By Dr Charlie Reinhardt

BIOCHEMICALS
released from weeds can inhibit crop development

It is common knowledge that plants compete for the basic resources required for plant growth and development, namely nutrient elements, water and sunlight. A far lesser known fact is that long after plant-plant competition was accepted by ecologists to be the sole determinant of plant-plant interactions, a new phenomenon in plant ecology was discovered.

Although demonstrated by a few botanists in the 18th century, it was poorly understood until the 1930s, when the term allelopathy was coined to describe it. Today, it is generally accepted that the phenomena of allelopathy and competition together contribute to plant-plant interference (allelopathy plus competition), which shapes plant communities in both natural and agricultural environments.

The term allelopathy is derived from the Greek word *allelos*, meaning mutual, and *pathos*, meaning harmful – hence allelopathy describes the phenomenon whereby plants wage biochemical warfare with the natural chemicals they produce. The definition of allelopathy used to be applied to higher plants only, but has since been expanded to also include fungi.


The deleterious effect of the weed (Cyperus esculentus) is the result of the interference phenomena of allelopathy and competition acting in unison. (Photograph: C Reinhardt)

Produced by all plants
All plants (weeds and crops) can produce and release these biochemicals, known as allelochemicals, through the processes of root exudation, leaching from leaf surfaces where allelochemicals can be sequestered in specialised glands, volatilisation (allelochemicals released in gaseous form) and plant residue decomposition.

The latter process involves microbial decomposition during which allelochemicals produced in the live plant are released unaltered, and/or new allelochemicals may be produced in the process of microbes feeding on dead plant material.

Allelopathic interactions are all the more complex because different classes of biochemicals are involved, such as alkaloids, amino acids, carbohydrates, flavonoids, phenolic compounds, steroids and terpenoids, with mixtures of different compounds sometimes having a greater allelopathic effect than individual compounds alone.

Furthermore, physiological and environmental stressors such as pests and diseases, solar radiation, herbicides, nutrient deficiency, low moisture and high temperature can determine the level of allelopathic effect exerted, because there usually exists a positive relationship between increased production of allelochemicals and stress levels in plants.

Live and dead plants
Different plant parts, including flowers, seeds, leaves, stems, bark, roots, fresh plant litter and decomposed plant material, can produce different allelochemicals in varying amounts, and release them into the environment in different ways.

Scientific literature abounds with research reporting not only growth-inhibiting allelopathic effects of weeds on crops, but also of crops suppressing weeds through the release of allelochemicals into the soil, from where it is taken up by weeds.

It is important to note that allelochemicals are released from live plants, as well as from dead and decomposed plant material such as organic mulches and compost. A particular allelochemical can simultaneously act as a herbicide, GOLDEN

PEANUT AND TREE NUTS

- Grootmaat-ontvangste by Hartswater & Hoopstad.
- 18 jaar al word produsente stiptelik betaal.
- Landboukundige diens.
- Verkrygers in elke area.
- Drie nuwe kultivarlyne geregistreer.
- Kwaliteit saad.
- Genoegsame saad vir 2015/16 aanplantings.
- Saadsuiwerheid.

Hartswater
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Soya bean plants showing varying degrees of nodulation. (Photograph: John McIntyre, Villa Crop Protection)

bactericide, fungicide or as an anti-feedant (feeding deterrent to insects and animals).

This multi-purpose nature of allelochemicals is not surprising if one considers that plants are not able to physically flee from threats as most other organisms are able to do. Most of the world's main weeds have been found to have allelopathic growth-inhibiting effects on a wide range of crops, and several crop species are known to suppress weeds in a similar way.

