AY-324-W

Agronomy Guide

Purdue University Cooperative Extension Service

Managing Alfalfa Autotoxicity

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Alfalfa stands thin over time due to pests, poor fertility, winter killing, and stresses associated with harvesting. It would be useful to be able to improve alfalfa stands by overseeding periodically or at specific locations in a field where plants have been lost. Numerous studies have shown that alfalfa seedlings grow very slowly and often die when placed in close proximity to established alfalfa plants. For instance, Asbil and Coulman (1992) overseeded an existing alfalfa stand with 4 or 11 lbs/A of alfalfa seed (Fig. 1). Overseeding had no impact on yield the year of overseeding and increased yield only 1 T/A in the year after overseeding. Plant populations increased from 1.5/ft^2 to 3 and 4 plants/ft^2 for plots receiving 4 and 11 lbs seed/A, respectively. At these seeding rates 18 and 55 seeds/ft^2 are planted, indicating that only 5 to 8% of the seed resulted in new plants. This extensive death of alfalfa seedlings when seeded into an established alfalfa stand is known as autotoxicity. Autotoxicity prevents managers from successfully thickening alfalfa stands by overseeding. It also can result in poor germination and reduced vigor of alfalfa seedlings replanted into destroyed (plowed or herbicide plus no-till) alfalfa fields without rotation (Fig. 2).

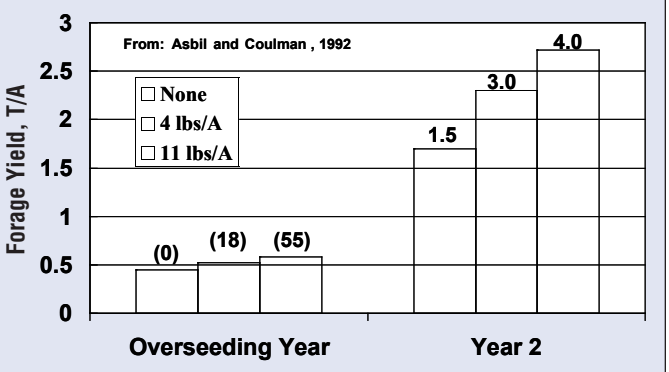

Figure 1. Influence of overseeding a poor alfalfa stand with 4 or 11 lbs/A of alfalfa seed. Forage yield was measured the year of overseeding and the year following overseeding (Year 2). Harvest number was the same for each treatment within a year. Numbers above bars indicate seeds planted per square foot in the overseeding year and plant density (plants/ft^2) in Year 2. Data are averaged over two years.

Figure 2. The effects of alfalfa autotoxicity on newly seeded alfalfa. The left strip plot was seeded 2 weeks after tillage of an existing alfalfa stand, whereas the right strip plot was tilled 18 months prior to seeding. The thin, inconsistent alfalfa stand in the left strip is indicative of alfalfa autotoxicity. Photo credit: Dr. John Jennings, University of Arkansas.

Autotoxicity - A Form of Allelopathy

Difficulty in reseeding/overseeding alfalfa is due primarily to the allelopathic effects of alfalfa plants and residue. Allelopathy is defined as the effect (in this case harmful) of one plant on another through the production of chemical compounds that escape

to the environment. Many of us have witnessed allelopathy. Black walnut trees produce a compound called "hydrojuglone" that slows plant growth under the tree. Autotoxicity is a form of allelopathy that occurs when a plant releases a compound that prevents germination or slows the growth of the same plant species.

Alfalfa Autotoxicity

The chemical factor(s) causing alfalfa autotoxicity have been studied, but unlike walnut trees, the identity of the compound(s) causing it remains unclear. The water-soluble chemical factor is more concentrated in leaf tissues and flowers when compared to stems and roots. Extracts of leaves and flowers have been shown to reduce germination (Fig. 3) and seedling growth (Fig. 4) of alfalfa much more than do extracts of stems, roots, and seeds (Chung and Miller, 1995b).

