Effects of Data Center Noise on the Growth of *Sorghastrum nutans* and *Bignonia capreolata*, and Their Capacity to Reduce Low-Frequency Sound

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Abstract

As the use of artificial intelligence expands, data centers—which process the requests of artificial intelligence—are becoming more prominent in urban settings. These data centers create significant amounts of background noise, which is becoming a concern for those who reside and work in proximity to them. In this project, we hope to find ways to reduce this noise through natural means such as plant cover. We grew *Sorghastrum nutans* (Indiangrass) and *Bignonia capreolata* (crossvine) with high decibel (dB) low-frequency sounds (LFS) to determine if the sounds would affect their growth. Once mature, we tested if they could reduce the volume of the LFS. Because sound is thought to activate mechanosensitive ion channels and calcium signaling that can alter gene expression and growth-hormone activity (Demey et al., 2023; Pagano & Del Prete, 2024), we hypothesized that the LFS would increase the rate of plant growth for Indiangrass and crossvine, and that these plants would be effective in reducing sound. We found that while sound conditions did not significantly impact the plant growth of the crossvine, they actually impeded the growth of the Indiangrass. We also found that while the Indiangrass had little effect on reducing the LFS, the crossvine did cause a reduction in the LFS serving as a promising candidate for further study.

Introduction

As artificial intelligence use continues to expand, the need for more data centers increases. While data centers provide benefits to innovation in the broader society, they have negative effects on the surrounding local communities and environments, specifically in regard to noise pollution and aesthetics. Data centers have been receiving significant attention recently for the noise they produce, particularly in the low-frequency range. Data center noise is both high frequency and low frequency. The high-frequency noise is absorbed by the building materials, including the concrete walls that surround the center, but the low-frequency sounds (LFS), which are difficult to block because of their long wavelengths, are emitted to the surrounding community. For the purpose of this paper, LFS is defined as sounds in the 20–200 Hz range (Waye et al., 2011). Many data centers have already taken measures to mitigate the sounds they produce, but the noise remains audible to nearby residents. Previous research has shown that being exposed to high amounts of consistent noise over a long period of time can have significant negative mental and physical health effects on people, including effects on the cardiovascular, psychological, and endocrine systems (Hahad et al., 2019) and on cognitive function (Liang et al., 2024). To address this, plants can absorb some noise. Horoshenkov et al. (2013) found that leaf area density and leaf angle were the main factors affecting sound absorption by plants in the 50 to 1600 Hz range. Research has also shown that noise affects the growth of plants in both positive and negative ways, and some plants have even been shown to grow better in noisy environments (Demey et al., 2023;Pagano & Del Prete, 2024). We chose Indiangrass (*Sorghastrum nutans*) and crossvine (*Bignonia capreolata*) because both grow to a very large final height, which makes them ideal for covering large vertical areas such as those found on the sides of data centers. Indiangrass is a fast-growing native prairie grass that grows 1 to 2.5 m tall, and crossvine is a rapidly growing, semi-evergreen vine that can reach 17 m (Wennerberg, 2004). We hypothesized that plants could be planted around a data center to mitigate the noise emission.

We are asking: Do vibratory noise conditions similar to those of a data center affect the growth of *Sorghastrum nutans* and *Bignonia capreolata*, and can these plants reduce the low-frequency sounds of

these conditions? Because previous research suggests that plants can have a physiological response to sound vibrations, we hypothesized that the LFS would increase the rate of plant growth for Indiangrass and crossvine, and that these plants would be effective in reducing sound.

Materials & Methods

Data center simulated noise

Noise from two different data centers in the San Francisco Bay Area was recorded using an omnidirectional condenser microphone. The first data center was Equinix Data Centers, and the other was Corosite. The noise was recorded about 5 ft. away from the data center, which is the approximate location where the plants would be placed. Each of the recordings was imported into Logic Pro, an audio production digital audio workstation. The equalization or EQ tool was used to find each of the frequencies at which the data center noise had the highest dB. Each of these frequencies was extracted and combined to create an average sound between the data centers. This simulated mix of frequencies was played continuously from a speaker for the duration of the experiment.

Plants

Sorghastrum nutans, more commonly known as Indiangrass, was purchased as seeds from Everwilde Farms. These seeds were planted in 3 x 3 x 4-inch plastic nursery pots with 0.4 L of Miracle Grow Organic Choice Potting Mix, with approximately 40 seeds in each pot. *Bignonia capreolata*, more commonly known as crossvine, was purchased as a seedling (about 8 weeks old) from Greenwood Nursery and was transferred to 10 x 10 x 14-inch (3-gallon) plastic nursery pots with 11 L of Miracle Grow Organic Choice Potting Mix. Metal trellises were set up for the crossvine to climb, and 5-10-5 fertilizer was used for the crossvine seedlings; 1/8 cup per plant was mixed into the soil once.

