutting time and concentration of IBA can be used to enhance the cuttings of red tip photinia *Photinia x fraseri*, and allow rooting activity. The best treatments were 4000 mg. L^{-1} and 6000 mg. L^{-1} of IBA concentration for cuttings taken on November 15th, which had the longest shoot (SL) and root (RL), greatest number of roots (NR), leaves (NL), average leaf area (ALA), also the best results in fresh and dry weights of vegetative and roots part (SFW, SDW, RFW and RDW). Furthermore, it has a best result in the quality index of seedlings.

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