Chapter 9: Biological Weed Control

William Curran, Meredith Ward, and Matthew Ryan

Summary

Biological control (biocontrol) tools for weeds include insects, mites, nematodes, pathogens, and grazing animals. Grazing animals and insects can directly impact weeds and reduce their growth and competitiveness. Other biocontrol organisms will feed on weed seeds and reduce seed return to the soil seedbank.

Introduction

Biological weed control is the deliberate use of a weed's natural enemies to decrease weed density. This method does not eradicate the target weed but exerts enough pressure on it to reduce its dominance to a more acceptable level. Biological control can be cost effective, environmentally safe, self-perpetuating, and well suited to an integrated weed management program. However, it is a long-term undertaking, the effects are not always adequate to prevent weed competition with the cash crop, and it only works with certain weeds.

There are four methods of biological weed control:

1) Classical – using a non-native organism (usually an insect) that is released in areas infested with the targeted weed and the biocontrol organism feeds on the weed and reduces the weed population over time;
2) Inundative – rearing an organism in a controlled setting then releasing it at high numbers to control native or invasive weeds;
3) Conservation – manipulating a cropping system to increase the populations of natural weed suppressing organisms; and
4) Grazing – using large herbivores such as cattle or sheep to reduce weed populations.

Classic and Inundative Biocontrol

In the Northeast, classical and inundative biocontrol tactics are used on several invasive weeds, such as bull and musk thistle, Canada thistle, purple loosestrife, mile-a-minute, and garlic mustard. Along with several promising insect biocontrol tools, some rust fungi and bacteria are being evaluated for managing several weeds, including the knapweeds and the thistles. Classical biocontrol is the identification and

release of a weed predator to control an invasive weed species. Invasive weeds often establish in new areas before the arrival of predators from their home range, so introducing predators from their home range can help suppress the invasive weed. Inundative biocontrol is the use of a weed predator but rather than allow the biocontrol agent to naturally increase in numbers, the predator is bred in a controlled environment and then a large number can be released in a small area to suppress weeds. Most of the potential for classical and inundative tactics is focused in perennial systems with low annual disturbance. Frequent disturbance, such as tillage, mowing, or natural phenomena (e.g. fires or floods) greatly affects the survival of biocontrol organisms. Over the long term, these biological weed control tactics may have a major impact on managing problem weeds in rangeland, pasture systems, and natural areas. However, research is ongoing, and the true impacts remain to be seen.

Classical and inundative biocontrol tactics are not currently available in agronomic crops where disturbance is common (through tillage, mowing, or other methods). However, conservation tactics and grazing animal management have the greatest potential to reduce weed populations. Both of these tactics provide broad spectrum weed control and can be successfully used today.

Conservation Biocontrol

Conservation biocontrol relies on understanding the biology and habitat suitability of the beneficial insects or rodents that feed on weeds or weed seeds. In order for a beneficial insect or rodent to contribute to weed control, the habitat (i.e. field) must meet its needs (i.e. for adequate food and shelter). With this knowledge, management practices are adjusted so that these organisms are promoted or encouraged. Establishing a winter cover crop using no-till is a conservation biocontrol practice because it protects invertebrates in the cropping system, such as ground beetles, which consume weed seeds on the soil surface. Establishing windrows that provide habitat for rodents such as field mice is another conservation biocontrol practice. Both insects and rodents readily feed on weed seeds, potentially reducing the number of weeds that emerge the next year. Decreasing soil disturbance and providing ground cover or refuge from predators is one of the key ways to conserve these naturally occurring biocontrol organisms.

This approach creates favorable habitats for the insects and rodents already present in an area. These organisms are then active when weeds are vulnerable. Organisms that feed on weed seeds (weed seed predators) are active when weed seeds are maturing (predispersal) and after they are dispersed (postdispersal). Sole use of this method of biological control will not completely suppress weeds and limit crop yield loss. However, the combination of conservation biocontrol with other cultural, mechanical or chemical management tactics could have a greater positive impact.

Numerous organisms are weed seed predators. Some of the most common (and

promising) are rodents, ants, crickets, and ground beetles. The amount of seeds consumed will vary depending on predator populations, weed seed availability, and field management. Reducing tillage, providing residue cover, and limiting insecticide use are key field management requirements. In an Iowa study, seed predation rates from May to November ranged from 7 to 22% of available weed seeds consumed or removed per day depending on crop type (Figure 9.1) (Westerman et al. 2005). Higher predation rates were observed in small grain and alfalfa as compared to corn and soybean.

