

Chemical Ecology Plant-Plant Interactions

Types of Interactions:

- can be positive or negative, intra-specific or inter-species

Examples:

1. "talking trees" (cooperation via plant-plant defense signals)
2. allelopathy (inhibition of competitors)
3. locating hosts (parasitic vascular plants)

1. History of research on communication between plants via volatiles

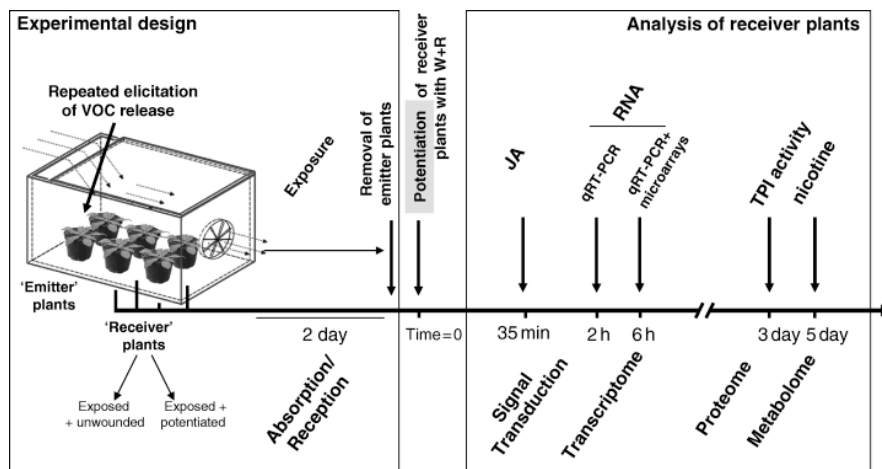
The talking tree hypothesis was the first articulation that herbivore attacked trees could warn other trees
- non-repeatable results, but interesting idea that has kept on going

The first 'real' discovery of volatiles that have effects on other plants was the discovery of methyl jasmonate
- methyl jasmonate (lipid product) can induce proteinase inhibitors (Farmer and Ryan, 1990) (cited 1464x)
- sagebrush (*Artemisia*) volatiles induce proteinase inhibitors in a different species (tomato) in enclosed containers. But: no documented tomato → tomato signaling
- nevertheless, this was the first proof of concept that plant volatile signaling can work.

Additional evidence that plant-plant defense signaling occurs

i) **intra-specific defense signals:** *Nicotiana attenuata* with suppressed green leaf volatile synthesis (GLVs)

- RNAi-suppression of **hydroperoxide lyase** leads to plants that cannot make GLVs
- by subtraction, Paschold et al., (2006) determined that 30-40 genes are induced (but not proteins) or nicotine ("plants are listening, but ignoring the message")

