ALLELOPATHY IN WEEDS AND CROPS: MYTHS AND FACTS

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Allelopathy is defined as the effect of one plant on another through the release of a chemical compound into the environment (Bhowmik and Inderjit, 2003). Allelopathic compounds, often considered plant-produced herbicides, can inhibit growth of nearby plants of the same and/or other species. The observation of allelopathic plant suppression is not new. Theophrastus observed that chickpea reduced nearby weed growth as early as 300 B.C., and Plinus Secundus (1 A.D.) reported that corn was "scorched" by chickpea, barley, and bitter vetch (Singh et al., 2001). While the concept of allelopathy is not original, effective demonstration of allelopathy on plant growth and the subsequent reliable application in agricultural pest management have been relatively minimal.

Many crop and weed species have been observed to have allelopathic properties (Table 1). Over 240 weed species have been reported to be allelopathic to other nearby plants of the same species (autotoxicity) or other crop and weed species. The use of allelopathy to favor the crop over weeds has been investigated in three aspects: 1) as an allelopathic winter cover crop that suppresses weeds prior to the cropping season; 2) as a living mulch during the cropping season to reduce weed interference; and, 3) as an isolated compound from an allelopathic plant, applied as an herbicide. To date, the use of allelopathic cover crops, such as rye and oat, has resulted in the greatest application of this concept in agriculture. Rye residue has been reported to reduce green foxtail, redroot pigweed, common ragweed, and common purslane emergence by 80, 95, 43, and 100%, respectively (Putnam and DeFrank, 1983). Oat allelopathy differs among crop cultivars. Grimmer and Masiunas (2005) reported that 20 of 24 tested oat cultivars reduced common lambsquarters germination, but that the amount of reduction ranged from 10 to 86% among cultivars. The timing, growth stage, soil type, and climatic conditions during cover crop growth also affect the amount observed allelopathy.

Table 1. Selected common crops and weeds with reported allelopathic properties. Adapted from Qasem and Foy (2001) and Batish et al. (2001).

Crops		Weeds
alfalfa	soybean	Canada thistle
asparagus	sunflower	cocklebur
barley	tomato	common lambsquarters
bean	wheat	field bindweed
beet		foxtail sp.
broccoli		jimsonweed
cabbage		kochia
clover		pigweed sp.
corn		quackgrass
cucumber		ragweed sp.
oat		smartweed sp.
pea		velvetleaf
potato		wild mustard
rapeseed		wild oat
rice		yellow nutsedge
rye		

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The effect of allelopathic crops on weed growth has been very difficult to isolate. Weed suppression by neighboring plants is a combination of allelopathy and physical interference. Physical interference includes impedance of light, water, nutrients, and other resource by the cover crop residue or living mulch. Allelopathic compounds are often very complex and short-lived, and therefore are difficult to isolate and identify. Allelopathy research conducted in greenhouses often doesn't account for the effect of microorganisms, climate, and soil type, and thus often exaggerates the potential weed suppression compared to field conditions. In field research, the effect of physical interference is difficult to separate from allelopathy. Despite these difficulties in research methodology, a few studies have demonstrated allelopathic effects of cover crops on weed growth. Creamer et al. (1996), for example, compared physical suppression by rye and barley residue that had been leached of allelopathic compounds with similar residue containing allelopathic compounds. Yellow foxtail emergence reduction by rye residue was attributed to physical suppression alone, while a combination of physical suppression and allelopathy in barley reduced yellow foxtail emergence by 81%. Petersen et al. (2001) reported that isolated allelopathic compounds from turnip-rape plants suppressed several weed species, including smooth pigweed, spiny sowthistle, and barnyardgrass.

Allelopathic species have also served as the source of plant-derived herbicides. The synthetic herbicides mesotrione (Callisto®) and glufosinate (Rely®, Liberty®) were originally derived from allelopathic compounds. Mesotrione is derived from leptospermone, a compound isolated from the callistemon or bottle brush plant. Glufosinate is derived from a compound found in microbes. The ability to develop more herbicides from allelopathic compounds is limited by several factors. Allelopathic compounds tend to be short-lived in the environment, complex, and unpredictable. Additionally, they are often non-selective in their control, expensive to synthesize, and in some cases, present potential mammalian toxicity, carcinogenic, and allergenic concerns. Despite these limitations, herbicides based on allelopathic compounds often represent novel target sites important in managing pesticide resistance, are water soluble, and are perceived as more "environmentally-benign."

Over 2,900 papers have been published on allelopathy for weed control, dating back to 300 B.C., yet weeds continue to be a concern in allelopathic crops. While allelopathic weed control has often proven difficult to research and demonstrate, it can be applied as a component in an integrated pest management system. In addition to weed suppression benefits, several allelopathic compounds also suppress pathogen and nematode pressure. Current research to increase the reliability of allelopathic pest suppression and to breed for increased allelopathy in crops may improve the practical applications of this concept.

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