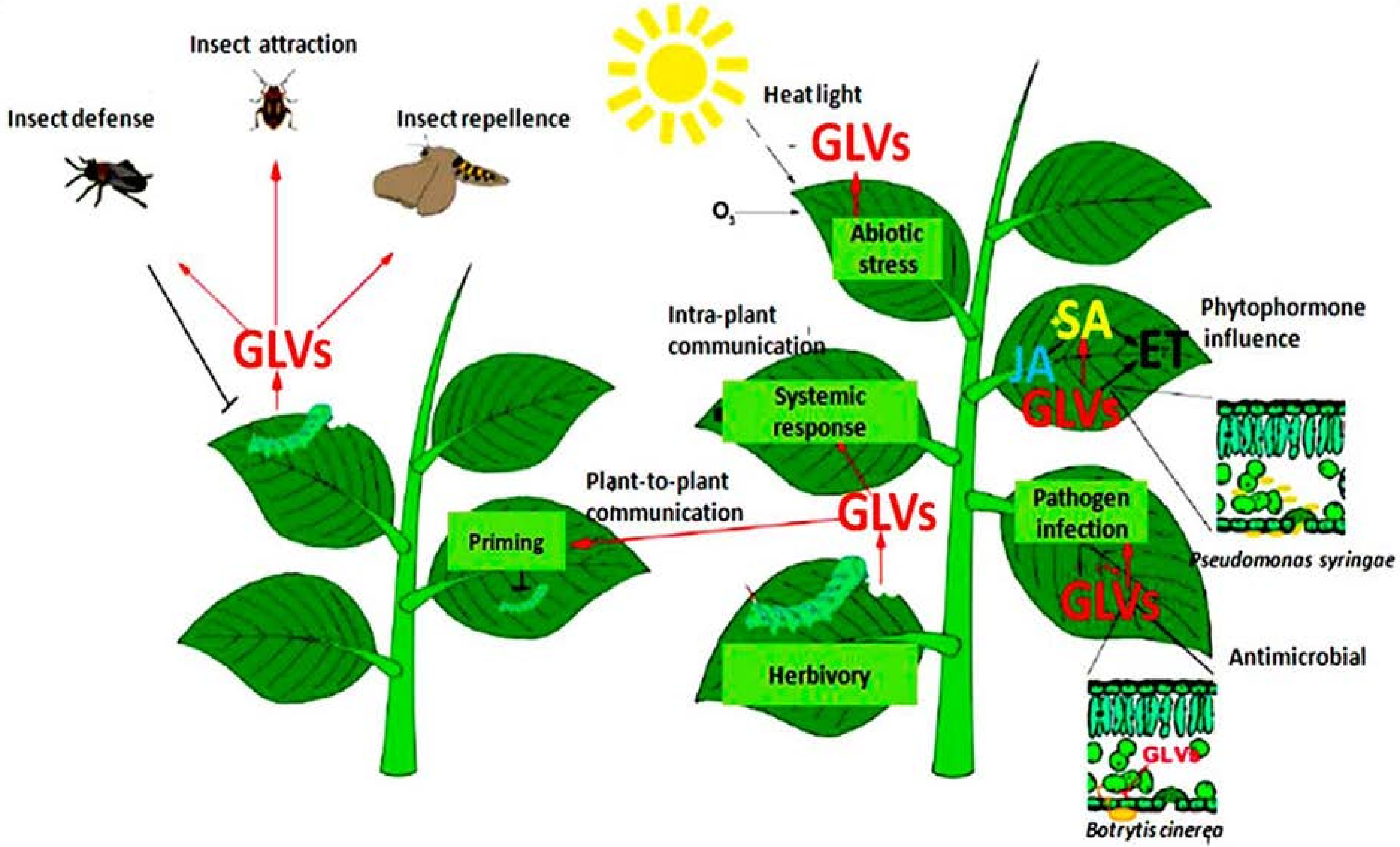
Volatile Organic Compound (VOC) based diagnosis