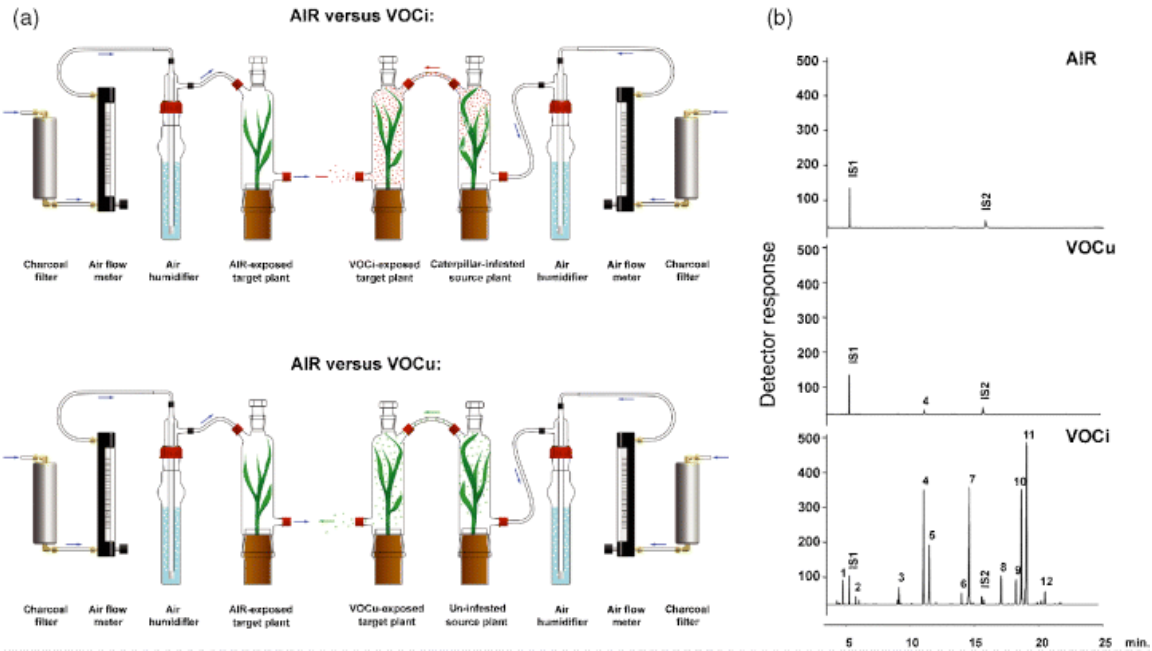


ii) **intra-plant signaling (priming):** *Populus* GLVs from one leaf can prime defenses in distal leaf via air flow

- the effect is via **priming**: early signals lead to greater volatile release by a second herbivore attack

iii) **plant-plant signaling in maize (via priming)**

- damage by caterpillar damage → releases volatiles (sesquiterpenoids. - ie β-farnesene)
- sophisticated set-up for air flow between maize plants
- wound-induced plants emit different volatiles than uninduced plants.
- a second wounding/caterpillar attack after the first damage shows greater response than non-primed plants (both direct and indirect defenses)
- herbivore growth is reduced if plants are volatile-induced previously, substantiating the priming effect.



- can plant-plant communication take place via shared mycorrhizae?
 - maybe.

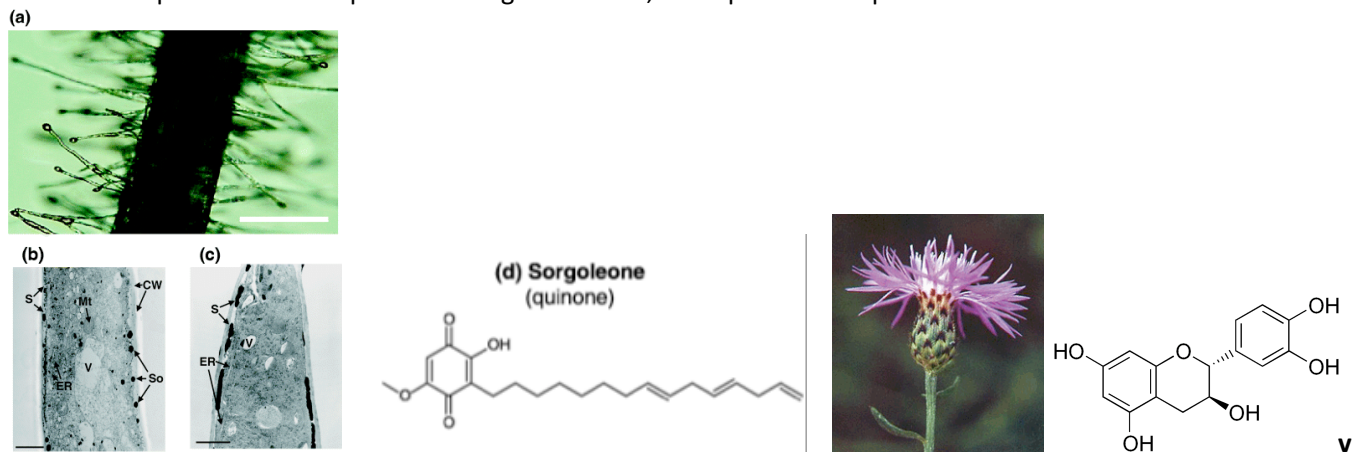
2. Allelopathy (negative interaction between competing plants)

