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Research Article

A different factor in the use of plants in landscape architecture: Sound (type, intensity and duration) in the example of *Hyacinthus orientalis* L.

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Abstract

The effect of music on people has been known for years and is still being researched from different aspects. The effects of music and sound waves on ornamental plants, whose effects on some vegetables, fruits and grains are examined, are also inquired. Especially the positive change in the development and showiness of the flowers of ornamental plant species with commercial importance will increase the market value of the plant. Again, with the effect of this sound wave, in order for the plants and their flowers to show the expected development, they should benefit from the planting environment and growing conditions at the maximum level. In the measurements taken from hyacinths (*Hyacinthus orientalis* L.) at the end of the duration that the plants were exposed to different types of sounds in different intensities, it was observed that these factors positively affected these parameters successively; 1 hour of bird sound in 50 dB, the number of leaves; 1 hour of bird sound in 90 dB, leaf width and floret length; 3 hours of bird sound in 70 dB, floret number; 3 hours of bird sound in 90 dB, the plant and flower height; 1 hour of bee sound in 50 dB, the stem thickness; 3 hours of vehicle sound in 50 dB, flower and floret width; 3 hours of vehicle sound in 70 dB, leaf length. At the end of the study, whereas it was determined that the bee sound had the least effect on the growth and flowering of the hyacinth, it was observed that the bird and vehicle sounds, that the plants were expose to in different intensities and durations, had a positive effect.

Keywords: flower; growth; hyacinth; intensity; landscaping; sound

Introduction

Ornamental plants, one of the important elements of landscape designs, help to maintain the balance of the ongoing interaction between the environment and people with their aesthetic and functional effects in the city and its immediate surroundings (Yuca and Aşur, 2022). In the urban landscape, the visual structure of the plants grown in a certain time is sometimes neglected, together with the characteristics of the area where the plant design is carried out and the habitat requirements of the selected plant species (Aşur, 2022). Hyacinth, one of the geophytic plants that make up an important part of these ornamental plants, has a significant visual

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effect. There are studies on plant compositions based on ecological characteristics, and there are various studies on the evaluation of ornamental plants in different landscapes.

Plants are living beings that breathe and grow. Plants are complex multicellular organisms where new practices are tested and initially considered as sensitive as humans to the effects of new trials (Kristen, 1997; Benford, 2002). The effects of different ecological factors on the physiological characteristics of plants have been extensively investigated (El-Naby *et al*., 2012). It was stated that different pretreatments were made in order to stimulate seed germination and seedling growth in different species used as ornamental plants in the same family as hyacinth (Raghav and Kasera, 2012, Tuncer, 2017).

As can be seen, the changes in plants caused by ecological factors and biotic and abiotic stress conditions are frequently studied.

In the science of acoustic biology, plants are subjected to music or sound waves to improve their yield and quality. Music is a harmonious and coherent blend of various frequencies and vibrations and has many different forms, qualities, and pitches (Chowdhury and Gupta, 2015). Plants are known to respond to external sound stimuli (Hou *et al*., 1994). It is believed that loud and unharmonious sounds can ruin the mood and health of a plant and blossoms. Soft rhythmic music on the other hand is better for their growth and blossoms, and thus may increase plants' rate of growth, their size and influence their overall health (Chowdhury and Gupta, 2015). Music does not only accelerate the growth but also significantly influences the concentration of various metabolites; e.g., chlorophyll and starch (Sharma *et al*., 2015). Some scientists are of the opinion that plants are devoid of a nervous system and therefore are unable to understand music or respond to music (Chowdhury and Gupta, 2015).

Studies investigating the effects of music on barley (Spillane, 1991) and other vegetables (Xiao, 1990) have demonstrated yield and quality improvements. Creath and Schwartz (2004), who stated that sound is a factor affecting plant growth, found that musical sound caused better germination percentage compared to the untreated control. Sound vibrations directly affect living systems. These effects caused by the various applied energetic conditions can be detected through seed germination (Creath and Schwartz, 2004). Within this scope, studies have also been conducted in which the effect of sound was examined by isothermal germination of seeds (Singh *et al*., 2013).

However, there are not many studies in this field due to the lack of proven scientific theories that plants respond to music and sound waves, as well as the inability to measure plant responses to instruments (Anonymous, 2017).

In this study, bird and bee sounds, which are naturally exist in the habitats of plants, and vehicle sounds that ornamental plants can be exposed to when used in urban landscape areas, were played in different intensities and durations and the effects of these sounds on plant and flower development of the hyacinth were examined.

