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ALLELOPATHY: CONCEPTS IN AGRICULTURE

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Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, by the release of chemicals from plant parts by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems.

Environmental impact: Allelopathy is a form of chemical competition. The allelopathic plant is competing through "interference" chemicals. Competition, by definition, takes one of two forms-exploitation or interference. Competition is used by both plants and animals to assure a place in nature. Plants will compete for sunlight, water and nutrients and, like animals, for territory. Competition, like parasitism, disease, and predation, influences distribution and amount of organisms in an ecosystem. The interactions of ecosystems define an environment. When organisms compete with one another, they create the potential for resource limitations and possible extinctions. Allelopathic plants prevent other plants from using the available resources and thus influence the evolution and distribution of other species. One might say that allelopathic plants control the environments in which they live.

Allelopathy is a process by which a plant releases chemicals that can either inhibit or benefit other plants. Since most allelopathic plants cause harm to other plants, that's the what I'll be discussing here. Species competition ensures the biodiversity of ecosystems. All plants and animals have developed techniques for out-competing other species for nutrients, water, territory, and other resources. For example, certain plants have extremely dense root systems.

Depending on the plant, allelopathic substances can be released from a plant's flowers, leaves, leaf debris and leaf mulch, stems, bark, roots, or soil surrounding the roots. Some of the chemicals biodegrade over time while others can be persistent in the soil.

Probably the most well-known allelopathic plant is the black walnut (*Juglans nigra)* tree. All parts of the tree-roots, bark, leaves, nuts, and even rainwater that falls off a leaf-release an allelopathic substance called juglone. Some species are affected by it and others aren't bothered at all

Other common trees with allelopathic properties include eucalyptus, sugar maple, tree-of-heaven, hackberry, southern waxmyrtle, American sycamore, cottonwood, black cherry, red oak, black locust, sassafrass, and American elm.

Different strokes for different plants: Many plants, however, easily tolerate juglone; these include vegetables such as melons, beans and carrots and trees such as Eastern redbud and southern catalpa. In low concentrations, juglone even appears to stimulate growth in some species-an anomalous effect observed in other allelopathic associations. For instance, it appears to have this effect on Kentucky bluegrass, a cool-season grass that may also produce allelopathic chemicals.

How to cope with allelopathic plants: Dr. Thomas Green, a professor of urban forestry at Western Illinois University, has studied the effects that turf grass and ornamental trees have on each other. These groups of plants tend to have incompatible needs and compete with each other both above ground and below.

"What we tend to do as horticulturists is pick Plant A that we like and Plant B that we like and put them together," Green said. He points out, though, that some of the associations we come up with have never occurred in natural situations, where associated plant species have often co-existed over eons and have possibly even evolved to tolerate each other's chemical toxins. Some grasses, and fescues in particular, are allelopathic. In many cases of tree-turf grass competition, Green has found it best for both the trees and the grasses to simply separate them by heavily mulching an area several feet out from the tree. "Mulch will eliminate competition of the roots with grass. It also preserves moisture for the fine surface roots of the tree. With mulch we're emulating nature-exactly what happens in the forest." This way, what was taken up by the tree into its leaves is directly recycled. Also, both direct competition and allelopathy between turfgrass and the tree are avoided.

Using allelopathy to your advantage: Often the ways farmers and gardeners have dealt with allelopathy-whether they pegged the phenomenon by name or not-have been simple and practical: separate a plant that inhibits the growth of others, or else use that plant to the garden's advantage.

Rye has allelopathic properties, as do several other

cover or "smother" crops-oats, wheat, barley and sorghum. In fact, Rice's *Allelopathy* cites a 1983 study that showed "populations of common purslane and smooth crabgrass were reduced 70 and 98 percent, respectively, by residues of sorghum." "Reduce competition-that would be the primary objective," said Dr. Bill Klingeman, a professor of plant sciences at the University of Tennessee, about allelopathic plants. "But the other benefit would be that if they outcompete other plants, then you get a uniform stand. If the plant helps you out, that's an added benefit." Synthesizing allelochemicals for their herbicidal applications, or using certain allelopathic plants in crop rotations or as companion plants, is yet another burgeoning branch of allelopathic research.

Nature of Allelopathy: Commonly cited effects of allelopathy include reduced seed germination and seedling growth. Like synthetic herbicides, there is no common mode of action or physiological target site for all allelochemicals. However, known sites of action for some allelochemicals include cell division, pollen germination, nutrient uptake, photosynthesis, and specific enzyme function.

Allelopathic inhibition is complex and can involve the interaction of different classes of chemicals like phenolic compounds, flavonoids, terpenoids, alkaloids, steroids, carbohydrates, and amino acids, with mixtures of different compounds sometimes having a greater allelopathic effect than individual compounds alone.

Furthermore, physiological and environmental stresses, pests and diseases, solar radiation, herbicides, and less than optimal nutrient, moisture, and temperature levels can also affect allelopathic weed suppression. Different plant parts, including flowers, leaves, leaf litter and leaf mulch, stems, bark, roots, soil and soil leachates and their derived compounds, can have allelopathic activity that varies over a growing season. Allelopathic chemicals can also persist in soil, affecting both neighboring plants as well as those planted in succession. Although derived from plants, allelochemicals may be more biodegradable than traditional herbicides but may also have undesirable effects on non-target species, necessitating ecological studies before widespread use.

Selective activity of tree allelochemicals on crops and other plants has also been reported. For example, *Leucaena leucocephala*, the miracle tree promoted for revegetation, soil and water conservation and animal improvements in India, also contains a toxic, non-protein amino acid in leaves and foliage that inhibits the growth of other trees but not its own seedlings. *Leucaena* species have also been shown to reduce the yield of wheat but increase the yield of rice. Leachates of the chaste tree or box elder can retard the growth of pangolagrass but stimulate growth of bluestem, another pasture grass.

Research strategies and potential applications: The basic approach used in allelopathic reseach for agricultural crops has been to screen both crop plants and natural vegetation for their capacity to suppress weeds. To demonstrate allelopathy, plant origin, production, and

Allelopathic Plant	Impact
Rows of black walnut interplanted with corn in an alley cropping system	Reduced corn yield attributed to production of juglone, an allelopathic compound from black walnut, found 4.25 meters from trees
Rows of Leucaena interplanted with crops in an alley cropping system	Reduced the yield of wheat and tumeric but increased the yield of maize and rice
Lantana, a perennial woody weed pest in Florida citrus	Lantana roots and shoots incorporated into soil reduced germination and growth of milkweed vine, another weed
Sour orange, a widely used citrus rootstock in the past, now avoided because of susceptibility to citrus tristeza virus	Leaf extracts and volatile compounds inhibited seed germination and root growth of pigweed, bermudagrass, and lambsquarters
Red maple, swamp chestnut oak, sweet bay, and red cedar	Preliminary reports indicate that wood extracts inhibit lettuce seed as much as or more than black walnut extracts
Eucalyptus and neem trees	A spatial allelopathic relationship if wheat was grown within 5 m
Chaste tree or box elder	Leachates retarded the growth of pangolagrass, a pasture grass but stimulated the growth of bluestem, another grass species
Mango	Dried mango leaf powder completely inhibited sprouting of purple nutsedge tubers.
Tree of Heaven	Ailanthone, isolated from the Tree of Heaven, has been reported to possess non-selecitve post-emergence herbicial activity similar to glyphosate and paraquat
Rye and wheat	Allelopathic suppression of weeds when used as cover crops or when crop residues are retained as mulch.

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