Definition: the suppression of growth of neighbouring plants by the release of phytotoxic compounds into the environment

Note: they chemicals need to be secreted, typically from root exudates

Sorghum and sorgoleone

- sorghum is a tropical cereal crop (like millet) - also contains cyanogenic glycosides, and tannins
- sorgoleone is a quinone, actively **secreted** from root hairs
- inhibits H⁺/ATPase in roots of other species
- 10 μM inhibits competitor seed germination, and up to 10-100 μM is found in soil



Spotted knapweed in BC - invasive weed problem for BC (rangelands, competes with native grasses and forages)
 - contains (-)-catechin, but role unclear, .. original experiments / catechin concentrations could not be repeated.
 - catechin is flavanol, related to the condensed tannins

3. Parasitic Plants and Phytochemical Signals

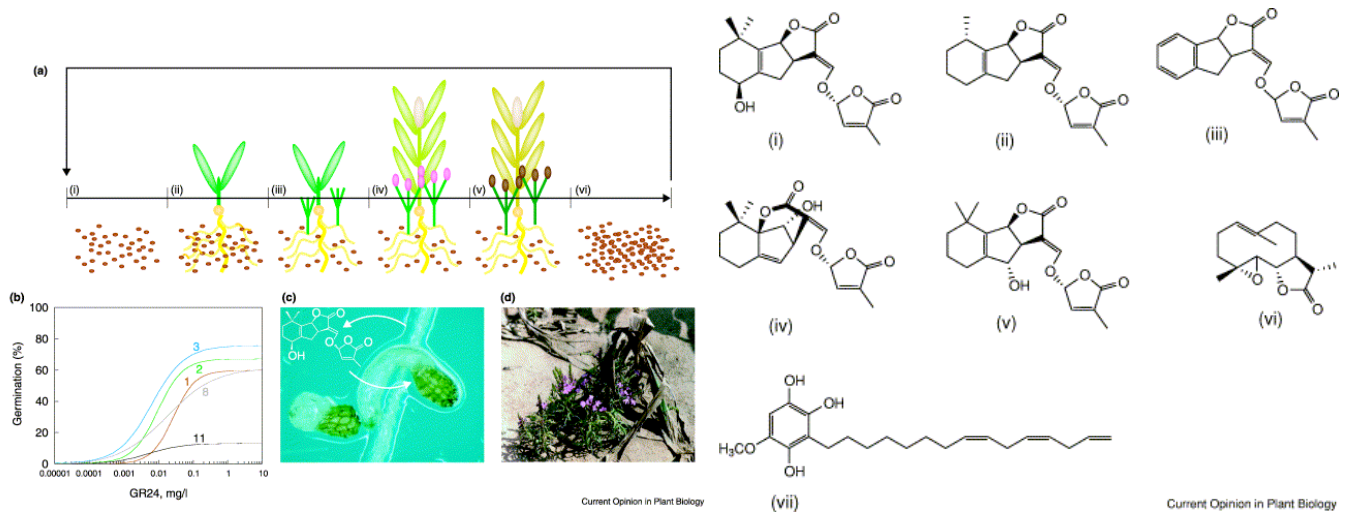
[Common parasitic plants: *Striga*, *Orobanche*, *Cuscuta*]

- obtain nutrients by tapping into vascular system of hosts (note: distinguish parasites from epiphytes, which only use other plants for support)

- dwarf mistletoes (*Arceuthium* - witches broom) in BC leads to significant forestry losses

- *Striga* (witchweed) can cause severe crop losses (root parasite on sorghum, rice, millet, maize)

=> How do these parasitic plants locate their hosts?