Materials and Methods

Materials

This study was carried out in Siirt University, Faculty of Agriculture, Department of Horticulture and Animal Sciences Laboratories between 2017-2018 years. The research material was commercial hyacinth bulbs (*Hyacinthus orientalis* L. 'Delft Blue') with a diameter of 10-14 cm purchased from a company (Figure 1).

Figure 1. Hyacinths used in the study

Methods

The study was established according to the factorial experimental design in randomized plots with 3 replicates and 3 bulbs in each replicate (Figure 1).

The study was conducted under laboratory conditions and the treatments were tested as shown in Table 1. Hyacinth bulbs were planted in mid-December in 2 kg plastic pots in containing garden soil. The plants were irrigated once a week during the study period.

Table 1. Sound type, intensity and duration applied to hyacinths

Control	Applied Sound	Type			Intensity			Duration	
		Bird Sound	Bee Sound	Vehicle Sound	Low 50 dB	Moderate 70 dB	High 90 dB	1 hour	3 hours

The sounds were played at the beginning of flowering of hyacinth bulbs with the opening of the first floret (March 03) and continued until the flowers withered (March 10). The sound intensities were set with Benetech brand GM1351 model 'Digital Sound Level Meter'.

Digital Sound Level Meter possesses the following features:

1.Accuracy up to ± 1.5 dB

2.Measurement range: 30dBA-130 dBA

3.Frequency response: 31.5 Hz-8.5 KHz

4.Sampling Rate: 2 times/s

The sounds uploaded to the flash memory were played with a standard music player placed in the center of the pots and applied in different durations (Figure 2). In addition, a control group was formed for comparison except for the plants subjected to sound treatments.

The effects of the treatments on leaf number, length and width; plant height; flower length and width; floret number, length and width; and stem thickness parameters of hyacinth plant were determined.

Figure 2. Setting up sound meter and applications

Statistical evaluations

The experiment was created in a factorial random plot design. Each treatment group was tested in 3 replications. The mathematical model of the trial plan is:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + e_{ijkl}.$$

Here: Y_{ijkl}: is an observation value of the growth parameter of interest, μ: general population mean, α_i: the effect of "Sound type" treatment, β_i: the effect of "Sound Intensity" treatment, γ_k: the effect of "Application Duration" treatment, $(\alpha\beta)_{ij}$, $(\alpha\gamma)_{ik}$, $(\beta\gamma)_{jk}$ and $(\alpha\beta\gamma)_{ijk}$ are interaction effects of relevant treatments, e_{ijkl}: random error (Winer, 1962). LSD and Duncan multiple comparison tests were applied to the treatments and interactions in which the differences between them were found statistically significant (Düzgüneş *et al*., 1987). Descriptive statistics in terms of the growth parameters are expressed with mean and standard error. Statistical analyzes were carried out using the R package program (R Core Team, 2021).

Results and Discussion

Plant design is considered important in making human life comfortable, as in the process of designing other products that are valuable for life in space designs. In the streets, squares and parks, which are public open spaces that connect the society as a common denominator in cities and affect the urban identity, functional ecological improvements are also realized with the right plant designs along with visual improvement (Aşur, 2019; Aşur *et al*., 2022). In order to create this design, it is of great importance to determine the morphological features of the related ornamental plants.

The effects of low (50 dB), medium (70 dB) and high (90 dB) doses of bird, bee and vehicle sounds on leaf length, plant and flower height, flower and floret width and number of florets of hyacinth flowers were found to be statistically significant at $p<0.01$ level (Table 2 and 3), while the effect on stem thickness was found to be significant at $p<0.05$ level (Table 2). The effects of treatments on the number and leaf width and floret length were found to be statistically insignificant (Table 2 and 3).

