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Effects of IBA concentrations on the rooting and growth of Cherry laurel (*Prunus laurocerasus* L.) cuttings

Ercan Oktan[a,*], Öznur Özkan[b], Neslihan Atar[b]

Abstract: This study was conducted to investigate the effects of different indole-3-butyric acid (IBA) concentrations on the rooting and subsequent sapling growth performance of cherry laurel (*Prunus laurocerasus* L.) cuttings under greenhouse and outdoor conditions. The cuttings were treated with four different hormone concentrations (0, 1000, 5000, and 8000 ppm IBA), and parameters including rooting success, root length, root collar diameter, and sapling height were evaluated. ANOVA and Duncan's multiple range test were applied at a 5 % significance level for statistical analysis of the data. The results indicated that hormone concentration had a statistically significant effect on root length (p=0.007), with the highest mean value obtained from the 1000 ppm treatment (29.81 cm), which was approximately 27 % higher than the control group. No significant difference was observed among groups in terms of root number (p>0.05). The highest root collar diameter was achieved with the 1000 ppm IBA treatment (6.77 mm), representing a 38 % increase compared to other treatments. Measurements taken on June 19, 2023, showed that hormone concentration had significant effects on root collar diameter and sapling height, while this effect was found to diminish by December 8, 2023. These findings demonstrate that IBA applications enhance the early rooting and adaptation success of cherry laurel cuttings, making them an important tool for sustainable and high-quality sapling production.
Keywords: Auxin, IBA, *Prunus laurocerasus*, Rooting, Root collar diameter, Sapling height, Vegetative propagation

1. Introduction

Global climate change has become one of the most significant environmental challenges today due to increasing greenhouse gas emissions and ecosystem degradation. Sustainable forestry practices play a crucial role in mitigating these impacts by enhancing carbon sequestration and preserving biodiversity (IPCC 2013). Cherry laurel (*Prunus laurocerasus* L.), a species that stands out with its evergreen foliage and high ecological adaptability, provides significant ecosystem services such as carbon storage capacity and erosion control (Kolaylı et al. 2003).

Cherry laurel is a valuable species that occurs naturally in Türkiye, particularly in the Black Sea region, and is also cultivated as an ornamental plant. Its dense foliage makes it a preferred species in landscape design. Moreover, the fruits and leaves, which possess strong antioxidant properties, present considerable economic potential as non-wood forest products. The fruits are rich in phenolic compounds, flavonoids, vitamins, and minerals that have immunomodulatory, anti-inflammatory, and cardioprotective effects (Halilova and Ercişli 2010). Traditionally, cherry laurel fruits have been used in folk medicine to treat digestive disorders, diabetes, and various inflammatory diseases. These properties reveal that cherry laurel is valuable not only ecologically but also in pharmaceutical and food industries.

Developing sustainable propagation techniques is essential for the conservation of natural populations and the expansion of this species. Cutting propagation stands out as a preferred method due to its advantages in ensuring genetic homogeneity and rapid sapling production. Auxin-based hormones, in particular, improve propagation efficiency by enhancing rooting success (Kumlay and Eryiğit 2011). The aim of this study is to reveal the growth and development differences of cherry laurel saplings and to evaluate the potential of hormone-assisted cutting propagation. The findings are expected to contribute to the sustainability of the species and shed light on its ecological and economic benefits in the context of climate change.

2. Materials and methods

This study aimed to determine how the growth and development performance of cherry laurel saplings changes after different hormone treatments. The experiment was conducted at the Research and Application Greenhouse of Karadeniz Technical University in Trabzon, Türkiye.

2.1. Plant material and cutting preparation

Cherry laurel was used as plant material in the study. Hardwood cuttings were collected from healthy individuals located at the Kanuni Campus of Karadeniz Technical University in February 2022. The cuttings were prepared to be approximately 15 cm in length, with their basal ends cut obliquely 2–3 cm above the base, and their surfaces refreshed to facilitate rooting. To reduce water loss, leaves on the lower part of the cuttings were

[a] Department of Forestry, Karadeniz Technical University, Trabzon, Türkiye
[b] Department of Forestry, Artvin Çoruh University, Artvin, Türkiye
[*] Corresponding: oktan@ktu.edu.tr
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removed, and those on the upper part were shortened (Figure 1a).