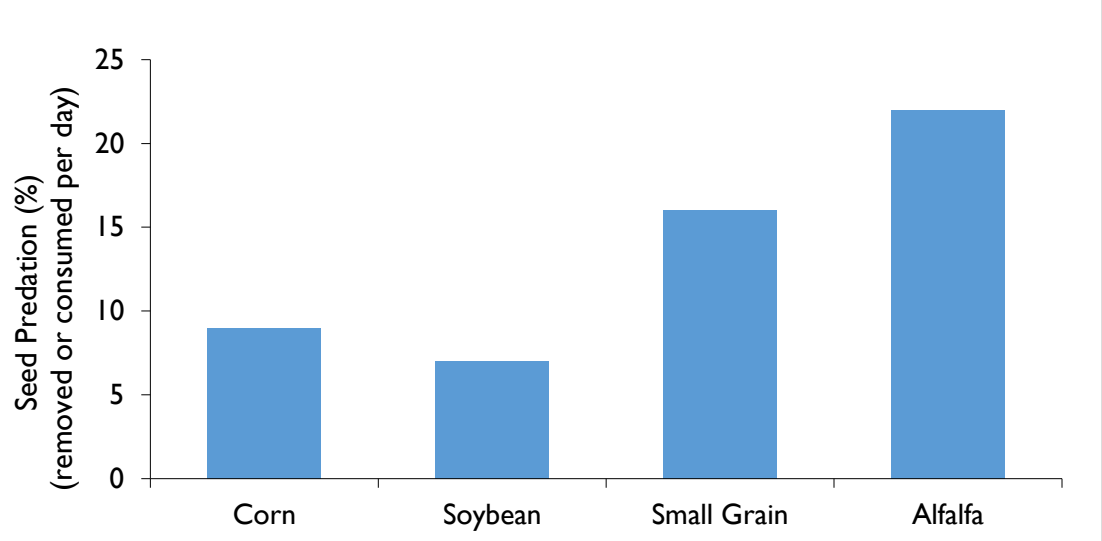

Figure 9.1. Seed predation rates in five cropping systems. More predation occurs in systems with less tillage (Westerman et al. 2005).

The rate of seed predation also increases as the crop canopy develops; spring-planted corn and soybean crops provide little protection for seed predators early in the growing season. In a Pennsylvania study (Ward et al. 2011), 38 to 61% of the giant foxtail seeds were removed (eaten) during two-week sampling periods in sweet corn. Peak predation occurred in late July and early August when the corn canopy was well developed (Figure 9.2). In another Iowa study, predation of giant foxtail seeds in wheat increased when red clover was planted into wheat in the spring (Davis and Liebman 2003). Seed predators likely seek habitats that provide enough cover to protect them and provide a plentiful food source.

Key seed predators have not been identified for most weeds. Best management practices to encourage weed seed predators are likewise not well-studied. However, typical farm management practices such as tillage and crop rotation can be slightly changed to incorporate practices that increase weed seed predator populations. For example, integrating a legume cover crop after small grain in a rotation can enhance predation because the plants provide protection for seed predators. Planting refuge

strips of perennial grasses around the crop field boundaries and in waterways can create favorable habitat for ground beetles, fungi, and nematodes. Increasing plant residue and decreasing tillage, especially in the fall, also can cause certain seed predator populations to flourish. Conservation biocontrol may improve our ability to manage weeds using less herbicide.