Table 2. The effects of sound type, intensity and application durations on the vegetative properties of hyacinth

Sound type	Intensity	Duration	Number of leaf (pcs)	Leaf length (mm)**	Leaf width (mm)	Leaf height (mm)**	Stem thickness (mm)*
Bird sound	Low 50 dB	1 hour	6.720	216.480 ^{J}	23.330	386.346 $^{D-F}$	10.346 $^{A-B}$
		3 hours	6.330	266.883 $^{F-H}$	24.766	380.726 $^{D-F}$	7.800 ^{C}
	Moderate 70 dB	1 hour	6.440	284.876 $^{C-F}$	25.680	398.193 $^{B-E}$	9.223 $^{B-C}$
		3 hours	6.553	307.590 $^{B-E}$	25.663	441.336 $^{A-B}$	9.080 $^{B-C}$
	High 90 dB	1 hour	6.220	313.910 $^{B-C}$	26.700	434.476 $^{A-C}$	9.156 $^{B-C}$
		3 hours	6.220	313.006 $^{B-C}$	24.403	455.176 ^{A}	10.050 $^{A-B}$
Bee sound	Low 50 dB	1 hour	6.386	226.116 $^{I-J}$	27.110	333.440 $^{G-H}$	11.720
		3 hours	6.166	245.196 $^{H-J}$	23.073	320.386 ^{H}	8.380 $^{B-C}$
	Moderate 70 dB	1 hour	6.330	265.266 $^{F-H}$	24.253	368.266 $^{E-G}$	8.706 $^{B-C}$
		3 hours	6.553	253.093 $^{G-I}$	25.970	349.653 $^{F-H}$	9.460 $^{B-C}$
	High 90 dB	1 hour	6.526	270.746 $^{F-H}$	25.553	368.013 $^{E-G}$	9.506 $^{B-C}$
		3 hours	6.110	330.426 $^{A-B}$	24.496	420.786 $^{A-D}$	8.633 $^{B-C}$
Vehicle sound	Low 50 dB	1 hour	6.443	284.743 $^{C-F}$	23.860	391.303 $^{C-F}$	9.450 $^{B-C}$
		3 hours	6.110	310.686 $^{B-D}$	25.846	391.116 $^{D-F}$	9.016 $^{B-C}$
	Moderate 70 dB	1 hour	6.220	322.286 $^{A-B}$	26.046	440.253 $^{A-B}$	8.570 $^{B-C}$
		3 hours	6.440	348.543 ^{A}	25.493	443.173 ^{A}	9.666 $^{A-C}$
	High 90 dB	1 hour	6.330	277.656 $^{E-G}$	23.513	363.100 $^{E-H}$	10.323 $^{A-B}$
		3 hours	6.443	279.940 $^{D-G}$	24.756	363.536 $^{E-H}$	9.763 $^{A-C}$
P value			NS	p<0.01	NS	p<0.01	p<0.05

*: p<0.05; **: p<0.01; NS: No Sigfnificant

The differences between the means with the same letter is statistically insignificant

As shown in Table 2, when the vegetative development of hyacinths is examined in terms of sound type, intensity and application duration, the lowest number of leaves was recorded as 6,110 when the plants were exposed to bee sound in 90 dB and vehicle sound in 50 dB for 3 hours. The highest number of leaves was recorded in the treatment of bird sound in 50 dB for 1 hour. The mean values of leaf length were determined between 216.480-348.543 mm. When leaf length values are examined; the lowest value was recorded in the treatment of bird sound in 50 dB for 1 hour and the highest value was recorded in the application of vehicle sound in 70 dB for 3 hours. Leaf width was determined between 23.073-26.700 mm and there was little difference between the values obtained from the treatments. The highest value of leaf width was recorded in 90 dB bird sound played for 1 hour, while the lowest value was recorded in 50 dB bee sound played for 3 hours. Plant height was determined by measuring the distance from the root collar to the tip of the uppermost floret in the flower spike of the hyacinths in the pots. The highest plant height values that were recorded as 455.176 mm and 443.173 mm were obtained successively from the 3 hours applications of bird sound in 90 dB and vehicle sound in 70 dB. The lowest plant height of 320.386 mm was recorded in the application of bee sound in 50 dB played for 3 hours, as in leaf width. Stem thickness varies between 7.800-11.720 mm. The lowest stem thickness was observed in 3 hours treatment of bird sound in 50 dB and the highest stem thickness was observed in 1-hour application of bee sound in 50 dB.