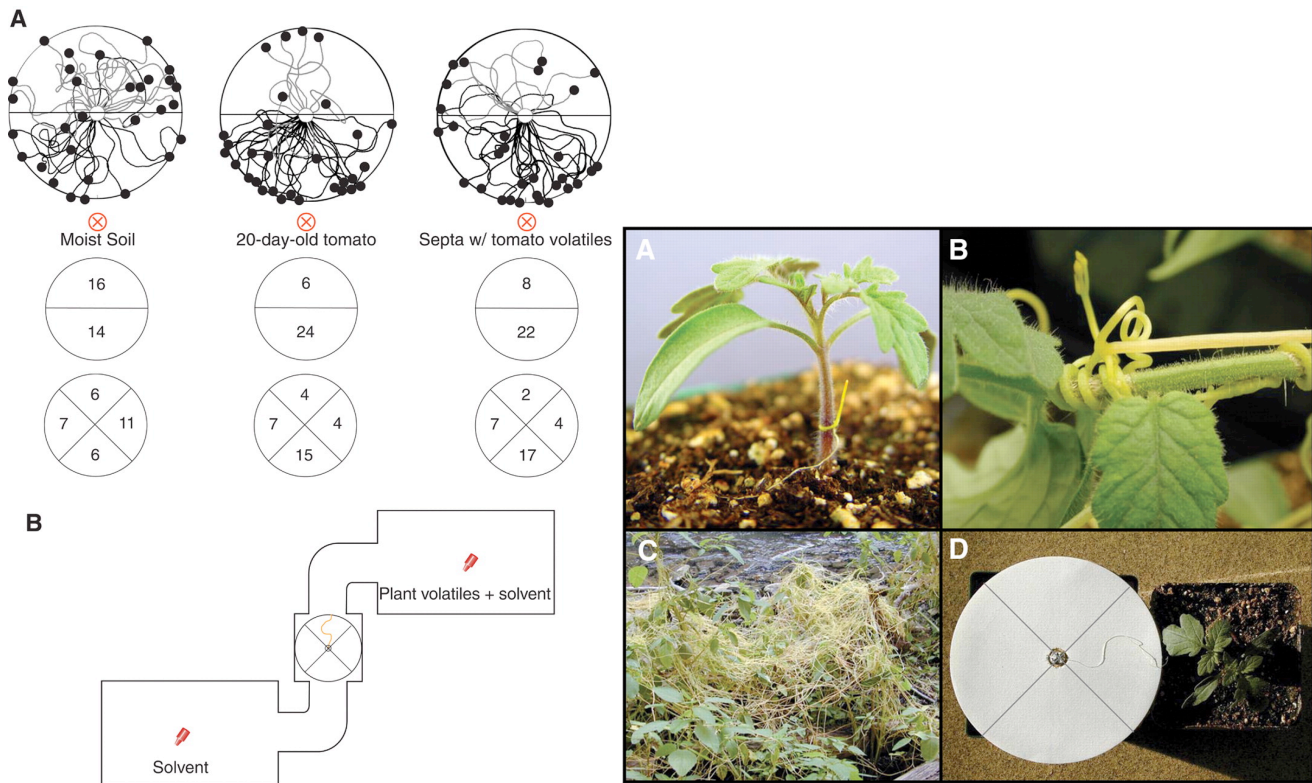
i) Germination stimulants (phytochemicals) in root exudates

- *Striga* seeds need a **germination stimulant** (from host roots)
- identified as several **lactones** exuded from roots (ie strigol, sorgolactone)
- same compounds found as **mycorrhizal fungus** branching signals for arbuscular mycorrhizae
- led to discovery of role as and **endogenous shoot growth regulators** (carotenoid derived), called strigolactones.
- strictolactones are now known as root-generated regulators of shoot branching - phytohormones.

ii) Seedling foraging for host plants - Runyon et al. (2006) Science 313

- *Cuscuta pentagona* (dodder) (morning glory family)
- germinates on its own, needs to find host after
- "forages" for and finds living plants - *what does it track?*
- use circumnutation to grow towards tomato host
- cool experiments to identify the signals

=> Therefore, several interacting organisms have learnt to '**eavesdrop**' on plants via their phytochemistry



Summary of plant-plant interactions

- only recently have these been documented - technically challenging, but recent advances in analytics make this feasible
- plants clearly detect volatiles from other plants and respond with enhanced defenses. It is difficult to establish the ecological benefit, or if this occurs under natural conditions
- some interesting very cool adaptations for detecting other plants in the case of parasitic plants
- several cases of mistaken conclusions (perhaps related technical challenges)