2.2. Hormone treatments

To promote rooting, the basal ends of the cuttings were treated with indole-3-butyric acid (IBA) in powder form. The experiment consisted of four different hormone treatments:

Control (0 ppm)
1000 ppm IBA
5000 ppm IBA
8000 ppm IBA

Each treatment group included 45 cuttings, for a total of 180 cuttings. During the application, the basal ends of the cuttings were dipped into the hormone powder and then lightly shaken to remove any excess (Figure 1b).

2.3. Growing medium and conditions

The cuttings were initially planted in 100 % perlite and rooted under greenhouse conditions (Figures 1c and 1d). The temperature in the greenhouse was maintained at 25 °C, and humidity at approximately 70 %. Moisture levels were maintained through regular irrigation, and the rooting period lasted about four months. Rooted cuttings were then transplanted into polyethylene bags to be acclimatized under outdoor conditions (Figure 1e). The growing medium used in the bags consisted of a mixture of 20 % river sand, 40 % forest soil, and 40 % red soil.

2.4. Experimental design and statistical analysis

The experiment was conducted using a completely randomized design (CRD). Statistical analyses of the data obtained from the measurements were performed using IBM SPSS Statistics 23.0 software package. The effects of different hormone concentrations on growth and development parameters were tested using analysis of variance (ANOVA). Duncan's multiple range test was applied to determine significant differences among treatment groups.

2.5. Measured parameters

Various parameters were measured at different stages to evaluate the growth and development performance of cherry laurel saplings:
At the time of removal from the greenhouse: root length (cm), root collar diameter (mm), and root number.
After transplanting to outdoor conditions and during the follow-up period: root collar diameter (mm) and shoot height (cm).
After being transferred outdoors, the saplings were monitored for one year, and the measurements were taken at six-month intervals (Figures 1f and 1g).

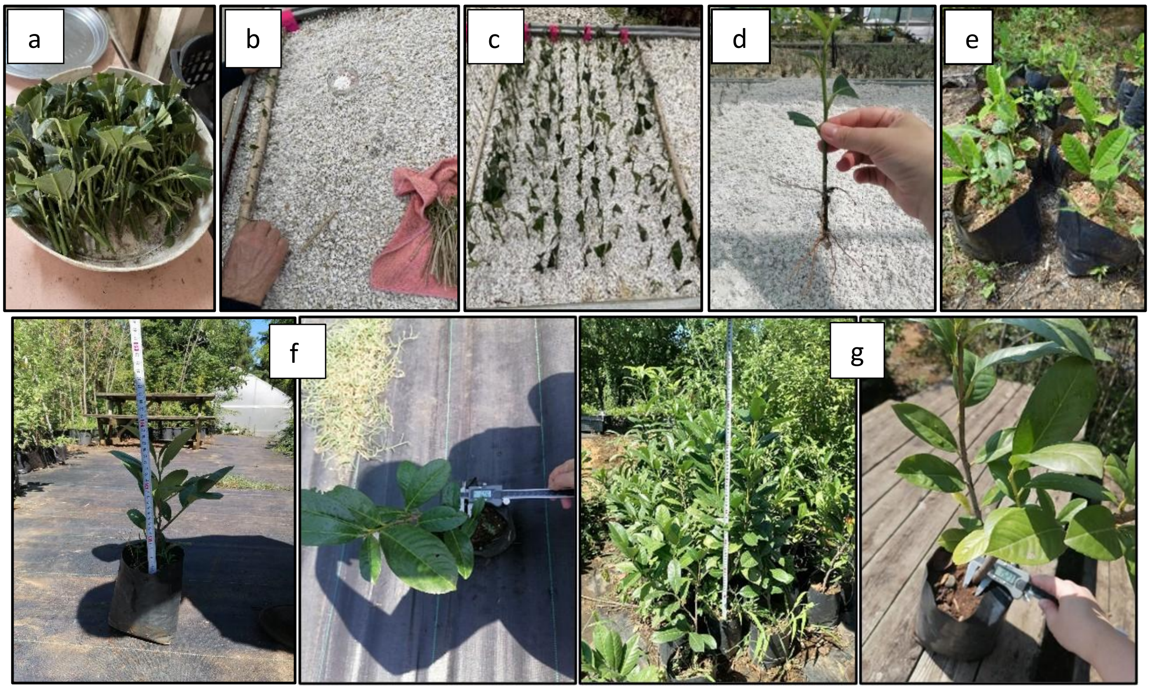

Figure 1. Hardwood cuttings of cherry laurel: (a) preparation of cuttings, (b) dipping in IBA powder, (c) planting in perlite medium, (d) observation of rooting data, (e) transplanting rooted cuttings into polyethylene bags for outdoor conditions, (f) first measurements taken on June 19, 2023, (g) second measurements taken on December 8, 2023.