Growing

The plants were grown on a wire metal shelving unit, in 9x9 square plant saucers, with a full spectrum grow light set 20 inches above. The plants were watered with a watering can, and each plant was watered thoroughly to keep the soil moist. The crossvine was watered once every 3 days, and the Indiangrass was watered every other day. The plants were separated into two groups. The control group grew under normal conditions in a quiet indoor location with no external noise. The experimental group grew in identical conditions, except they were placed next to a speaker playing the simulated data center noise (see Figure 1a). The grow lights and speaker were connected through a power strip and smart plug, which controlled the grow lights to create a day/night cycle. The Indiangrass plants grew for 3 weeks, and the crossvine grew for 4 weeks.

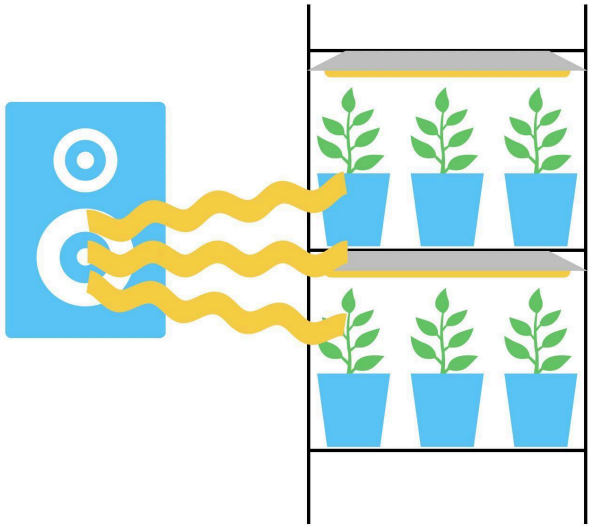


Figure 1a: Set-up for plant growth + sound. Potted plants were placed on a wire shelving unit with a full-spectrum grow light above each shelf. A speaker placed 4 feet from the plants continuously played the simulated data center noise. Control plants were grown under identical conditions in a quiet room without a speaker. Diagram not to scale.

Measurements

Height measurements were taken from each plant every week for 4 weeks for the crossvine and 3 weeks for the Indiangrass. The measurements were taken using a ruler to measure from the soil height to the plant's highest point. We also counted the number of leaves on each Indiangrass plant. Growth was calculated as the change in height from the start to the end of the study.

Sound experiment

For the noise reduction experiment, a mature plant of each type was placed inside a sound chamber, which was a 4-ft-long cardboard tube (see Figure 1b). The simulated data center noise was played through a speaker on one side, and a decibel meter was placed on the other side to capture how much of the sound was being blocked by the plant. Three tests were run for each plant type. The control was also done with no plant.

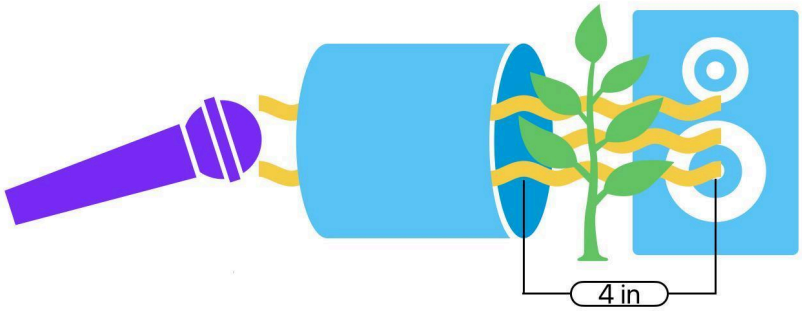


Figure 1b: Diagram of sound chamber/measurement. The simulated data center noise was played from a speaker at one end of the tube, and a decibel meter at the opposite end recorded the sound level passing through. There was a 4 in gap between the speaker and the start of the tube, and in the tests with a plant, the plant was placed in this gap. The tube was 4 ft long and made of cardboard. Each plant type was tested three times, along with a no-plant control.

Results

Growth

Growth was measured as the change in plant height (cm) over the study period.

Indiangrass. Indiangrass exposed to simulated data center noise grew an average of 6.00 cm (± 1.00, n = 5), compared with 11.75 cm (± 3.10, n = 4) for plants grown in silence, a difference of 5.75 cm (Table 1A). This difference was statistically significant based on a Student's t-test ($t = 3.57$, $p = 0.029$).