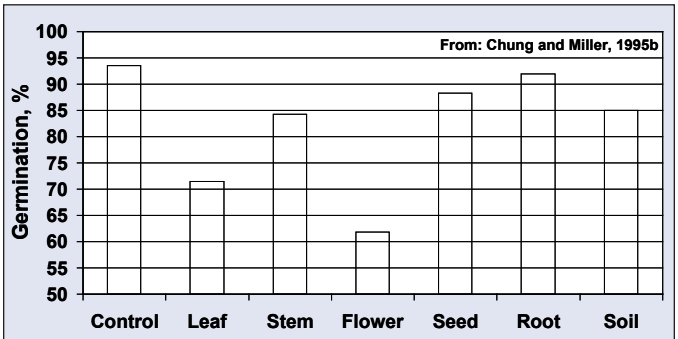

Figure 3. Impact of water extracts obtained from different alfalfa tissues and the soil surrounding alfalfa plants on germination of alfalfa seeds. Extracts obtained from leaves and flowers have the greatest inhibitory effects on germination. Controls were provided water.

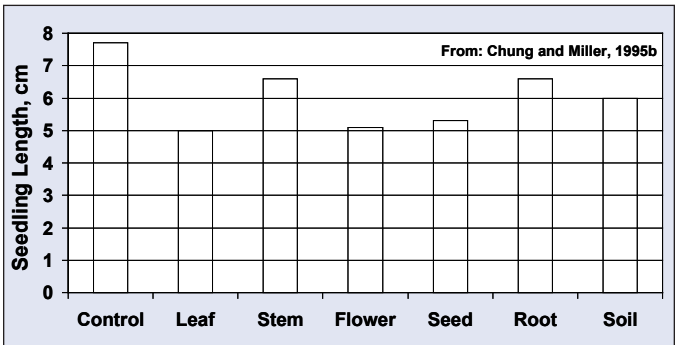

Figure 4. Impact of aqueous extracts obtained from different alfalfa tissues and the soil surrounding alfalfa plants on growth of alfalfa seedlings. Extracts obtained from leaves and flowers have the greatest inhibitory effects on germination. Controls were provided water.

In addition, stage of alfalfa growth can impact autotoxicity. Extracts obtained from forage at the reproductive stage of growth contains more autotoxin than does forage at the vegetative stage of growth (Fig. 7; Hegde and Miller, 1992). Medicarpins and phenolics have been implicated, but the true identity remains a mystery. Whatever the factor's nature, it is a potent inhibitor of alfalfa seedling vigor and disrupts root development leading to death of the taproot and more root branching (Fig. 5).

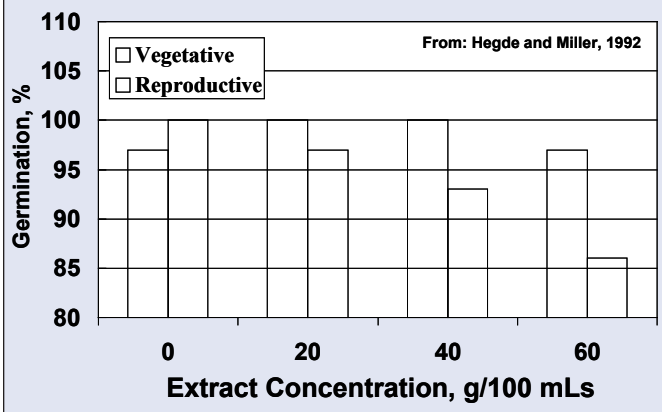

Figure 7. Influence of extract source and concentration on germination of alfalfa seeds. Vegetative or reproductive alfalfa herbage was extracted with concentrations ranging from 0 to 60 g dry wt./100 mL of water. Vegetative herbage extracts did not reduce germination at 20 or 40 g/mL concentrations but did reduce germination at 60 g/mL. Extracts of reproductive herbage reduced germination at each concentration assayed.

Figure 5. The impact of autotoxicity on alfalfa root morphology. Taproots of plants seeded within 2 weeks of tillage of an existing alfalfa stand (left) die, resulting in formation of branched roots that are less effective in nutrient and water uptake. Taproots of plants seeded 18 months after tillage of an existing alfalfa stand (right) possess the normal, carrot-like morphology. Photo credit: Dr. John Jennings, University of Arkansas.

Seedlings growing in close proximity (within eight inches) of existing alfalfa plants often die, or grow very slowly. Seedlings 8 to 16 inches from an existing alfalfa plant often survive, but their shoot growth is usually stunted and root development is poor (Fig. 6). Seedlings that emerge more than 16 inches from an existing alfalfa plant often grow normally. The negative effects of autotoxicity on alfalfa seedlings make it difficult to overseed an existing, but thin alfalfa stand. Even at low populations of existing alfalfa plants where overseeding might be attempted (2 plants/ft^2), most seed and seedlings end up within 16 inches of an existing alfalfa plant, and as a result, grow poorly.