3. Results and discussion

In this study, the effects of different hormone treatments on the rooting and sapling quality of cherry laurel were comprehensively examined during both the initial rooting period and at different time intervals throughout sapling development. The findings revealed that hormone concentration produced variable effects on different parameters of sapling growth. In the first stage, the normal distribution of the root length and root number data obtained from the cuttings was evaluated. Subsequently, analysis of variance (ANOVA) and Duncan's multiple range tests were applied to these variables, and statistical differences among groups were interpreted. In the sapling stage, root collar diameter and shoot height measurements taken on June 19, 2023, and December 8, 2023, were analyzed in terms of both periodic differences and overall trends ($\alpha = 0.05$).

3.1. Rooting and early growth findings

Measurements taken after the initial rooting stage indicated that the data for root length and root number followed a normal distribution, which was confirmed by the Kolmogorov–Smirnov test. This step is critical for assessing data suitability before proceeding with statistical analyses.

According to the Kolmogorov–Smirnov test results presented in Table 1, the root length data showed a normal distribution with $p>0.05$ ($p = 0.200$). This result allows for the use of parametric tests for root length data. Examination of the box plot in Figure 2 shows that the median value is centered, the lower and upper quartiles are symmetrically distributed, and only a few outliers are present. These outliers were not considered influential enough to affect the overall distribution, indicating a homogeneous data structure.

Similarly, according to the Kolmogorov–Smirnov test results presented in Table 2, the root number data also exhibited a normal distribution with $p>0.05$. The box plot in Figure 3 shows that the root number data are symmetrically distributed around the median, with no significant outliers. The balanced interquartile range further supports the homogeneity of root number data and confirms its suitability for parametric tests.

The results of the analysis of variance (ANOVA) regarding the effect of the hormone factor on root length are presented in Table 3. The analysis revealed a statistically significant difference among the groups ($p<0.05$). This finding indicates that the applied hormone concentrations had a significant effect on root length.

Table 1. Normality test for root length data.

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Root length	0.074	66	0.200*

a; p > 0.05 indicates that data are normally distributed (Lilliefors correction applied).

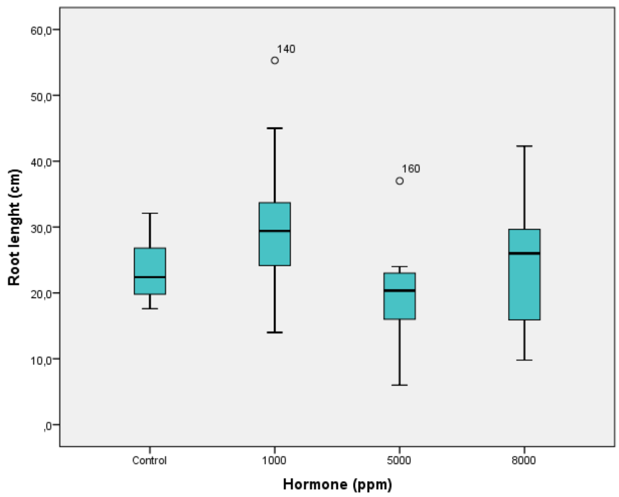

Figure 2. Box plot distribution of root length.

Table 2. Normality test for root number data.

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Root number	0.077	66	0.200*

a; p > 0.05 indicates that data are normally distributed (Lilliefors correction applied).

