



Weed Seed Predators: Potential Contributors to Weed Control

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Competition between weeds and crops in the U.S. for limited resources causes an overall yield loss of 12% annually and this damage and loss costs U.S. farmers at least \$23 billion annually (Pimentel *et al.*, 2000). To control weeds in major crops, most farmers have relied mainly on herbicides. In 2002, almost 194 billion acres of cropland across the U.S. were treated with herbicides (USDA, 2002) and U.S. farmers spent almost \$5 billion on chemical weed control making them the most widely used crop protection chemicals (Kiely *et al.* 2004). A number of negative consequences result from herbicide use including ground and surface water contamination (Barbash and Resek 1996; Larson *et al.* 1997) and the evolution of herbicide resistant weeds (Heap 2006). The negative impacts that herbicides can have on the environment necessitate the need to seek alternative weed management practices that better promote integrated and ecologically-based pest management principles.

Conservation biological control may improve our ability to manage weeds using less herbicide. Enhancing populations of neutral enemies can help reduce pest populations. Creating habitats that are attractive to pest suppressive organisms at a time when weed populations are vulnerable could increase the effectiveness of biological control. The sole use of biological control will not be effective enough to suppress

weeds and prevent crop yield loss, but combining this tactic with other cultural, mechanical or chemical management tactics could have a greater positive impact than any single tactic alone.

Numerous insects consume weed seeds. Some of the most common and most promising bio-control agents include rodents, ants, crickets and ground beetles. Weed seed predation rates will vary depending on predator populations, the food supply (weed seeds), and how the field is managed. In an Iowa study, seed predation rates from May to November ranged from 7 to 22% per day depending on crop type (Figure 1) (Westerman *et al.*, 2005). Higher predation rates were observed in small grains and alfalfa compared to corn and soybean. The rate of seed predation typically increases as the crop canopy develops within a field. Spring planted corn and soybean crops provide little protection for seed predators early in the growing season compared to small grains or established alfalfa. In another study, predation of giant foxtail seeds in wheat was increased by over seeding wheat with red clover in the spring (Davis and Liebman, 2003). Seed predators likely seek habitats that provide adequate cover for their protection as well as a plentiful food source.

Identifying specific predator organisms and the tactics that promote their conservation and use is an exciting area of study with a growing body of knowledge.

Farming practices

- Seed predation can be responsible for up to 90% of seed loss in agroecosystems
- Seed predators include rodents, ants, crickets and ground beetles.
- Ways to increase weed seed predation
 - ◆ Reduce pesticide use
 - ◆ Reduce tillage frequency
 - ◆ Delay tillage events
 - ◆ Incorporate cover crops
 - ◆ Plant fencerows, filter strips and refuge strips

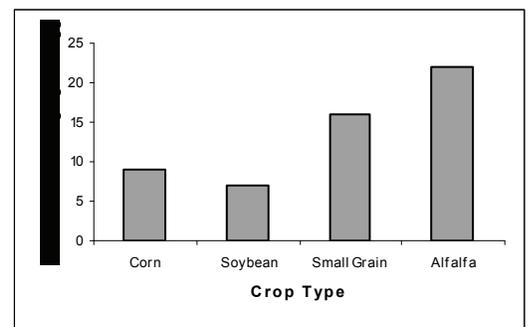


Figure 1. Seed predation rates in five cropping systems. Westerman *et al.*, 2005

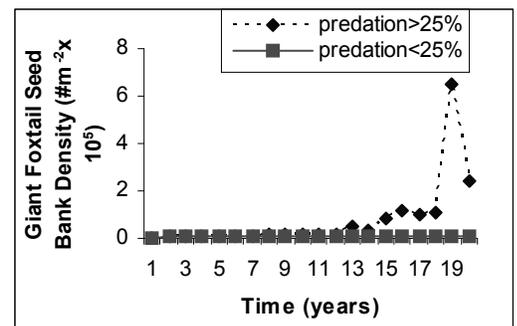


Figure 2. Effect of seed predation on giant foxtail seed bank. Hartzler *et al.*, 2006

Weed Seed Predation Continued

can be altered to increase populations of weed suppressive organisms. As an example, integrating a legume cover crop after small grains in a farming rotation, may enhance predation by providing protection for seed predators.