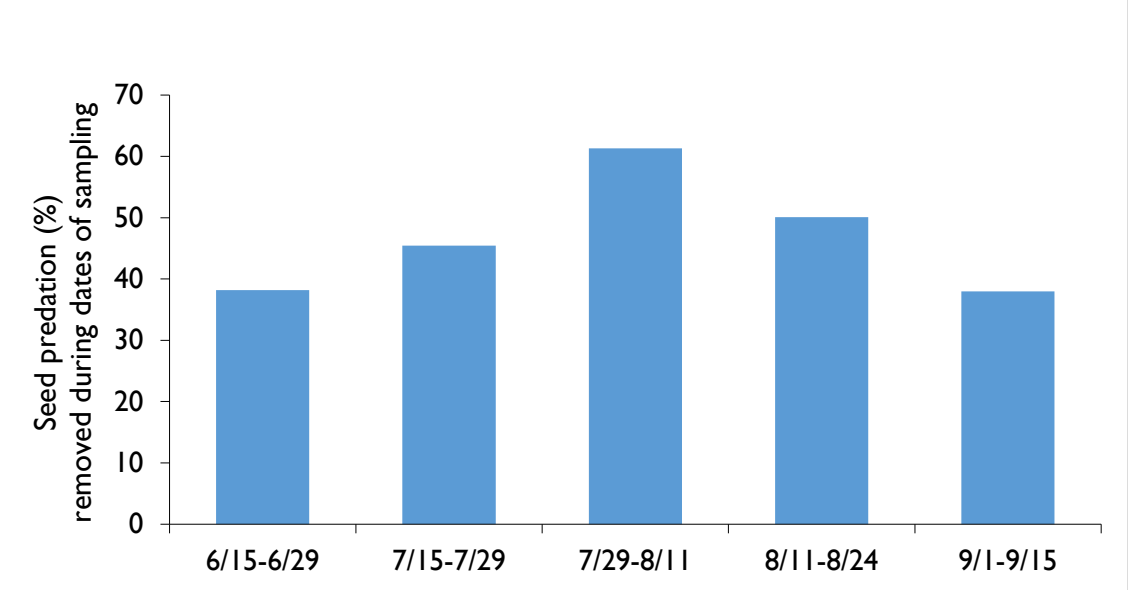

Figure 9. 2. Seed predation in Central Pennsylvania sweet corn during 2005 in (Ward et al. 2011).

Potential beneficial seed predators

Mice. Mice are opportunistic feeders, consuming high-density food sources that are easily available. As a result, seeds are their primary food source (Zhang et al. 1997). Mice can consume 90 to 100% of an area's weed seeds in a 12-hour period (Abramsky 1983).

Rodents locate seeds using their olfactory senses and can even find seeds buried under the soil surface (Table 9.1) (Abramsky 1983). Rodents feed first on the large seeds and when bigger seeds have been consumed or removed, they then shift to smaller seeds. Mice also are one of the few weed seed predators that consistently eat hard shelled seeds (Brust and House 1988). Unfortunately, mice can be problematic in some cropping systems by feeding on crop seeds. They also may disrupt irrigation equipment, plastic mulch, and other agricultural tools. Encouraging

Table 9.1. Efficiency of buried barley seed removal by rodents (Abramsky 1983).

Depth (in)	Amount of seeds removed (g)	% removed
0.4	102	79
1.2	104	80
2.0	70	70
6.0	47	47

vertebrate predators like mice may be best suited to large scale annual row crop production where the risk of crop or equipment damage is minimal.

Ants. Most of the research looking at ants as weed seed predators has been conducted in Europe and Australia with little information from the United States. Ants are diurnal insects that spend the day actively foraging and feeding and remain in their nests at night. Ants feed on weed species with small seeds (Brust and House 1988), such as common ragweed, redroot pigweed, and common lambsquarters. In pastures, these insects can remove 2 to 30% of Italian ryegrass seeds within 24 hours and up to 43% of small-seeded weed seeds over a 20-day interval (Jacob et al. 2006). Feeding preference studies have shown that the amount of each seed type removed by ants was strongly influenced by the amount and kinds of other seeds in the immediate area (Zhang et al. 1997). This suggests that certain weed seeds are more readily consumed than others. Ants also tend to colonize agricultural fields in high numbers. However, their activity can be reduced by tillage and high levels of crop residue or stubble (Jacob et al. 2006). This suggests that ants could be important seed predators in row crops after inter-row cultivation has ceased.