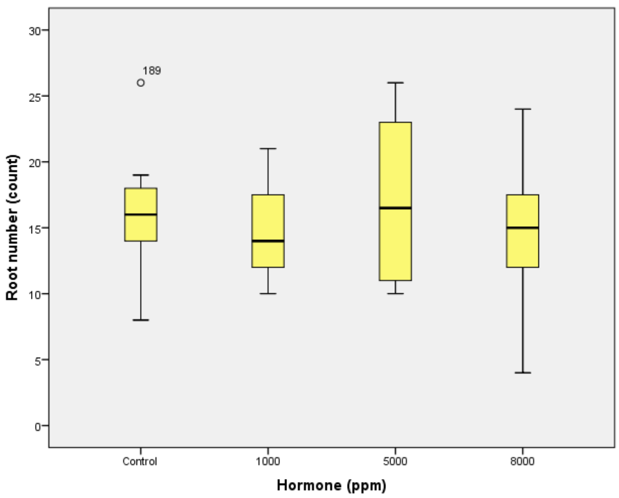

Figure 3. Box plot distribution of root number.

Table 3. Analysis of variance (ANOVA) results for the effect of hormone factor on root length.

	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	835.047	3	278.349	4.454	0.007
Within Groups	3874.483	62	62.492		
Total	4709.530	65			

**; p < 0.05 indicates a statistically significant difference among groups.*

To determine which groups accounted for these differences, Duncan's multiple range test was performed, and the results are presented in Table 4. According to Duncan's test, the highest mean value was obtained from the 1000 ppm IBA treatment, which formed a separate homogeneous group on its own. The control, 5000 ppm IBA, and 8000 ppm IBA treatments were included in the same homogeneous group and yielded similar values. Figure 4 graphically illustrates the changes in mean root length according to hormone concentrations, clearly showing that the 1000 ppm IBA treatment achieved the highest mean value. These findings are consistent with those reported in the literature. Aydın and Er (2023) found that the highest rooting rate and root length in softwood cuttings of sweet cherry rootstocks were obtained from the 1000 ppm IBA treatment. Similarly, Sekhukhune et al. (2024) reported that 1000 ppm IBA was the most effective concentration for promoting root development.

Table 4. Duncan's multiple range test results for hormone concentrations based on root length.

Hormone*	N	Subset for alpha = 0.05	
		1	2
5000	14	20.100	
Control	13	23.500	
8000	20	23.625	
1000	19		29.816
Sig.		0.241	1.000

**; Means for groups in homogeneous subsets are displayed. The harmonic mean sample size = 15.937. Group sizes are unequal, and the harmonic mean was used. Type I error levels are not guaranteed.*

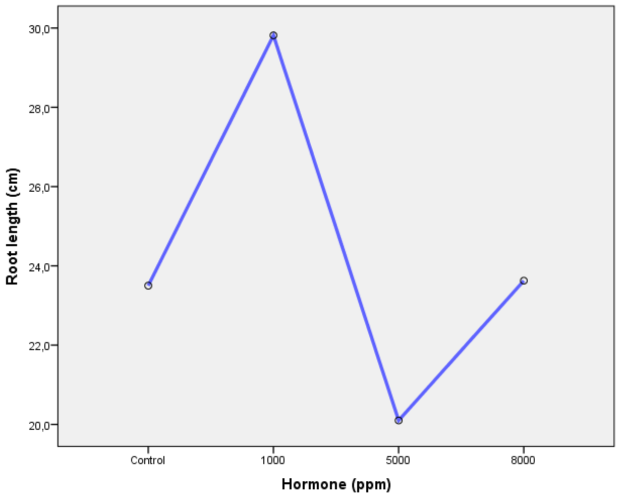

Figure 4. Changes in mean root length according to hormone concentrations.

According to the analysis of variance (ANOVA) results for root number, no statistically significant difference was found among the hormone concentration groups (p>0.05).

3.2. Sapling growth findings and time-series analysis

The effects of different hormone concentration on sapling growth were examined using measurements taken on two different dates as well as analyses based on all measurements combined.

3.3. Evaluation of all measurements

According to the overall analysis results, hormone concentration had a statistically significant effect on root collar diameter (p<0.001) (Table 5). Based on Duncan's multiple range test results, the 1000 ppm IBA treatment had the highest mean value at 6.77 mm and formed a separate homogeneous group. The control, 5000 ppm IBA, and 8000 ppm IBA treatments produced statistically similar results (Table 6). The ranking of mean values was 5000 ppm IBA < Control < 8000 ppm IBA < 1000 ppm IBA, and Figure 5 graphically presents the changes in mean root collar diameter according to hormone concentrations. The figure clearly shows that the 1000 ppm IBA treatment achieved the highest mean value, whereas the 5000 ppm IBA treatment resulted in the lowest value.