Creating refuge stripes of perennial grasses around the boundary of crops can create an ideal overwintering site for beneficial ground beetles, fungi and nematodes. Increasing plant residue and decreasing tillage, especially

in the fall can cause certain seed predator populations to flourish. Consider ways to increase or conserve potential beneficial seed predators in your farming operation.

Promising Weed Seed Predators

Rodents

Mice are opportunistic feeders, consuming the easiest available high density food source in an area. As a result, their primary food is seeds (Zhang *et al.*, 1997). Mice can consume up to 100% of available weed seeds in a 12 hour period (Image 1). High predation rates are the result of rodents finding a high density food source, filling their mouth with as many seeds as possible, caching or storing the seed and making repeated trips back to collect additional seeds (Abramsky, 1983).

Rodents locate seeds by scent and can even find seeds buried under the soil surface (Table 1) (Abramsky, 1983). Rodents feed first on larger

seeded broadleaf weed species (Cardina *et al.*, 1996) such as velvetleaf, giant ragweed, jimsonweed, and morningglory, then shift to smaller seeds after the bigger seeds have been collected (Abramsky 1983). Mice are also one of the few weed seed predators that feed consistently on hard shelled seeds (Brust & House, 1988). Unfortunately, while mice can be prolific weed seed predators, they can also be problematic in some cropping systems, feeding on desirable crop seeds and/or disrupting irrigation equipment, plastic mulch, and other tools and equipment used in the agricultural production.



Image 1. A mouse consuming seeds.
bbc.co.uk

Table 1. Efficiency of removal of buried seeds by rodents. Abramsky, 1983

Depth (in)	Number of Seeds Removed	% Removed
2.54	102	79%
7.62	104	80%
12.7	70	70%
38.1	47	47%

Ants

Ants are diurnal insects that spend the day actively foraging (Image 2) and feeding. Ants have been found to feed on small seeded weed species (Brust & House, 1988) such as redroot pigweed and common lambsquarters. They can remove up to 43% of small weed seeds over a 20 day interval and 2 to 30% of annual ryegrass seeds within 24 hours in pastures (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. A strongly preferred seed is removed less frequently if it occurs in the midst of

abundant non-preferred seeds. In contrast, non-preferred seeds are taken much more readily if they occur with abundant preferred seeds (Zhang *et al.*, 1997). Ants also tend to colonize in agricultural fields in high numbers; however, their activity is reduced by tillage and possibly by higher levels of crop residue or stubble (Jacob *et al.*, 2006). As a result, ants could be more significant seed predators in row crops after inter-row cultivation is complete.

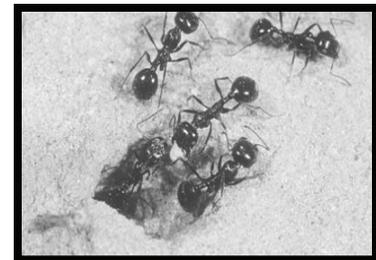


Image 2. Ant seed predation. University of Würzburg, Germany

Crickets

When in large numbers, crickets are considered an economic pest in new seedlings of no-till alfalfa and clover. However, they can also be important weed seed predators. Crickets are nocturnal omnivores (generalists) that consume dead and living insects, broadleaf plants, grasses and seeds. They emerge in early August and have peak activity in the middle of September with populations decreasing in October (Carmona *et al.*, 1999). Field observations (Image 3) and laboratory studies showed that they consume common agricultural weed seeds such as velvetleaf, common lamb-squarters, redroot pigweed, large crabgrass, common ragweed, and giant foxtail. Crickets can cause greater than 76% weed seed removal in 24 hours (Figure 3) and a single female northern field cricket can con-

sume over 200 redroot pigweed seeds per day (Carmona *et al.*, 1999).