Vanol and Vaidya (2014) applied various frequencies and types of sounds (classical music, rhythmic rock music and non-rhythmic traffic noise) to guar plants and monitored parameters such as the number of seeds germinated in petri-dish plates, plant height and numbers for 13 days. Consequently, compared to the plants in the control group, it was observed that classical music and rhythmic rock music had a positive effect on the plants, while non-rhythmic traffic sounds had a negative effect. In our study, traffic sound positively affected plant height. Loud, high-frequency tones increased the germination rate of *Alyssum* seeds, while random noise had the opposite effect (Pixton, 1977). *Alyssum* is a seasonal plant. It differs from hyacinth, which is a bulbous plant. This difference between plant genera and groups influenced the level of their susceptibility to sounds. Therefore, this study indicates that traffic sound may have a positive effect as much as bird sound. Vibration can be used to stimulate seeds or plants (Braam and Davis, 1990). Leafy plants planted to reduce and prevent noise pollution developed differently from leafy plants planted in a quiet environment (Martens and Michelsen, 1981; Bache and MacAskill, 1984). This can be advantageous in gaining an insight into the environment in which sounds, such as acoustic signals, are used and the adaptive value of sound on plants (Gagliano, 2013).

As seen in Table 3, the flower length varied between 127.086-198.330 mm. The highest and the lowest values were obtained successively in the 3 hours applications of bird sound in 90 dB and bee sound in 50 dB. The highest and lowest mean values of floret number were determined by playing 70 dB of bird sound for 3 hours and 1 hour respectively. When moderate intensity of bird sound was played for 3 hours, 42.386 florets were recorded, and when it was played for 1 hour, 22.720 florets were recorded.

In terms of floret length parameter, the highest value (20.620 mm) was obtained by playing bird sound in 90 dB for 1 hour while the lowest value (16.673 mm) was obtained by playing vehicle sound in 90 dB for 1 hour. The lowest floret width of 20.500 mm was obtained by playing bee sound in 50 dB for 1 hour, while the highest value ranges between 29.133-32.783 mm and all the highest mean values were statistically in the same group. The highest value of floret width in the same group was measured as 32.783 mm after the application of vehicle sound in 70 dB for 3 hours. The effects of double interactions between factors to the growth parameters were given in Appendix 1.

Table 3. The effects of sound type, intensity and application durations on the flower properties of hyacinth

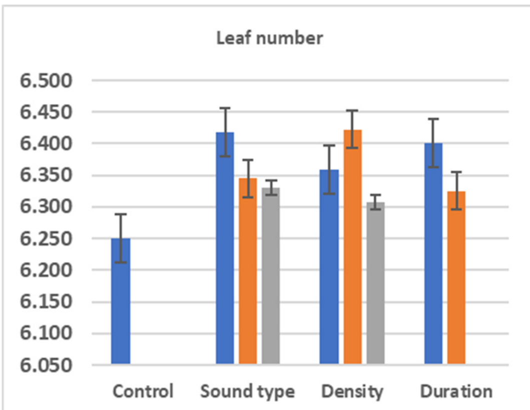
Sound type	Intensity	Duration	Flower length (mm)**	Flower width (mm)**	Floret number (pieces)**	Floret length (mm)	Floret width (mm)**
Bird sound	Low 50 dB	1 hour	129.243 $^{F-G}$	52.836 $^{A-B}$	30.610 $^{B-D}$	17.613	26.160 $^{A-C}$
		3 hours	159.170 $^{B-E}$	53.100 $^{A-B}$	29.886 $^{B-D}$	17.806	28.290 $^{A-B}$
	Moderate 70 dB	1 hour	158.913 $^{B-E}$	52.253 $^{A-B}$	22.720 ^{D}	18.643	29.133 ^{A}
		3 hours	178.476 $^{A-B}$	54.056 $^{A-B}$	42.386 ^{A}	18.306	29.223 ^{A}
	High 90 dB	1 hour	167.113 $^{B-D}$	52.656 $^{A-B}$	29.996 $^{B-D}$	20.620	31.403 ^{A}
		3 hours	198.330 ^{A}	54.790 $^{A-B}$	36.773 $^{A-C}$	17.903	30.250 ^{A}
Bee sound	Low 50 dB	1 hour	142.553 $^{E-G}$	40.996 ^{C}	33.776 $^{A-C}$	17.166	20.500 ^{C}
		3 hours	127.086 ^{G}	46.586 $^{B-C}$	32.386 $^{A-D}$	19.793	32.413 ^{A}
	Moderate 70 dB	1 hour	146.093 $^{D-G}$	51.513 $^{A-B}$	36.110 $^{A-C}$	16.940	29.350 ^{A}
		3 hours	158.596 $^{B-E}$	40.940 ^{C}	26.333 $^{C-D}$	17.960	21.266 $^{B-C}$
	High 90 dB	1 hour	158.836 $^{B-E}$	48.420 $^{A-C}$	36.110 $^{A-C}$	17.566	29.653 ^{A}
		3 hours	153.556 $^{C-E}$	51.863 $^{A-B}$	31.443 $^{A-D}$	18.760	32.296 ^{A}
Vehicle sound	Low 50 dB	1 hour	153.776 $^{C-E}$	47.846 $^{B-C}$	35.610 $^{A-C}$	17.683	29.293 ^{A}
		3 hours	172.826 $^{B-C}$	57.303 ^{A}	34.773 $^{A-C}$	19.286	32.783 ^{A}
	Moderate 70 dB	1 hour	155.283 $^{C-E}$	51.356 $^{A-B}$	35.776 $^{A-C}$	17.710	28.438 $^{A-B}$
		3 hours	149.330 $^{D-F}$	51.856 $^{A-B}$	31.553 $^{A-D}$	16.963	32.093 ^{A}
	High 90 dB	1 hour	160.400 $^{B-E}$	52.263 $^{A-B}$	39.220 $^{A-B}$	16.673	27.930 $^{A-B}$
		3 hours	149.273 $^{D-F}$	47.886 $^{B-C}$	37.886 $^{A-B}$	18.813	27.546 $^{A-C}$
P value			$p<0.01$	$p<0.01$	$p<0.01$	NS	$p<0.01$