In contrast, no statistically significant difference was found among hormone treatments for the sapling height parameter (p>0.05). The mean height values ranged between 16.47–18.77 cm, with no apparent difference between the control group and hormone treatments. This finding suggests that sapling height is influenced not only by hormone application but also by genetic structure and environmental growing conditions.

Table 5. Analysis of variance (ANOVA) results for the effect of hormone factor on root collar diameter.

	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	88.626	3	29.542	8.814	0.000
Within Groups	599.923	179	3.352		
Total	688.549	182			

**; p < 0.05 indicates a statistically significant difference among groups.*

Table 6. Duncan's multiple range test results for hormone concentrations based on root collar diameter.

		Subset for alpha = 0.05	
Hormone*	N	1	2
5000	40	4.8940	
Control	33	5.4139	
8000	57	5.7000	
1000	53		6.7747
Sig.		0.052	1.000

**; Means for groups in homogeneous subsets are displayed. The harmonic mean sample size = 43.613. Group sizes are unequal, and the harmonic mean was used. Type I error levels are not guaranteed.*

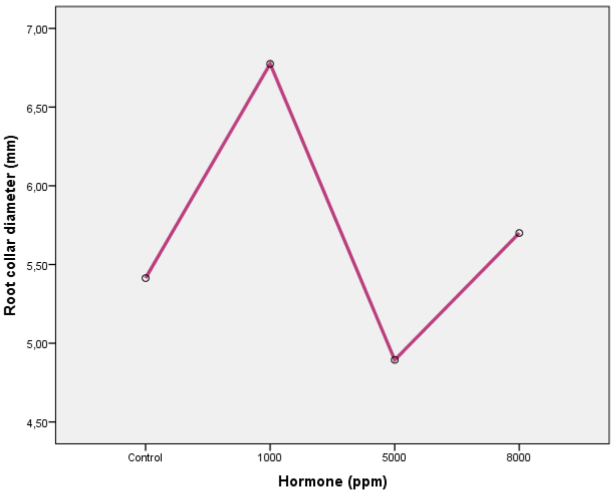

Figure 5. Changes in mean root collar diameter according to hormone concentrations.

3.4. Results of measurements of June 19, 2023

According to the first measurements taken on this date, hormone concentration had a significant effect on both sapling height (p<0.05) and root collar diameter (p<0.05) (Tables 7 and 9). In particular, the 1000 ppm IBA treatment exhibited the best growth performance for both parameters, as confirmed by the results of Duncan's multiple range test (Tables 8 and 10). This finding indicates that hormone application plays a critical role during the initial adaptation and growth period of saplings after being transplanted into pots.

In the measurements taken on June 19, 2023, it was determined that hormone concentration had a statistically significant effect on Sapling height (Table 7). According to Duncan's multiple range test results, the highest mean value was observed in the 1000 ppm IBA treatment, which formed a separate homogeneous group. The control and 8000 ppm IBA treatments were included in the same homogeneous group, while the 5000 ppm IBA treatment partially diverged from these groups. The 1000 ppm IBA treatment formed a distinct homogeneous group on its own (Table 8). This result demonstrates that the 1000 ppm IBA treatment was the most effective hormone concentration for increasing sapling height.

The changes in mean sapling height according to hormone concentrations are presented in Figure 6. The figure clearly shows that the 1000 ppm IBA treatment achieved the highest mean value, while the control group had the lowest mean value. This finding indicates that hormone concentration particularly promote growth during the early development stage and play an important role in increasing sapling height.

In the measurements taken on June 19, 2023, it was determined that hormone concentration had a statistically significant effect on root collar diameter (p<0.001) (Table 9). The results of Duncan's multiple range test (Table 10) showed that the 1000 ppm IBA treatment had the highest mean value (6.14 mm) and formed a separate homogeneous group. The control, 5000 ppm IBA, and 8000 ppm IBA treatments produced statistically similar results. The ranking of mean values was 5000 ppm IBA < Control < 8000 ppm IBA < 1000 ppm IBA. Figure 7 graphically presents the changes in mean root collar diameter according to hormone concentrations, clearly showing that the 1000 ppm IBA treatment had a considerably higher mean value than the other treatments.