Image 3. A common method of measuring seed predation involves lightly attaching seeds to sandpaper or a similar material and placing

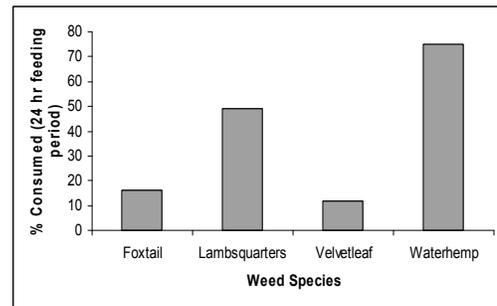


Figure 3. Weed seed predation by crickets. Carmona *et al.*, 1999

Ground Beetles



Image 4: Ground beetle, *Harpalus pensylvanicus*. Murray, 2006

Ground beetles, also known as carabid beetles, are common throughout North America in agroecosystems. *Harpalus pensylvanicus* a common carabid found in Pennsylvania and a known seed predator (Image 4), overwinters as an adult and has the greatest abundance from July through September in Pennsylvania (Figure 4) (Murray and Curran, 2006). Adults consume plant tissues, pollen, fungi, insects and seed; they prefer smaller sized broadleaf and grass seeds (Best & Beegle, 1977). Ground beetles can be responsible for up to 90% of weed seed predation in some agroecosystems. At the Penn State University Research Farm in Central Pennsyl-

vania, giant foxtail seed predation by insects including ground beetles ranged from 37% to 62% in a 14-day period from June through early September in a sweet corn crop (Figure 5). A single ground beetle can consume up to 11 seeds daily and seed removal can be as high as 120 to 130 seeds $\text{ft}^{-2}\text{day}^{-1}$ (Honek *et al.*, 2003). Unlike rodents, ground beetles do not survive periods of intense disturbance such as fall or spring plowing. Fortunately, many ground beetles are fairly mobile and they can abandon fields in autumn and overwinter in refuge strips, fence rows and filter strips. They do not necessarily prefer one crop over another, but instead 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 reproducing can increase ground beetle activity.

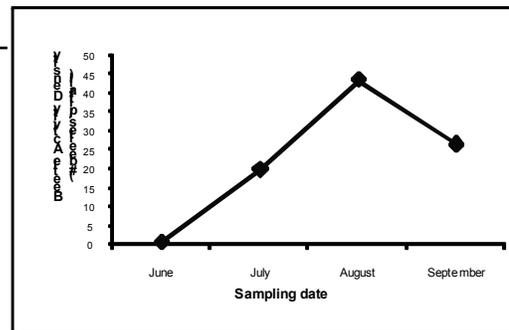


Figure 4. *Harpalus pensylvanicus* activity over time in Central PA. Murray, 2006

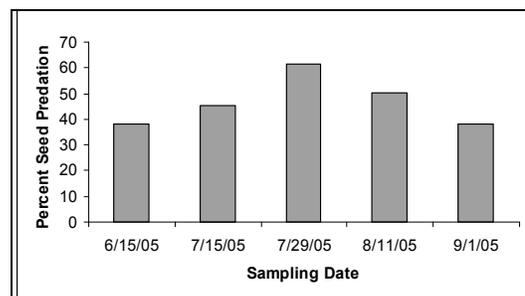


Figure 5. Weed seed predation rates at Pennsylvania State University Rock Springs Research Farm. Murray, 2006

Ways to Increase Weed Seed Predation

- Reduce pesticide use and especially insecticides. Insecticides often kill not only target insects but also beneficial insects. When you do need to apply a pesticide, use lower toxicity/softer pesticides that are not persistent in the environment. Do not apply pesticides to fencerows, refuge strips or border alleys that serve as refuges for seed predators.

- Reduce tillage events and use conservation tillage and no-till practices. These practices create “preferable” habitats for weed seed predators by decreasing disturbance events and destruction of beneficial habitat.

<p>Beneficial insects require:</p> <ul style="list-style-type: none"> •Food •Water •Overwinter habitats •Shelter from adverse conditions 	
<p><i>Agricultural practices such as pesticide applications, cultivation, tillage and harvesting reduce available habitats for beneficial in-</i></p>	
	<p>Suitable habitats can be found in:</p> <ul style="list-style-type: none"> •Herbaceous strips •Fencerows •Hedgerows •Woodlots •Uncultivated field areas

- Delay tillage. Weed seed predation occurs mostly on the soil surface. It is important to keep weed seeds on, or near, the soil surface. Delaying or eliminating tillage in the fall leaves seeds on the soil surface longer resulting in higher predation rates by insects and mammals.

- Incorporate cover crops into your cropping system. Cover crops help hold the soil in place and create better habitats for seed predators and other organisms. Promote and maintain diverse fencerows, filter strips, and refuge habitats that allow overwintering sites and protection for ground beetles, rodents, crickets and other seed predators.