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Autotoxicity and Alfalfa Establishment

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Introduction

Re-establishment of alfalfa (*Medicago sativa* L.) has often been unsuccessful because of autotoxic effects of the crop on seedlings (Tesar 1993). Farmers and ranchers have known for many years that re-establishment of alfalfa after plowing or reseeding a poor stand without plowing to "thicken up" an unproductive stand may not be successful (Dexter, 1940). Wing (1909) stated that "alfalfa should not be sown again until it has rested some seasons" and "there are hidden influences that we do not understand that make soils unfriendly to plants that have grown in them too long."

Allelopathy and Autotoxicity

Allelopathy is defined as the direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that escape into the environment (Rice, 1984). Autotoxicity is an intraspecific form of allelopathy that occurs when a plant species releases chemical substances that inhibit or delay germination and growth of the same plant species (Putnam, 1985). Alfalfa (*Medicago sativa* L.), a perennial legume forage crop, contains water-soluble substances that are autotoxic as well as inhibitory to other species (heterotoxic).

The harmful autotoxic effect of alfalfa upon itself during and after establishment was first defined by Jensen et al. (1981). They stated that autotoxicity exists "when a plant inhibits the growth of the same species." For alfalfa, autotoxicity exists when it has

lower germination, poorer establishment, and/or lower productivity when grown after itself than after another species or after fallow (Tesar, 1993). The aqueous extract of alfalfa shoots inhibits root elongation, shoot elongation, and/or germination of alfalfa itself; a phenomenon termed **autotoxicity** (Hedge, 1992).

When does Autotoxicity Occur?

Field reports indicate an autotoxic effect when alfalfa is no-till seeded within several days after glyphosate application to alfalfa. Some research has shown, however, that there is little or no harmful effect of autotoxicity in the field if seedings are made several weeks or months after plowing or spraying old alfalfa with glyphosate to kill the alfalfa.

Mueller-Warrant and Koch (1980) reported that seeding within several days after glyphosate application on the field reduced seedling densities and harvest yields. Tesar (1993) reported reduced density and lower yield when year-old alfalfa was spring seeded two days after glyphosate treatment than when treated the previous fall.

Jensen (1984) reported no difference in density or yields after 5-year-old alfalfa was fall-plowed four months before spring seeding. Mueller-Warrant and Koch (1980) showed that "a 2 to 3 week wait" until seeding after spring-applied glyphosate on six-year stands of alfalfa produced the best stands.

Tesar (1993) reported the lack of any significant autotoxicity after fall plowing of year-old-alfalfa 195 days before spring seeding is important since fall plowing on non-erosive soil is often recommended for good seedbed preparation in spring. The lack of any significant autotoxicity in 6-, 4-, and 1-year-old alfalfa with delayed seeding indicated that seeding failures can be reseeded if there is an interval of at least 2 weeks after plowing or tilling or 3 weeks after glyphosate application to the failed stand. No autotoxic effect was evident when seedings were made, 9, 18, or 49 days after plowing established alfalfa or when no-till seedings were made 21, 23, or 35 days after glyphosate treatment of established alfalfa.

What Causes Autotoxicity?

Researchers have identified inhibitory compounds which are involved in alfalfa autotoxicity (Hall and Henderlong, 1989; Dornbos et al., 1990). In 1989, Hall and Henderlong reported a phenolic water-soluble phytotoxic substance in alfalfa.

Earlier work by Miller et al., (1988) indicated that **medicarpin** was implicated as the allelochemical in alfalfa that causes autotoxicity. Medicarpin produced by alfalfa and applied exogenously to alfalfa seeds reduced their germination by 59% after 6 hours when used in a filter paper bioassay. Dornbos et al. (1990) reported that medicarpin, sativan, four methoxy-medicarpin, and five methoxysativan were present in alfalfa foliage and might be contributing to autotoxicity.

In 1992, Hedge reported that shoots of alfalfa contain autotoxic water-soluble chemical compounds. Among the several phenolic compounds assayed for their phytotoxicity on root and shoot growth of alfalfa, coumarin and trans-cinnamic acid at 60,+/- 10 micrograms mL⁻¹ were the most inhibitory. Hedge's work indicated that mixtures of five or more phenolic acids were more phytotoxic than their respective individual components except in the case of trans-cinnamic

acid and coumarin. At that time, Hedge concluded that autotoxicity in alfalfa may be caused by an interaction of many, yet uncharacterized compounds present in shoots.

In 1993, Tesar suggested that the dissipation of autotoxic effects with elapsed time in days between plowing of glyphosate application and seeding for alfalfa stands ranging in age from 1 to 7 years is probably due to decomposition of **phytotoxic compounds**. In 1995, Chung and Miller concluded that although several compounds have been studied, none has been conclusively identified as the main autotoxic factor.

Summary and Recommendations

Research results indicate that alfalfa can be re-established without significant autotoxicity if seedlings are made at least two weeks after glyphosate application in established alfalfa or after seedling failure (Tesar, 1993). Reseeding of poor stands of alfalfa or continuous alfalfa culture is possible without autotoxicity problems using the following practices:

- (1) seeding at least 2 weeks after plowing
- (2) early fall glyphosate application on alfalfa and early spring no-till seeding
- (3) spring or early summer no-till seeding at least 3 weeks after spring glyphosate application on alfalfa. Other practices essential for successful continuous culture of alfalfa are maintenance of adequate soil fertility and proper soil pH, and use of cultivars with resistance to harmful soil- and debris-borne pathogens.

Un-resolved Questions

Is there a rainfall or irrigation requirement to dilute toxic effect?

Is there a temperature minimum for decomposition?