**: $p<0.01$; NS: No Significant

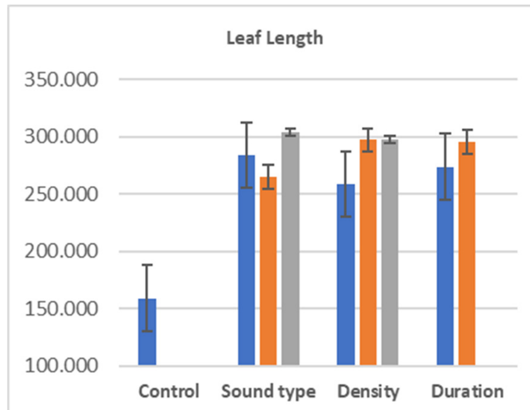
The differences between the means with the same letter is statistically insignificant

As can be seen from Table 3, the highest values in terms of flowering parameters were mostly obtained by playing bird sound to hyacinths. Flower length plays an important role in the flower quality of hyacinths. The size of the flower spike is important in terms of quality of hyacinths, which are known for the color, fragrance and showiness of their flowers. In this respect, flower length and width significantly affect the quality of the hyacinths. It is the florets that provide these properties in the flower. The size of the florets (length-width) makes the flower spikes showy. The more florets are, the more voluminous the flower spike is. Therefore, the number of florets is as important as their size. Flower length and floret width were obtained by playing high intensity of bird sound (in 90 dB). Playing the moderate and high intensities of bird sound for 1 and 3 hours generally affected the floret width positively. The highest floret number was obtained by playing the bird sound at moderate (70 dB) intensity for 3 hours. It was observed that playing high intensity (90 dB) of the bird sound for 1 hour affected the floret width positively. According to the table, it is clear that all intensities of sounds, except for low intensity of the bird sound, affected the flower quality positively.

Statistical comparisons of the mean values of the sound type, intensity and duration applications are shown in the tables as single, double and triple interactions (Appendix 1). At the same time, the comparison of the factors that were applied to all measured parameters with the control groups are shown in Figure 3 (a-j).



(a)



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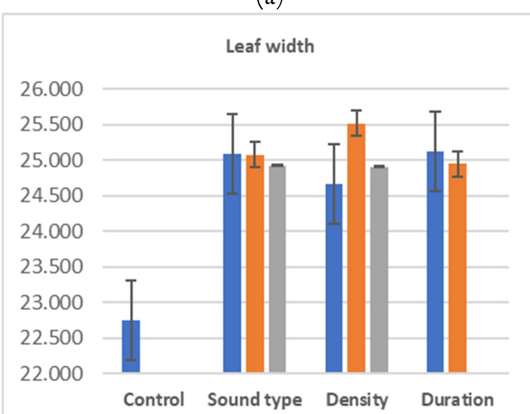