Table 7. Analysis of variance (ANOVA) results for the effect of hormone factor on sapling height measured on June 19, 2023.

	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	70.661	3	23.554	4.658	0.006
Within Groups	273.073	54	5.057		
Total	343.734	57			

**; p < 0.05 indicates a statistically significant difference among groups.*

Table 8. Duncan's multiple range test results for hormone concentrations based on sapling height measured on June 19, 2023.

Hormone*	N	Subset for alpha = 0.05	
		1	2
Control	10	9.7900	
8000	18	10.7389	
5000	13	11.3385	11.3385
1000	17		12.8765
Sig.		0.093	.079

**; Means for groups in homogeneous subsets are displayed. The harmonic mean sample size = 13.731. Group sizes are unequal, and the harmonic mean was used. Type I error levels are not guaranteed*

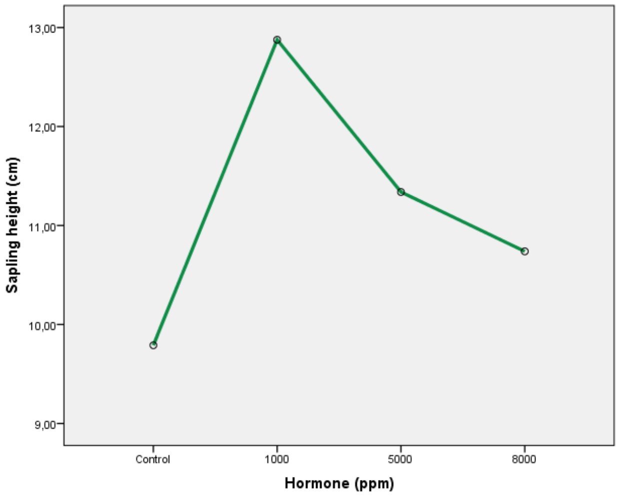

Figure 6. Changes in mean sapling height according to hormone concentrations measured on June 19, 2023.

3.5. Results of measurements of December 8, 2023

In the measurements taken on December 8, 2023, hormone concentration was found to have no statistically significant effect on root collar diameter (p>0.05) or sapling height (p>0.05). This result indicates that the effect of the hormone diminished as sapling development progressed, and growth performance became similar to that of the control group. The findings suggest that hormone concentration is particularly effective during the early growth and adaptation stages, whereas sapling growth at later stages is determined primarily by environmental conditions and genetic factors.

In this study, the effects of different hormone concentration on the rooting and sapling development of cherry laurel cuttings were comprehensively evaluated. Normality tests performed at the initial stage (Tables 1 and 2) revealed that root length and root number data were normally distributed. The results of the analysis of variance (ANOVA) for hormone concentrations indicated statistically significant differences in root length (p<0.05), with the 1000 ppm IBA treatment yielding the highest mean value of 29.81 cm (Tables 3 and 4, Figure 4). This value was approximately 27 % higher than the mean root length of the control group (23.50 cm). This result is consistent with studies reporting the critical role of IBA in enhancing root elongation (Chandramouli 2001; Bayraktar et al. 2018; Khan et al. 2020).

In terms of root number, no significant difference was detected among the groups (p>0.05), with mean values ranging between-14.00–17.07. This suggests that the hormone primarily stimulated root cell elongation and thickening rather than increasing root number. Henrique et al. (2006) and Husen et al. (2017) reported that appropriate IBA concentrations promote root elongation but result in limited increases in root number.

When sapling growth data were evaluated collectively (Tables 5 and 6, and Figure 5), it was observed that hormone concentration had a significant effect on root collar diameter (p<0.001), with the 1000 ppm IBA treatment providing the highest mean value (6.77 mm). This value was 38 % higher than the mean value of the 5000 ppm IBA group (4.89 mm). According to Duncan's multiple range test, the 1000 ppm IBA treatment formed a separate homogeneous group, whereas the control, 5000 ppm IBA, and 8000 ppm IBA treatments were grouped together. No significant differences were observed among the groups for sapling height (p>0.05), with mean values ranging between-16.47–18.77 cm. This result suggests that sapling height is influenced not only by hormone application but also by genetic structure and growing conditions.

