De-mystifying the study of volatile organic plant compounds

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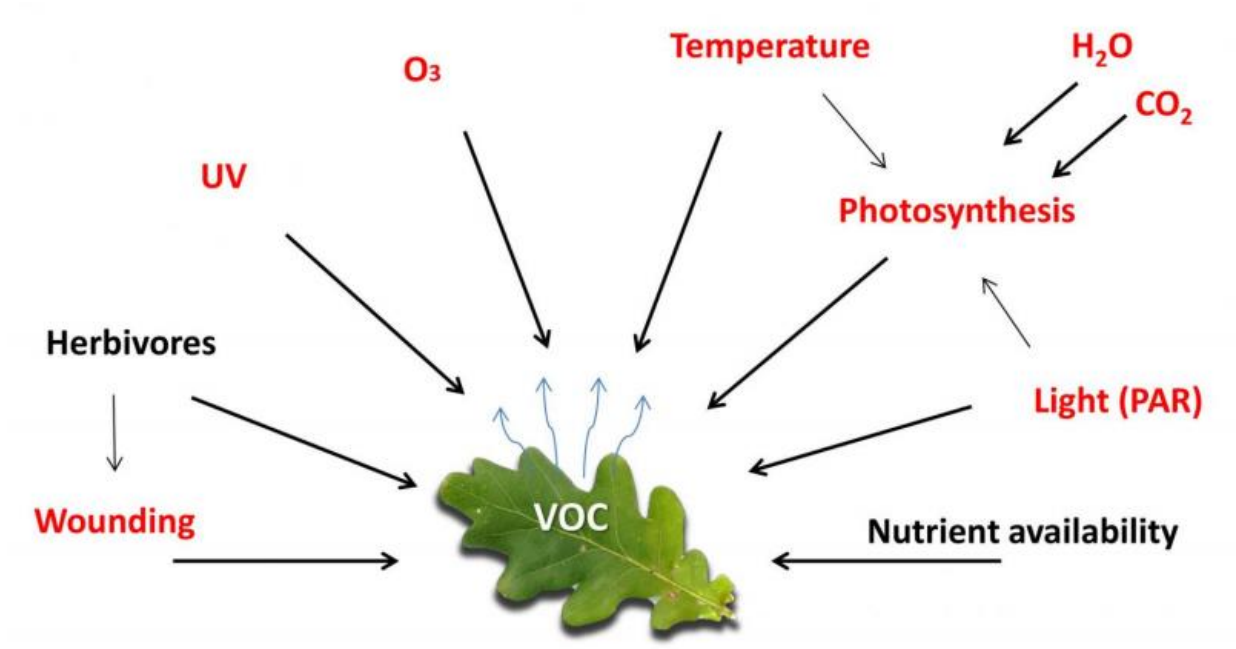

The impact of abiotic and biotic factors on plant VOC emission. The factors in red are affected by any plant enclosure. Credit: Materic, D., D. Bruhn, C. Turner, G. Morgan, N. Mason, and V. Gauci. 2015. Methods in plant foliar volatile organic compounds research. *Applications in Plant Sciences* 3(12): 1500044. doi:10.3732/apps.1500044

Similar to human pheromones, all plants emit signaling chemicals. The chemicals, called volatile organic compounds (VOCs), are ubiquitous. The smell of freshly cut grass is caused by a VOC. Ever wonder why

Christmas trees easily catch fire? Conifer trees emit a flammable group of VOCs called terpenes.

VOCs protect plants from stress, attract insects for pollination and seed dispersal, and even send warning signs to neighbor plants and animals that predators are attacking. VOCs essentially mediate relationships between plants and the organisms with which they interact.

"VOCs also affect our climate globally," says lead author of a new review of VOCs, Dušan Materić. "Most VOCs emitted in the atmosphere are actually emitted from plants, predominantly from leaf surfaces." Some plant VOC emissions, like isoprene, contribute approximately 600 million tons of carbon into the atmosphere every year, which is more than the amount of carbon emitted by all sources of methane combined.

Because the global significance of VOCs crosses several borders of disciplinary science - environmental, physical, biological, chemical, mathematical - the research requires collaborations across STEM fields. Despite this, biological research on foliar VOCs (VOCs emitted from leaf surfaces) is rare. Thanks to a new review by Materić, Vincent Gauci, and researchers from The Open University in England, biologists and environmental scientists have resources to study these essential, yet elusive, foliar compounds.

The review is published in a recent issue of *Applications in Plant Sciences* and is geared toward plant scientists with no background in the physical or analytical methods necessary to navigate the science of VOCs. "We hope that this work will help scientists who would like to move into the field of plant foliar VOCs research to get a comprehensive overview of available sampling methods and measurement techniques as well as their cost," says Materić.

Foliar VOCs are difficult to measure and highly unstable. Volatile organic compounds have low boiling points, resulting in molecules that easily evaporate into the air. VOCs react quickly with other chemicals and with surfaces of instruments used to measure them.

To sample VOCs at high precision, a chamber is placed around a plant leaf or branch. But measuring VOCs from a single leaf is difficult. Most leaves emit trace amounts of VOCs and create a slew of technical and analytical challenges for scientists. Plant chambers can change many of the factors that trigger the release of VOCs, like temperature, light, and moisture (see Image), causing a false reading of natural VOC emissions.

The review explains the trade-offs in available VOC measurement techniques, allowing scientists to easily pair robust methods with scientific questions. Using schematics and straightforward instructions, Materić and colleagues break down the pros and cons of two complex techniques—gas chromatography and chemical ionization mass spectrometry.

Although both techniques can separate and measure different types of VOCs, gas chromatography allows scientists to store samples long-term and still end up with highly accurate readings. Chemical ionization mass spectrometry (using hydronium ions [H3O+]), on the other hand, measures VOCs in real time. For example, mass spectrometry can measure in which seasons entire pine forests emit the most terpenes into the atmosphere. However, certain types of VOCs can't be measured or distinguished simultaneously using mass spectrometry, which can be necessary to understand the ecological and physiological functions of VOCs for plants.

Expected advances in the field will include techniques to capture low concentrations of VOCs with high-resolution time data. For example, simultaneous changes in the amount of VOCs that a plant secretes can

determine how quickly it responds to insect attacks or heals a recent wound.

More information: Dušan Materić et al. Methods in Plant Foliar Volatile Organic Compounds Research, *Applications in Plant Sciences* (2015). DOI: 10.3732/apps.1500044

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