Managing weeds with crop rotation

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"Rotation of crops...is the most effective means yet devised for keeping land free of weeds. No other method of weed control, mechanical, chemical, or biological, is so economical or so easily practiced as a well-arranged sequence of tillage and cropping."

— C.E. Leighty. 1938 Yearbook of Agriculture

Diversity is key. Dissimilar crop species with disparate management practices impose a wide range of stresses and mortality factors, creating an unpredictable environment to which the weed community is continually adjusting (Liebman and Staver, 2001). Diversity, however, may also establish and/or perpetuate weed problems. Fall cucurbits, for example, may permit considerable weed growth after vines run, causing abundant seed rain (see sidebar, Figure 1, below). Cover crops, while frequently noted for their ability to reduce weed biomass, often contain weeds going to seed. Perennial legumes or sod crops favor perennial weeds such as quackgrass, and do not include timely soil disturbance events that promote germination losses of annual weeds. Thus, while diversity *is* key, successful weed management requires cropping sequences that feature practices that minimize, or better, eliminate, "credits" to the weed seedbank, while maximizing seed "debits."

Short-season cash or cover crops, whose growth is terminated before weeds set seed, are the most useful elements in preventing weed seed credits (Figure 1). The tillage events necessary for these crops are often well-timed to preempt seed rain of winter annual weeds. Ideally, the crops are then terminated before their associated summer annual weeds set seed. In considering longer-season crops, good weed control, a competitive canopy, and opportunity for hand roguing surviving weeds are key attributes.

Debiting strategies require consideration of weed seedbank ecology (Gallandt, 2006). Because germination is the most effective way to deplete the seedbank, it may be useful to consider primary tillage practices that maintain seeds at or near the soil surface, in the "active seedbank," where seeds are most likely to experience environmental conditions that encourage germination. Seed predation is also an important source of loss from the seedbank, and a further reason to keep seeds at the soil surface. Avoiding fall tillage and rapid weed seed burial maintains seed at the soil surface where they are more readily consumed by predators.

Initial conditions of the seedbank should be carefully considered in short-term crop sequence planning. Where the starting weed pressure is very high, a clean fallow period is the best strategy for drawing down the seedbank (Mohler, 2009; Nordell and Nordell, 2007). Because weed species vary in their seasonal patterns of emergence, the timing of fallow periods should target the most problematic species or group of weeds. Winter annuals, for example,

exhibit peak emergence in the late fall and early spring—summer annuals, in the warmer periods of June and July. Shallow tillage coincident with this emergence periodicity will stimulate germination of the targeted group of weeds, and subsequent tillage kills these seedlings.

If the seedbank is at a moderate level, cropping options may be expanded to include crops that are both amenable to effective cultivation, and are sufficiently competitive that abundant weed seed rain is unlikely. These so-called "cleaning crops," seem to vary from farm to farm. Onions, for example, are a cleaning crop for some growers. A long-season and uncompetitive crop, growers know onions must be nearly weed free, so they make frequent cultivation a priority for this crop. This frequent, shallow cultivation offers benefits similar to fallowing strategies, encouraging successive flushes of weeds that are removed by subsequent cultivation events. While the need for repeated cultivation may be viewed negatively in the short-term, the long term effect is depletion of the seedbank. Potato and sweet corn are cleaning crops for some growers. These crops can be aggressively cultivated and weeds kept at a minimum. Slow to establish, uncompetitive species, e.g., carrot and parsnip, onion and leek, are ideally planted in the cleanest of fields.

Weed Seed Rain

We measured common lambsquarters weed seed rain in a broccoli, winter squash rotation, managed without cover crops (control), with fall cover crops, two consecutive years of red clover (2-Yr. CC), or alternate years of vegetables and cover crops with summer fallowing (e.g., after strategies described by Nordell and Nordell, 2007; Figure 1). The alternate year cover crop system consistently had the lowest common lambsquarters seed rain (see Alt.-Yr. CC, solid boxes, below). This, combined with the seedbank depleting fallowing periods during the cover crop years, prevented this species from increasing over the four years of the experiment (data not shown).

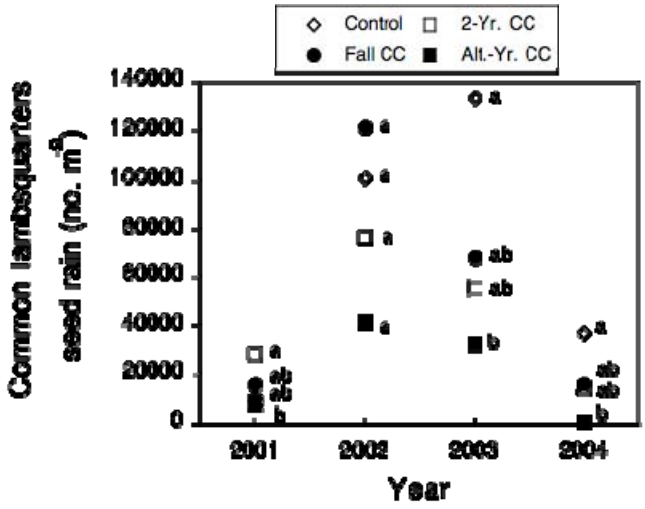

Figure 1. Effect of cover crop systems on common lambsquarters seed rain in 2001 through 2004. Within a year means labeled with different lowercase letters are significantly different based on Tukey's HSD ($P < 0.05$). Gallandt, E.R. unpublished data.

Given the importance of the relative size of the weed seedbank to the success of subsequent weed management practices, it seems counterproductive for an otherwise clean rotation sequence to include a crop likely to result in abundant weed seed rain (e.g., my problem with winter cucurbits). Rotation blocks could consider likelihood of seed rain as a first separating criterion. "Weed-free" blocks could be managed with a long-term vision for improving weed management conditions. Elsewhere, the commonly used "critical period" for weed control can continue to guide management, focusing on control of weed seedlings in the

early to mid-period of crop growth. Before the start of this period, weeds are too small to reduce crop yield; after this period crop competition alone will avoid weed-related yield losses. In other words, “beat the weeds back” early to ensure a good crop and don’t worry about weedy crops late in the season. There are many successful farmers who rely on this approach to weed management. They focus on repeated cultivation and hand weeding until crops are judged to be sufficiently weed-free. However, seed rain from weeds surviving the critical period means that weed pressure is likely to increase over time. In response, the frequency of cultivation and hours of hand weeding will have to increase to simply maintain a given level of weed control. The alternative, managing for improving weed conditions, requires careful deployment of diversity, minimizing credits and maximizing debits to the seedbank (Gallandt, 2006).

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