Crossvine. Crossvine exposed to noise grew an average of 27.08 cm (± 6.26, n = 3), compared with 29.35 cm (± 15.17, n = 3) for the control group, a difference of 2.27 cm (Table 1B). This difference was not statistically significant ($t = 0.24$, $p = 0.828$).

Table 1A: The difference in heights (cm) of individual Indiangrass plants from week 0 to week 3. The difference in heights were averaged across experimental groups.

Replicate #	Growth in Simulated Noise (cm)	Growth in Control Conditions (cm)
1	5	10
2	6	9
3	7	16
4	7	12
5	5	
Average	6.00	11.75

Table 1B: The difference in heights (cm) of individual crossvine plants from week 0 to week 4. The difference in heights were averaged across experimental groups.

Replicate #	Growth in Simulated Noise (cm)	Growth in Control Conditions (cm)
1	21.11	30.76
2	33.6	13.52
3	26.52	43.76
Average	27.08	29.35

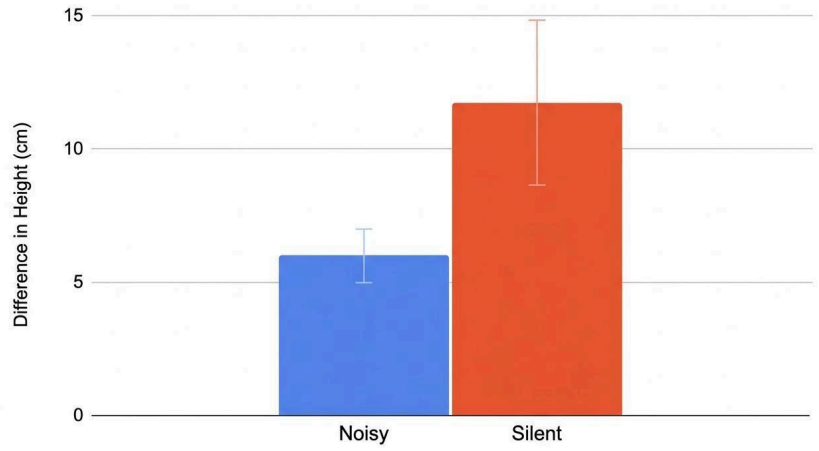


Figure 2A: Graph of averaged measurements for Indiangrass. The average difference in height for plants in the simulated noise environment (Noisy, n = 5) was 6.00 cm with standard deviation of 1.00, and 11.75 cm with standard deviation of 3.10 for the control environment (Silent, n = 4). Error bars show ±1 SD. The difference was statistically significant (p = 0.029).

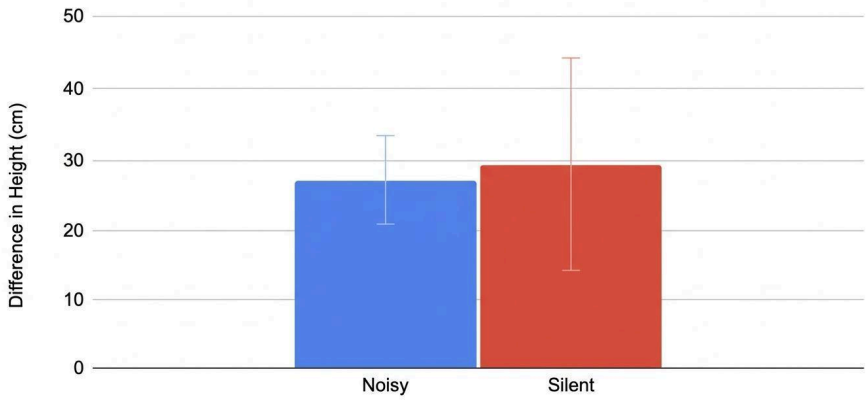


Figure 2B: Graph of averaged measurements for crossvine. The average difference in height for plants in the simulated noise environment (Noisy) was 27.08 cm with standard deviation of 6.26 (n = 3), and 29.35 cm with standard deviation of 15.17 for the control environment (Silent, n = 3). Error bars show ±1 SD. The difference was not statistically significant (p = 0.828).

Sound reduction

Sound reduction was measured as the decibel level that passed through the sound chamber with and without a plant present.

Indiangrass. With Indiangrass in the chamber, an average of 79.07 dB (± 0.59) passed through, compared with 79.97 dB (± 0.57) with no plant, a reduction of 0.90 dB (Table 2, Figure 3A). This reduction was not statistically significant (t = 1.91, p = 0.129).

