Chewing vibrations prompt plant to react with chemical releases

Plants know and hear when they’re being eaten alive by predators. Picture a speaker at field’s edge pumping out high-frequency vibrations to corn as the rows pick up the sound and ramp up production of pest-resistant chemistry.

The plant-whispering scenario sounds futuristic, but the concept might not be as far-fetched as it first seems. Plants recognize the sound of herbivores feeding on their leaves and use information based on vibrations traveling through their tissues.

At the forefront of sound and vibration research in plants, Rex Cocroft and Heidi Appel of the University of Missouri (MU), have peeled back a significant layer on the mysteries surrounding exactly how plants “hear” signals from their environment and what they are listening for. In what might turn out to be a major building block for further discovery, Cocroft and Appel’s collaboration shows plants detect chewing sounds made by insects and can respond with defensive measures. Essentially, acoustic information allows plants to detect her-bivore attacks and counter by releasing chemicals.

Cocroft, professor of biological sciences at MU, spearheaded the audio portion of multiple experiments. He recorded the sound of caterpillars feeding using a vibration microphone with laser technology. The lasers use reflected light to determine how fast a surface is moving back and forth. For example, when chewing, a caterpillar repeatedly removes a small strip of plant tissue until a hole appears. That feeding vibration is patterned—far more than when a caterpillar is moving around on a leaf. Later, when Cocroft’s recorded vibrations were played back, the Arabidopsis plant responded by increasing its production of mustard oil.

“The plant that we studied is in the mustard or cabbage family and is known for producing mustard oils in the leaves,” says Appel, who directed the chemistry side of the research. “A caterpillar that eats nothing but mustard oil plants can get poisoned if the levels get too high.”

When plants are attacked, they respond with defensive chemistry that can take from a few hours to a few days to build up. Sometimes, a plant doesn’t experience change right away but gets primed instead.

Appel, senior research scientist in the division of plant sciences in the College of Agriculture, Food and Natural Resources and the Bond Life Sciences Center at MU, uses the analogy of cocking a gun—preparing for a response to a later attack.

“That’s what we found in this case: a priming response to the feeding vibration. If a plant had received feeding vibrations before it was attacked by caterpillars, it reacted with more defense.
than if it hadn’t heard the feeding vibrations. A silent playback device served as a control,” Appel continues.

While the first experiment showed plants responded to chewing vibrations, but not indicating if the response to the chewing vibration was unique, it left open the possibility that plants might respond to any vibration in a similar manner. However, during the second experiment, Cocroft played some plants chewing vibrations; some plants insect songs; and other plants wind vibrations. Also in the second experiment, Appel went beyond mustard oil detection and measured levels of anthocyanins—the chemical that gives flowers and red wine their color.

The results confirmed their initial discovery: An increase in anthocyanins was exclusive to the Arabidopsis plants that heard chewing vibrations.

Science hasn’t yet shown how plants distinguish chewing vibrations from wind or other movements. However, plant cells have proteins called mechanoreceptors embedded in the membranes that signal when moved in certain ways. Appel suspects the mechanoreceptors are sensing vibration.

The next step of research will be to determine how perception and detection work inside plants.

Cocroft and Appel’s first experiments centered solely on Arabidopsis, a model plant Appel compares to the white rat in the medical world or E. coli in the bacterial world. Their work also focused on a single pest, the cabbage butterfly caterpillar. The duo believes they’ve discovered a common phenomenon and plan on widening the research to include more plants and pests with a grant from the National Science Foundation.

“There are maybe 400,000 species of plants, and what are the chances that we just happened to pick the one species that has this ability to detect vibration? The ability for plants to pick up sound is pretty clear, but the advance from this study is unique,” Cocroft notes.

“Rather than playing plants a sound that is foreign to their natural environment, we approached it from a plant perspective,” he adds. “What everyday sounds would be relevant? This wasn’t Beethoven’s 5th; this was a chewing herbivore capable of doing a lot of damage to the plant.”

They hope to answer three questions during their next phase of research: Does the Arabidopsis reaction occur in other plants and with other insects? What parts of vibration do the plants use to identify the activity as feeding? Are the mechanoreceptors responsible for feeding detection?

Appel is hopeful other scientists will take the sound and vibration research and apply it in agriculture.
“Decades ago, basic research on plant hormones provided the understanding necessary for the eventual discovery of herbicides,” she says. “There may be an equally important discovery that arises from this work, and we certainly hope so.”

Cocroft echoes the possibilities for agriculture. “Could sound be played out to plants in a field causing them to respond in a beneficial way? Sure, it’s very speculative, but it’s also something that could happen in the future,” he adds.

To learn more about how plants can hear sounds of danger and other technologies on the fast track to the farm.