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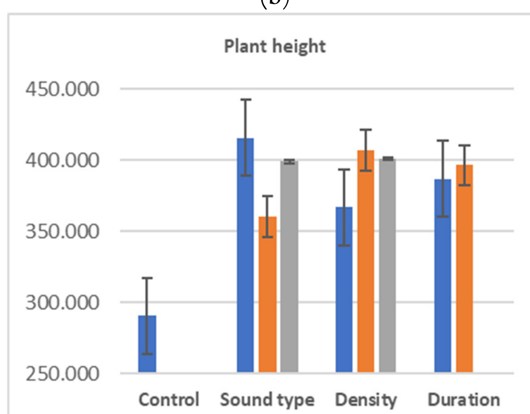

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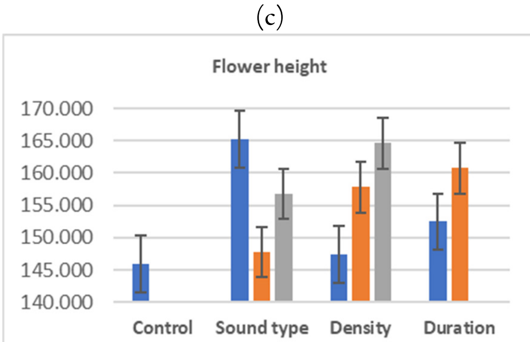

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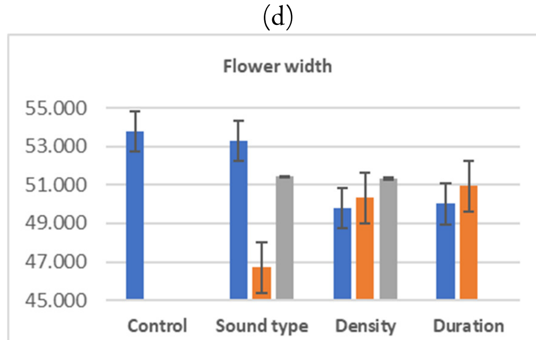

(f)

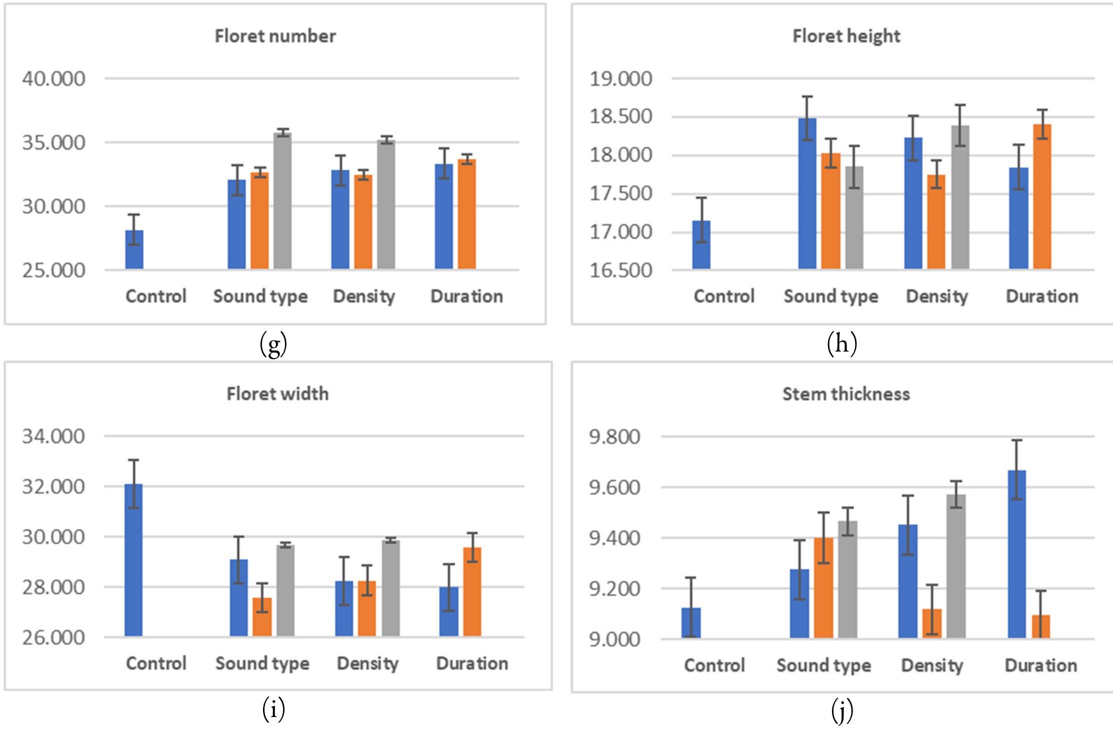

Figure 3. Comparison of the applications with the control group plants for the investigated parameters
The colours imply; in Sound Type: ■ bird sound, ■ bee sound, ■ vehicle sound; in Sound Intensity: ■ low, ■ moderate, ■ high; in Application Duration: ■ 1 hour ■ 3 hours.