Crossvine. With crossvine in the chamber, an average of 75.37 dB (± 1.21) passed through, compared with 80.27 dB (± 1.04) with no plant, a reduction of 4.90 dB (Table 2, Figure 3B). This reduction was statistically significant (t = 5.32, p = 0.006).

Table 2: Noise Penetration for Indiangrass and Crossvine measured in dB

Replicate #	Indiangrass present	No Indiangrass	Crossvine present	No crossvine
1	79.5	80.6	74	79.1
2	78.4	79.5	76.3	81.1
3	79.3	79.8	75.8	80.6
Average	79.07	79.97	75.37	80.27

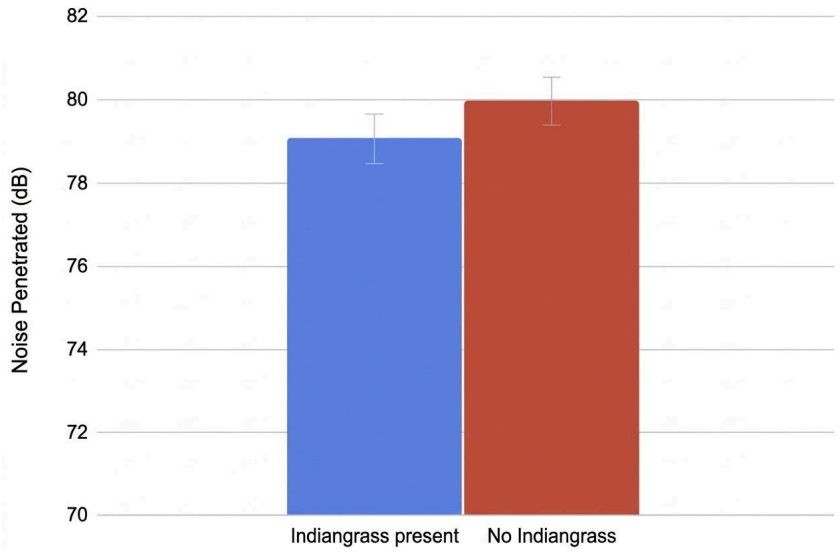


Figure 3A: Graph of noise let through the sound chamber with and without Indiangrass. The average noise level measured was 79.07 dB (SD = 0.59) with Indiangrass present and 79.97 dB (SD = 0.57) with no Indiangrass (n = 3 tests each). Error bars show ±1 SD. The difference was not statistically significant (p = 0.129).

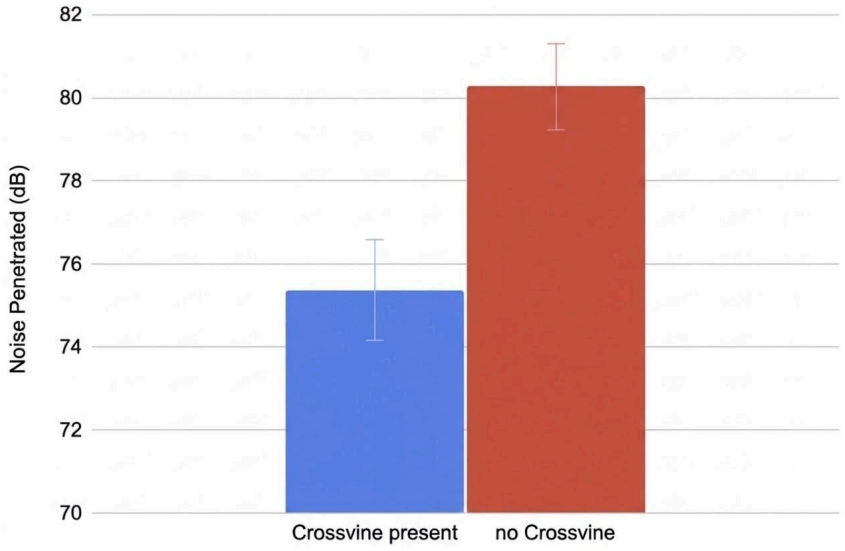


Figure 3B: Graph of noise let through the sound chamber with and without crossvine. The average noise level measured was 75.37 dB (SD = 1.21) with crossvine present and 80.27 dB (SD = 1.04) with no crossvine (n = 3 tests each). Error bars show ±1 SD. The difference was statistically significant (p = 0.006).