Volatile compounds as biomarkers

- Plants emit many volatile organic compounds (VOCs) into their immediate surroundings that serve essential functions in growth, communication, defense, and survival
- VOCs emitted from leaf surfaces are terminal metabolites of the host plant and can indicate its physiological health status.
- VOC profiling may describe “plant-to-plant” and “plant-to-pest” communication and therefore, gaining importance.
- VOC markers (hexenols, hexenals, hexenyl esters, and classes of terpenoids and indoles) may help in rapid discrimination of fungal infection and insect vector feeding



Insect attraction
Insect defense
Insect repellence
GLVs
Heat light
GLVs
O3
Abiotic stress
Intra-plant communication
Systemic response
SA
JA
ET
GLVs
Phytophormone influence
Plant-to-plant communication
Priming
GLVs
Pathogen infection
Pseudomonas syringae
GLVs
Herbivory
Antimicrobial
GLVs
Botrytis cinerea

Applications and success stories

- In peanut plants (*Arachis hypogaea*) VOC profile of healthy controls were significantly different than those infected with white mold (*Sclerotium rolfsii*); the major differences were in concentrations of methyl salicylate and 3-octanone
- The feeding behavior of beet armyworms (BAW) on healthy and white mold-infected leaves showed that the BAW preferentially consumed more on the white mold-infected leaves.
- BAW naturally emitted trace amount of hexenyl acetate, linalool, and methyl salicylate, which retarded the growth of *S. rolfsii*. In contrast, the emission of induced volatiles by *S. rolfsii* infected plants, specifically methyl salicylate and 3-octanone, attracted insect vectors such as BAW.

- VOCs profiling of potato tubers inoculated with late blight (*Phytophthora infestans*) and dry rot (*Fusarium coeruleum*) after harvest identified 52 volatiles. The most abundant compounds were benzothiazole, 2-ethyl-1-hexanol, hexanal, 2-methyl propanoic acid-2, 2-dimethyl-1-(2-hydoxyl-1-methylethyl)-propyl ester, 2-methylpropanoic acid-3-hydroxyl-2,4,4-trimethyl-pentyl, various esters, and phenol.
- The differences in the emitted VOC profile of potato tubers inoculated with *P. infestans* and *F. coeruleum* were evident and provide an early warning VOC system for postharvest disease management in potato.
- Similarly, infection by *Phytophthora cactorum*, (causes crown rot diseases in strawberries) results in the release of *p*-ethylguaiacol and *p*-ethylphenol as characteristic VOCs from the infected portion of the strawberry plant/fruit.

- Cucumber mosaic virus (CMV) in cultivated squash (*Cucurbita pepo*):
- CMV-infected plants showed an overall net increase in the quantities of VOCs such as (E)-2-hexenal, 6-methyl-5-hepten-2-one, (E)-β-ocimene, methyl benzoate, linalool, 4-ethyl-benzaldehyde, (Z)-3-hexen-1-yl butyrate, (Z)-3-hexen-1-yl 3-methylbutyrate, (E)-2-decenal, ethyl acetophenone, 3,5-dimethyl-1,2,4-trithiolane, citronellyl propionate, b-selinene, and (Z) jasmone in all plants, but no major qualitative difference in VOC profiles could be identified in infected plants.
- Both insect vectors, *Aphis gossypii* and *Myzus persicae*, were preferentially attracted to CMV-infected plants, in a similar way with BAW to mouldy peanut plants, despite the smaller size and inferior quality of CMV-infected plants. This demonstrates that the plant is inducing altered VOCs profile in response to viral infection, a mechanism known as “super normal stimulus”.

- The volatile signature of plants could be analyzed using gas-chromatography (GC) technique to analyze the presence of the specific VOC that is indicative of a particular disease.
- To enhance the performance of compound separation and analysis, the gas chromatography is often combined with mass spectrometry (GC-MS) to identify unknown compounds in the volatile sample.
- GC/GC-MS can provide more accurate information about the plant disease due to its high specificity. It also allows the detection of diseases at different stages based on the quantitative information collected from the VOC sample.