Annual weeds and crops

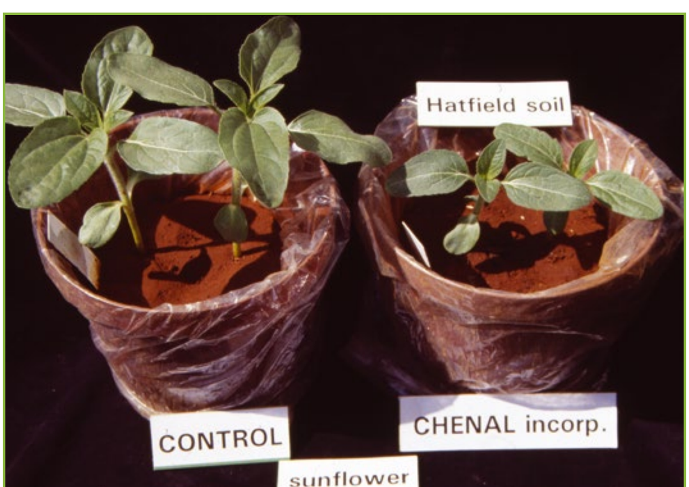
Annual weeds well known for having allelopathic potential, to name but a few, *Amaranthus* spp. (pigweed group), *Bidens* sp. (blackjack group), *Chenopodium* spp. (goosefoot group), *Conyza* spp. (fleabane group), *Cynodon dactylon,* (couch grass), *Cyperus* spp. (yellow, purple nutsedge), *Digitaria* spp. (finger grass), *Tagetes minuta* (khaki weed), *Senecio consanguineus* (John Deere bossie), *Sorghum halepense* (Johnson grass), *Striga* spp (witch weed group of plant parasites) and *Xanthium strumarium* (cocklebur).

One study demonstrated the significant inhibition of sunflower and various other crop plants where fresh material of *Chenopodium album* (white goosefoot) was incorporated in soil (1% mass/mass).

Annual crops with proven allelopathic potential include maize (low potential), sunflower (high potential), legumes (moderate to high potential), small grains (high potential), rice (high potential) and sorghum (high potential). Among the oilseeds crops, sunflower and canola stand out regarding their ability to suppress weed growth and development, irrespective of whether it is effected during active growth of the crop or by means of an organic mulch consisting of these crops' residues.

Sunflower and canola plant litter is well known for its ability to strongly suppress weed emergence and growth, and unique biochemicals (allelochemicals) with herbicidal properties have been identified in these and several other annual crops, and found to have reproducible allelopathic effects on weeds.

The principle through which crop litter can suppress weeds rests on the premise that allelochemical concentration is directly related to plant litter biomass, thus explaining the observation that a minimum load (biomass) of plant mulch is required for effective weed suppression. This is a key consideration in reduced tillage systems where crop residues have other valuable purposes, such as preventing soil erosion, and promoting water infiltration and retention of soil moisture.



Suppression of sunflower by allelochemicals released from 1% (mass/mass) soil-incorporated foliage material of the weed Chenopodium album (white goosefoot). (Photograph: C Reinhardt)

Optimum biomass

Knowing the optimum crop litter biomass for weed suppression purposes is important, because whereas a lower than optimum biomass will likely fail to suppress weeds, a higher than optimum biomass might be detrimental for the crop itself (autotoxicity is the term used to describe same-species allelopathic effect, or a crop can be allelopathic to other crops).

Producers of soya bean and other legumes that are dependent on N-fixing bacteria should be mindful of not only the direct allelopathic effects which live and/or dead weeds may have on crop growth and development, but also of indirect allelopathic effects due to inhibition of N-fixing bacteria by those same allelochemicals.

A scientific study has found that residue of *Chenopodium murale* (nettle-leaved goosefoot) releases phenolic allelochemicals, which deleteriously affect the growth and nodulation of chickpea and pea. It is known that members of the *Fabaceae* plant family produce flavonoid compounds that signal to symbiotic rhizobia and encourage root nodule formation where symbiotic dinitrogen fixation occurs.

Because it is impossible to predict which type of allelochemicals and in what amounts it will be produced and released by a weed at any stage of its lifecycle, either before or after its death, the safest option is to keep weed numbers (weed biomass) as low as possible.

For more information and references, contact Dr Charlie Reinhardt, extraordinary professor of Weed Science at the University of Pretoria and dean of Villa Academy, on 083 442 3427 or email dr.charlie.reinhardt@gmail.com.