Figure 6. Alfalfa seedlings in close proximity to an existing alfalfa plant exhibit reduced growth clearly demonstrating the autotoxic effect that existing alfalfa plants have on alfalfa seedling development. Alfalfa was seeded in an cross pattern over the "flagged" plant in the center of the photo. Note the reduced seedling growth extending out approximately 15 inches in each direction from the center of the flagged plant. Beyond 15 inches there is little reduction in growth of the new alfalfa seedlings. Photo credit: Dr. John Jennings, University of Arkansas.

Alfalfa autotoxicity is not limited to overseeding, but also has been observed when alfalfa is seeded into a field that previously grew alfalfa. Numerous studies have been conducted in order to understand the autotoxic effects of alfalfa on establishing alfalfa in the same field. Measured, reductions in stand have averaged about 20% with yield reductions ranging from 8% (not significant) to as high as 52% (Table 1). This broad range in responses suggests that environment, management, and/or possible plant genetics impact autotoxicity responses of alfalfa seedlings.

Location	No. Expt.	⇓ Yield, %	⇓ Density, %	Reference
Alberta	1	52		Goplen and Webster, 1969
Illinois	1	23	26	Miller, 1983
Michigan	4	16		Tesar, 1993
Nebraska	2	29		Kiesselbach et al, 1934 Kehr et al., 1983
Virginia	1	21		Bryant and Hammes, 1981
Missouri	3	8	19	Jennings and Nelson, 2002

Table 1. Summary of alfalfa autotoxicity experiments indicating that yield and stand density can be reduced by reseeding alfalfa into a recently destroyed alfalfa field.

Recent work (Seguin et al., 2002) indicates that location where the experiment is conducted and year in which the alfalfa is sown influence conclusions regarding autotoxicity. For example, alfalfa stands were reduced about 20% both years at Location 1; unaffected Year 1, but reduced 10% Year 2 at Location 2; and reduced 10% Year 1, while increasing 15% in Year 2 at Location 3 (Fig. 8).

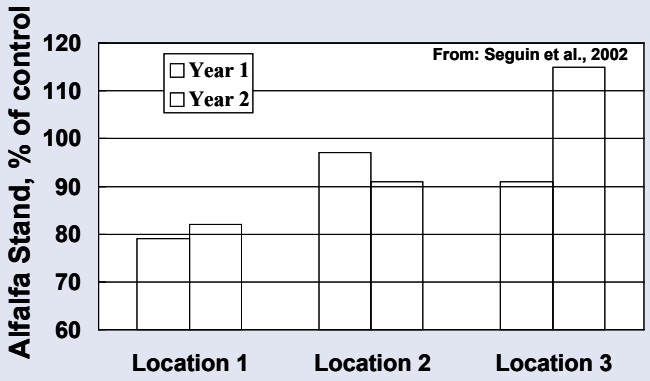

Figure 8. Influence of year and location on autotoxicity after reseeding alfalfa into a field that previously was in alfalfa. Consistent results were obtained at Location 1, but results at Locations 2 and 3 varied with year.

Results of research in Michigan are often used to guide alfalfa reseeding decisions. Autotoxicity under tilled and no-till conditions were studied, and seeding was done beginning immediately after the existing alfalfa stands were killed weekly (Tesar, 1993). Regardless of tillage system, seedling stands and forage yield in the seeding year and beyond were unaffected by autotoxicity if replanting was delayed three weeks or more after the stand was destroyed (Figs. 9-11). In this study, successful replanting was possible by Day 14 if tillage was

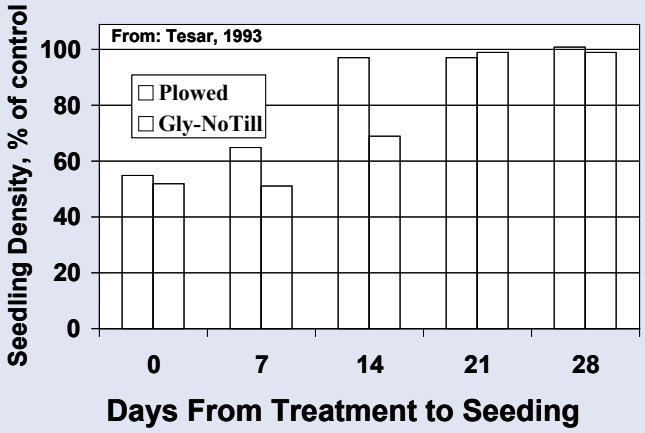

Figure 9. Influence of tillage system and time after destroying an existing alfalfa stand on seedling density of reseeded alfalfa. An existing alfalfa stand was destroyed using conventional tillage (plowed) and reseeded, or killed with glyphosate and no-till seeded at weekly intervals beginning immediately after stand destruction.