Crickets. When crickets gather in large numbers in new seedings of no-till alfalfa and clover, they are considered a pest. However, they also can be important weed seed predators. Crickets are nocturnal omnivores that consume dead and living insects, broadleaf plants, grasses, and seeds. They emerge in early August with peak activity in the middle of September and populations decreasing in October (Carmona and Landis 1999). Field observations and laboratory studies showed crickets consume common agricultural weed seeds such as velvetleaf, common lambsquarters, redroot pigweed, waterhemp, large crabgrass, common ragweed, and giant foxtail. Cricket populations tend to peak in late summer about the same time that summer annual weeds produce and shed seeds. Crickets can remove more than 76% of weed seeds in 24 hours in a m^2 (Figure 9.3), and a single female northern field cricket can consume over 200 redroot pigweed seeds in a single day (Carmona and Landis 1999).

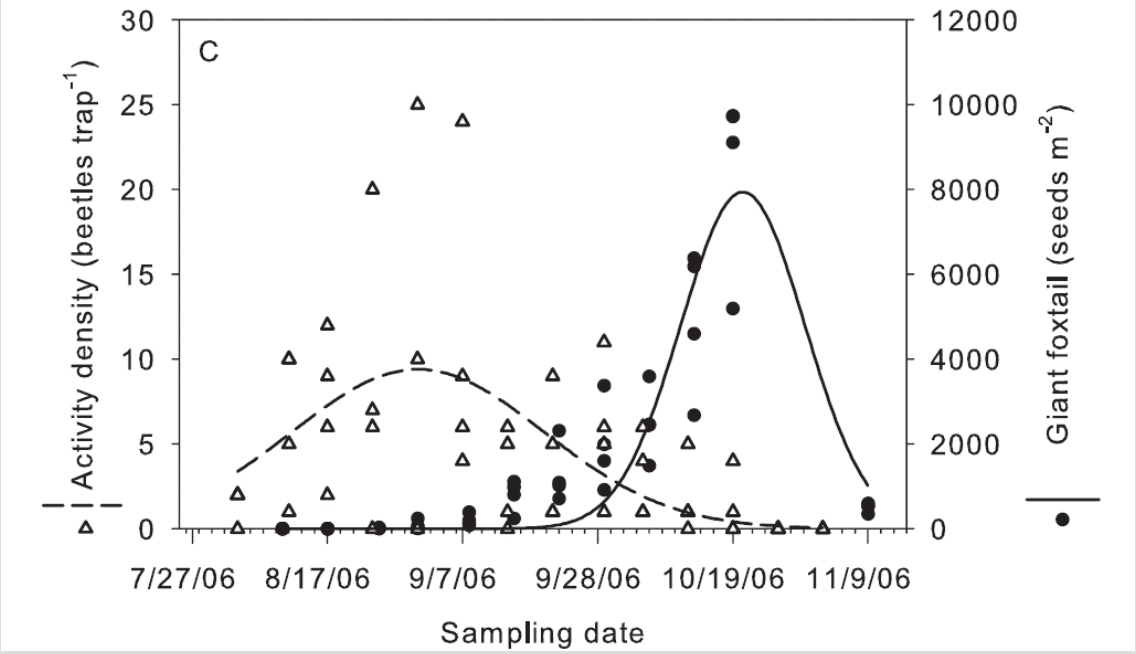

Figure 9.3. Ground beetle (*Harpalus pensylvanicus*) activity (left) and giant foxtail seed rain (right) over time in 2006 in Pennsylvania. Activity density numbers represent how many beetles are active and captured over a 72-hour period. Although the presence of the beetle overlapped with giant foxtail seed rain, beetle activity was greater in August and early September, while foxtail seeds were not dispersed until later in the fall (Ward et al. 2014)

Carabid beetles. Ground beetles, otherwise known as carabid beetles, are common throughout the Mid-Atlantic region in agricultural landscapes (Photo 9.1). *Harpalus pensylvanicus,* a common carabid found in Pennsylvania and a known seed predator, emerges from hibernation in the spring, and is most active from July through September in the Mid-Atlantic region. Adults consume plant tissue, pollen, fungi, insects and seeds, preferring small broadleaf and grass seeds (Best and Beegle 1977). Ground beetles can be responsible for up to 90% of weed seed predation in some agroecosystems. A single ground beetle can consume up to 11 seeds daily, and an active population can remove as many as 120 to 130 seeds per square foot per day (Honek et al. 2003). However, ground beetle activity does not always coincide when weeds seeds are shed from the plant (Figure 9.3) (Ward et al. 2014).

Photo 9.1. Ground beetle feeding on weed seed (Photo credit: E. Gallandt, Univ. of Maine).