Under normal conditions (100 dB and 800 Hz), sound enhanced the growth of *Chrysanthemum* callus and the assimilation of cellular tissues, improved and accelerated the physiological activities of plants (Yiyao *et al.*, 2002). In another study with *Chrysanthemum*, it was observed that root formation was accelerated, root metabolism was increased and plant growth was correspondingly enhanced under suitable sound stimulation (Bochu *et al.*, 2001; Yi *et al.*, 2003). Maize plants exposed to music grew faster, they were greener, and their stalks were thicker and stronger than the ones that weren't exposed to music (Hicks, 1963). In pure tone processing, hypocotyl elongation and gene expression of *Arabidopsis taliana* seeds were enhanced by both 50Hz and 90dB sound stimuli (Johnson *et al.*, 1998). Sound wave stimulation can significantly increase or inhibit the ATP content of *Actinidia chinensis* callus. Moderate sound stimulation can increase ATP synthesis activity and this has a positive effect on the energy metabolism of plants (Xiaocheng *et al.*, 2003; Yang *et al.*, 2004).

QGWA-03 plant sound device (frequency range: 100-2000 Hz), tomato yield increased by 13.2% and gray mold disease decreased by 9.0% (Tianzhen *et al.*, 2009). In a study, five different types of music (Indian classical music, Vedic chants, Western classical music and rock music) were played to the rose (*Rosa chinensis*) for 1 hour each in the morning and after sunset for 62 days. At the end of the study, shoot length, internode length, number and diameter of the flowers were recorded and significant differences were observed. It was seen that the plants exposed to Vedic chants showed the maximum shoot elongation, maximum number of flowers and highest diameter of flowers. The internode elongation was highest in plants exposed to Indian classical music. This clearly shows that the subjecting the plants to Vedic chants or Indian classical music promotes the growth of plants (Chivukula and Ramaswamy, 2014).

Although the mechanism is not fully understood, it has been reported that seedlings and mature plants exposed to music (classical music and natural sounds such as birds, insects, water, etc.) have increased polyamine levels and uptake compared to control plants (Qin *et al.*, 2003). Music has been reported to affect, promote or restrict the plant growth depending on the type of music played (Chivukula and Ramaswamy, 2014).

Conclusions

Hyacinth is an ornamental plant used in landscaping. The effect of bird and bee sounds that naturally exist in open areas, and the effect of vehicle noise on the development of the plant in urban areas where it was planted were determined. The results obtained will be beneficial for determining the planting areas of hyacinth bulbs. It was observed that bird sound is slightly more effective than other sound treatments in the vegetative growth parameters of hyacinths. The bird sound, compared to the others, was observed to have a positive effect on the number and width of leaves and plant height parameters. Leaf width and plant height were obtained by playing bird sound at high intensity (90 dB). When 50 dB of bee sound was played for 3 hours, it decreased the leaf width and the plant height compared to the others when 50 dB of bee sound was played for 1 hour, the highest stem thickness value was obtained. It is clear that all levels of intensity and durations of the bee sound had a decreasing effect on all parameters except stem thickness.

The positive effect of 3 hours of vehicle sound at moderate intensity on leaf length and plant height were observed and it is believed that this provides an advantage in terms of the use of hyacinth plants in landscaping, urban refuges, parks and indoor landscaping. The positive effect of 3 hours of vehicle sound at moderate intensity on leaf length and plant height were observed and it is believed that this provides an advantage in terms of the use of hyacinth plants in landscaping, urban refuges, parks and indoor landscaping.

Consequently, it can be said that the treatments made with bee sound have less effect in comparison with other sound types; in vegetative development and flower quality, the doses and durations of bird and vehicle sounds have the increasing, positive effect on the parameters.

Authors' Contributions

Conceptualization: AÇ; Data curation: AÇ; Investigation: AKM; Methodology: AÇ, AKM, Project administration: AÇ; Resources AÇ; Software: NM, Supervision: AÇ, AKM, NM; Validation: NM; Visualization AÇ, NM; Writing - original draft: AÇ; Writing - review and editing: AÇ, NM. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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