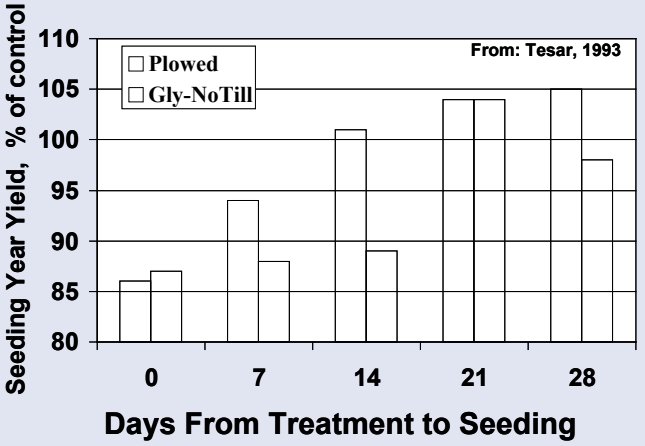

Figure 10. Influence of tillage system and time after destroying an existing alfalfa stand on seeding-year forage yield of reseeded alfalfa. An existing alfalfa stand was destroyed using conventional tillage (plowed) and reseeded, or killed with glyphosate and no-till seeded (gly-no-till) at weekly intervals beginning immediately after stand destruction.

used, but waiting until Day 21 was necessary if existing alfalfa stands were killed with glyphosate and alfalfa reseeded using no-till methods.

Inconsistent results over time and locations make it difficult to predict how replanting decisions might impact alfalfa reseeding successes on an individual farm. Nevertheless, guidelines have been developed that should reduce the risk of autotoxicity impacting productivity of alfalfa re-seeded fields that previously were alfalfa.

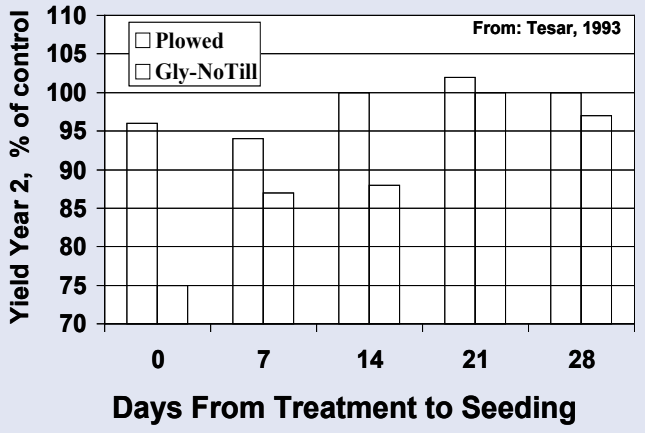

Figure 11. Influence of tillage system and time after destroying an existing alfalfa stand on second-year forage yield of reseeded alfalfa. An existing alfalfa stand was destroyed using conventional tillage (plowed or killed with glyphosate and no-till seeded (gly-no-till)) and reseeded at weekly intervals beginning immediately after stand destruction.

Guidelines

1. For least risk, wait at least one year before reseeding alfalfa into a field previously in alfalfa.
2. At a minimum, do not reseed alfalfa into a previous alfalfa field until at least two weeks after destroying the previous alfalfa stand using tillage.
3. If you are no-tilling alfalfa after killing the previous alfalfa stand with herbicide, wait three to four weeks before reseeding alfalfa.
4. In all cases, remove alfalfa forage prior to killing the stand in order to reduce the abundance of autotoxic compounds released to the soil from leaves and flowers.
5. Irrigation and rainfall leaches the toxic-causing compound out of the soil profile and reduces autotoxicity. Reseeding delays should be extended if dry weather occurs while old alfalfa stands are being destroyed.
6. Additional tillage prior to reseeding alfalfa mixes the soil and reduces autotoxicity.
7. Autotoxicity tends to disappear from sandy soils sooner than soils with a clay texture. Therefore, reseeding delays should be extended on clay-containing soils.
8. Reseed a seeding failure promptly before autotoxicity can become a problem.

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