Caroline Rempe
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Plants in Translation: The Language of Plants

"Crunch, crunch, crunch," echoes up and down the long green leaf of a rice plant. The leaf has become caterpillar food. Seemingly defenseless, with its roots deeply embedded in the earth, the plant has nowhere to run, nowhere to hide. But, the plant has a secret weapon. Tiny chemicals are released with each crunch of the caterpillar's sharp mandibles; they silently drift through the air carrying a message to a wasp – a female wasp seeking a sacrificial babysitter.

This wasp follows the chemicals to their source – the caterpillar. She injects her eggs into the body cavity of the caterpillar where they can comfortably hatch and grow inside a protective, living shelter. The young will gradually eat the caterpillar from the inside out before pupating and finally bursting out of the dying caterpillar as adult parasitoid wasps. Caterpillar enemies of the rice plant are eliminated while fostering a new generation of wasp helpers within themselves.

This elegant system is dependent on the type and proportion of tiny airborne chemicals that are released – the grammatical structures and nuanced phrasings of this language of plants. Where such effective defense systems already exist in nature, there is no need to use synthetic pesticides that can negatively impact the environment, killing both helpful parasitoids and pollinators.

Dr. Feng Chen's laboratory at the University of Tennessee, Knoxville is motivated by the agricultural implications behind understanding different levels of plant-insect interactions. "I grew up in the countryside of China," says Dr. Feng Chen. "My parents were farmers. I appreciate the challenges that farmers have to face in growing a good crop. Therefore, discovering new technologies to improve crop production has been a passion for me."

Dr. Chen has been working to understand the interactions between plants and insects since his days as a postdoc, first understanding that flower scents can both attract pollinators and deter undesirables, then realizing that plants are capable of actively producing airborne chemicals to communicate with other organisms in their community.

Plant-insect communication is often mediated by the chemical language of terpenes, which are small, airborne molecules that we might associate with the distinct scents of eucalyptus, cinnamon, or lavender. These plants and many other aromatic materials are also imbued with medicinal and anti-microbial traits by their terpenes. Terpenes that were created in the enzymatic chemical factories called terpene synthases. Carefully regulated, these factories are built up and ordered to make specific amounts and types of one or many chemicals as ordained by the plant's governing biosynthetic pathways. The messages sent by way of these factory products are thought to be very intentional, each with a particular purpose.

The Chen lab is working to understand the different dialects and origins of this chemical language. By sequencing the genes and isolating the proteins that produce terpenes, researchers can follow regulation and even ancestry of plant communication chemicals; they can identify which plant varieties are most efficient at certain types of communication for effective pest control or even identify the most efficient terpene-producing individuals within a single population for breeding purposes.

The identification of the most effective terpene producers is even now assisting in the recovery of the beautiful dogwood tree. A recent fungal blight has placed an endangered status on dogwoods in areas of the northeastern United States, so breeding programs that optimize tree health and ability to reproduce (attract pollinators) are helping them survive.

The dogwood, despite its showy flowers, has no humanly identifiable scent. Yet it does require pollinators with whom it must somehow communicate. So the Chen lab scientists used their chemical separation and identification (gas chromatography-mass spectrometry) techniques to observe which chemical compounds the dogwood flowers do release, finding a selection of the same tiny terpene chemicals that are known to be used by other pollinator-calling flowers.

Tree cultivars that can produce the most chemical messengers for pollinators are interbred to enhance their pollinating ability, which in turn will enhance breeding capabilities. Resistant strains can thus be efficiently interbred to increase the dogwood's chance for survival. As a side effect, the same interbreeding that produces a healthy, pollinator-communicative tree could result in a dogwood that emits humanly identifiable scents!

Imagine letting plants do their own pest control by calling on the right wasp. Imagine vigorous, healthy populations of once-endangered flowering trees. Imagine being able to smell the sweet scent of a dogwood blossom in the evening. These are a few of the infinite possibilities offered by an understanding of the aromatic, anti-microbial, and medicinal terpenes – an understanding researchers are only beginning to tap.