Discussion

Growth of plants

The Indiangrass that was exposed to the noise grew significantly less than the Indiangrass in quiet conditions, gaining an average of 6 cm compared to 11.75 cm, a difference of 5.75 cm (p = 0.029). Crossvine, on the other hand, was not meaningfully affected. The noise-exposed plants grew 27.08 cm on average, and the control group plants grew 29.35 cm on average, a difference of only 2.27 cm (p = 0.828).

The growth of the crossvine was about the same with or without noise, which suggests that it can tolerate this kind of sound. One reason we think the Indiangrass exposed to the noise might not have grown as much might be its structure. Its blades are thin and flexible, so they may have moved in response to the vibrations from the low-frequency sound. Plants that are exposed to repeated mechanical stimulation sometimes grow shorter (Braam, 2005; Chehab et al., 2009), so the movement might have slowed the experimental Indiangrass's growth.

Crossvine is a vine with larger leaves and a thicker stem, so it may have been able to grow. It may have had more resistance to the low-frequency noise because of its more resistant structure.

Sound insulation from plants

Crossvine reduced the sound passing through the chamber by an average of 4.9 dB, from 80.27 dB with no plant to 75.37 dB with a plant present. This reduction was statistically significant (p = 0.006). Humans can notice changes in decibels of 3 dB and higher, so a change of 4.9 dB is definitely perceptible by people. Indiangrass lowered the sound by only 0.9 decibels, from 79.97 decibels with no plant present to 79.07 decibels with the plant present. This difference was not statistically significant (p = 0.129), and 0.9 decibels is usually too small a difference for people to hear, so the Indiangrass had almost no practical effect.

The difference in sound reduction between the crossvine and Indiangrass plants lines up with what some previous research has found on plant sound absorption. Horoshenkov et al. (2013) found that leaf density and leaf angle were the main factors controlling absorption between 50 and 1600 Hz. Crossvine has dense, large leaves, so it has much more surface area to block the path of sound than the Indiangrass, which has thinner blades. This may explain why the crossvine blocked more sound.

Limitations

There were few limitations that may affect how these results can be applied:

First, the sample size was limited. We were only able to run the growth experiment for 4 to 5 weeks and only used 3 plants per group for the crossvine and 4 to 5 plants per group for the Indiangrass. This reduces the statistical power of the study and therefore limits how statistically significant our results may be. All of the plants in the experimental, noise-exposed group were only receiving noise from one speaker. Only having one noise source compared to a more surround noise source for a real-life application may affect how the plants react to the noise, because it is very difficult to isolate noise this loud coming from the speaker. The control group of plants was in a different location, a few rooms away from the experimental group, to keep their noise level down. Second, despite efforts to create a uniform

environment for the experiment using grow lights, standardized amounts of water, and obstruction of natural light, there may be small differences in the amount of light, temperature, or even airflow that may also have contributed to the growth of the plants. And third, the simulated noise that was played for the plants, both in the growing stage and noise reduction testing stage, may not perfectly reflect the nuances of sound from an actual data center.

Conclusion

In this study, we wanted to know if low-frequency noise like the kind of data centers make changes to how *Sorghastrum nutans* (Indiangrass) and *Bignonia capreolata* (crossvine) grow, and if these plants can cut down that noise. We hypothesized that the noise would help the plants grow faster, but that was not supported for either plant. The Indiangrass significantly less in the noise (6.00 cm compared to 11.75 cm, $p = 0.029$), while the crossvine grew similarly in test and control environments (27.08 cm compared to 29.35 cm, $p = 0.828$), suggesting that crossvine is unaffected by this kind of noise. In the sound chamber, the crossvine lowered the noise by 4.90 dB ($p = 0.006$), which is enough for people to notice. The Indiangrass only lowered it by 0.90 dB, which was not significant ($p = 0.129$). Overall, crossvine looks like a potential solution for planting around data centers, but Indiangrass does not, since the noise slowed growth and it did not block much sound.

Since we had small sample sizes, only one speaker, and a short growing time, these results are just a starting point, and they leave us with some questions. Would crossvine keep growing normally in data center noise for a whole season or even a few years? Would it block more noise as it gets bigger or has thicker leaves, like leaf density would suggest? Our decibel meter only measured the overall sound level, so which low frequencies does crossvine block the most? Would it work the same outside, with wind, weather, and losing some leaves in the winter? Last, was the Indiangrass slowed down by the sound itself or by its thin blades moving around, and would other plants with thicker, evergreen leaves block more noise? As data centers continue to expand, answering these questions could provide an environmentally friendly solution to shape how we may use plants to not only beautify a building, but also reduce its negative impact on the health of the people working and living in its surrounding environment.

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