Time-based analyses showed that, in the measurements taken on June 19, 2023, hormone concentration caused significant differences in root collar diameter (p<0.05), with the 1000 ppm IBA group achieving the highest values (height = 12.87 cm; diameter = 6.14 mm) (Tables 7 and 10, Figures 6 and 7). In contrast, in the measurements taken on December 8, 2023, the effect of hormone concentration was not statistically significant (p>0.05), and all groups reached similar levels. This result indicates that the effect of the hormone is particularly pronounced during the early adaptation and growth period, while in later stages, environmental factors and genetic potential become more decisive (De Klerk et al. 1999; Han et al. 2009).

Table 9. Analysis of variance (ANOVA) results for the effect of hormone factor on root collar diameter measured on June 19, 2023.

	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	36.656	3	12.219	7.688	0.000
Within Groups	85.822	54	1.589		
Total	122.478	57			

**; p < 0.05 indicates a statistically significant difference among groups.*

Table 10. Duncan's multiple range test results for hormone concentrations based on root collar diameter measured on June 19, 2023.

		Subset for alpha = 0.05	
Hormone*	N	1	2
5000	13	4.0115	
Control	10	4.6220	
8000	18	4.8533	
1000	17		6.1412
Sig.		0.104	1.000

**; Means for groups in homogeneous subsets are displayed. The harmonic mean sample size = 13.731. Group sizes are unequal, and the harmonic mean was used. Type I error levels are not guaranteed.*

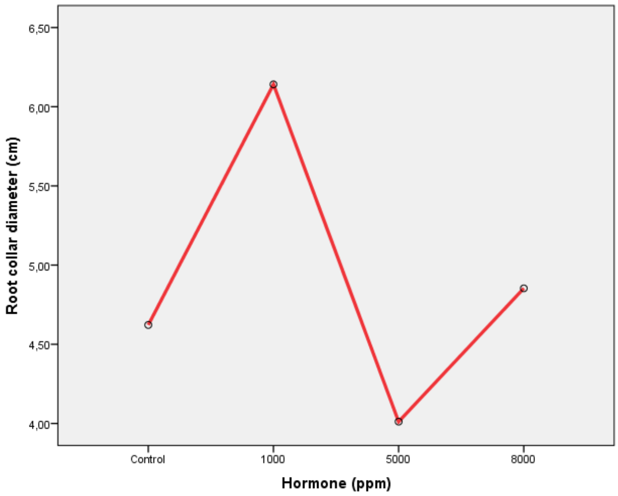

Figure 7. Changes in mean root collar diameter according to hormone concentrations measured on June 19, 2023.

4. Conclusion

This study revealed that IBA applications significantly affected the rooting and sapling development of cherry laurel cuttings. The best results were obtained with the 1000 ppm IBA treatment, which provided marked increases in root length and root collar diameter. The findings showed that the effect of the hormone was particularly pronounced during the early growth and adaptation period but diminished over time. This emphasizes that selecting the appropriate hormone concentration and applying it at the correct time is critical for producing high-quality and vigorous saplings (South et al. 1985; Carlson 1986).

These results are consistent with previous studies on cherry laurel propagation. Ribeiro et al. (2008) and Sülüşoğlu and Çavuşoğlu (2010) reported that IBA treatments improved rooting percentage, root number, and root length in semi-hardwood cuttings, supporting the present findings. Similar results were also reported by Schulze et al. (2017), who demonstrated that IBA-treated cherry laurel cuttings exhibited higher rooting rates and more uniform root systems compared to untreated controls.

From a practical perspective, these findings provide guidance for nursery management and restoration practices: using moderate IBA concentrations at the proper developmental stage improves rooting success, seedling uniformity, and production efficiency.

Future studies should investigate combinations of auxins (e.g., IBA + NAA), evaluate the effects of seasonal variation and genotype differences, and consider environmental factors such as substrate and humidity. Such research will contribute to the development of optimized propagation protocols, enabling sustainable and large-scale production of cherry laurel for forestry and ornamental applications.

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