Unlike rodents, ground beetles do not survive intense disturbances, such as fall or spring plowing. Fortunately, many of these insects are fairly mobile and can abandon fields in autumn to overwinter in fence rows, field edges, and water ways. They do not necessarily prefer one crop over another but may prefer different crop types throughout the growing season. Decreasing or eliminating soil disturbance, especially in the late summer when beetles are feeding, mating, and laying eggs, can increase ground beetle activity.

Although conservation biocontrol could be an important part of a weed management program, additional research is needed to completely understand this tactic. Individual farmers can incorporate practices that encourage weed seed predation and monitor how these practices affect their weed management program. Integrating conservation biocontrol is only one tool in a suite of practices that complement each other to reduce the annual return of weed seeds to the seedbank.

Grazing Animals

Grazing management can minimize the spread of certain weeds and control large weed infestations. However, in most cases, grazing does not eradicate a mature infestation of weeds. For grazing animals to be useful for weed control, fencing maybe required to adjust grazing pressure. Increasing grazing pressure by increasing animal numbers and grazing duration at key times during the growing season prevents livestock from grazing selectively (eating some plants and not others). They then must consume more undesirable species. The key to this method of weed control is to concentrate stock on weed infestations at key stages of weed growth and keep them off pasture or weeds at other times (Popay and Field, 1996). Grazing animals for weed control is limited to time periods between crops or shortly after the crop is established when grazing can be tolerated and the crop is able to recover quickly.

Key Points

- Biological control tools for weeds include insects, mites, nematodes, pathogens, and grazing animals.
- Biological control can be cost effective, environmentally safe, self-perpetuating, and well suited to an integrated weed management program.
- Biological control is a long-term undertaking: it is not immediate or always adequate, only certain weeds are potential candidates, and the rate of failure can be high.
- Seed predation can be responsible for up to 90% of seed loss in agroecosystems.
- Some of the most promising seed predators are rodents, ants, crickets, and ground beetles.
- Reduced tillage can increase predation because weed seed predation occurs mostly on the soil surface.
- Cover crops create better habitats for seed predators.
- Promote and maintain diverse fencerows, filter strips, and refuge habitats that allow overwintering and protection for ground beetles, rodents, crickets and other seed predators.

References

Abramsky Z (1983) Experiments on seed predation by rodents and ants in the Israeli desert. Oecologia 57:328-332

Best RL, Beegle CC (1977) Food preference of five species of carabids commonly found in Iowa corn fields. Environ Entomol 6:9-12

Brust GE, House GJ (1988) Weed seed destruction by arthropods and rodents in low-input soybean agroecosystems. Am J Alt Agric 3:19-25

Carmona DM, Landis DA (1999) Influence of refuge habitats and cover crops on seasonal activity-density of ground beetle (Coleoptera: Carabidae) in field crops. Environ Entomol 28:1145-1153

Davis AS, Liebman M (2003) Cropping system effects on giant foxtail (*Setaria faberii*) demography: I. Green manure and tillage timing. Weed Sci 51:919-929

Honek A, Martinkova Z, Jarosik V (2003) Ground beetles (Carabidae) as seed predators. Eur J Entomol 100:531-544

Jacob HS, Minkey DM, Gallagher RS, Borger CP (2006) Variation in postdispersal weed seed predation in a crop field. Weed Sci 54:148-155

Popay I, Field R (1996) Grazing animals as weed control agents. Weed Technol 10:217-231

Ward MJ, Ryan MR, Curran WS, Law J (2014) Giant foxtail seed predation by *Harpalus pensylvanicus* (Coleoptera: Carabidae). Weed Sci 62:555-562

Ward MJ, Ryan MR, Curran WS, Barbercheck ME, Mortensen DA (2011) Cover crops and disturbance influence activity-density of weed seed predators. Weed Sci 59:76-81

Westerman PR, Wes JS, Kroff MJ, Van Der Werf W (2003) Annual losses of weed seeds due to predation in organic cereal fields. J Ecol 40:824-836

Zhang J, Drummond F, Liebman M, Hartke A (1997) Insect Predation Of Seeds and Plant Population Dynamics. https://digitalcommons.library.umaine.edu/aes_techbulletin/39/. Accessed December 16, 2017