Biological Control of Weeds

Liebman (2001)

The intentional use of living organisms to suppress, reduce or eradicate a pest population.

The promotion of herbivory and disease to suppress weed recruitment, growth and reproduction.

Weed Research 2000 40, 83-98 (Muller-Scharer et al.)
Biological weed control has been used most successfully against invading plant species threatening endangered ecosystems, habitats and species. Its application in intensively managed agroecosystems, however, is difficult because of the ephemeral nature of these habitats with high disturbance levels and the fast control process needed relative to the short duration of the cropping season.

3 approaches: A. Conservation; B. Inoculation; C. Inundation

Biological control (microorganisms, invertebrates, and vertebrate organisms) to control pest organisms: The use of living organisms to control weeds:
defoliation, seed predation.

A. Conservation (the system management or augmentative approach)

Modification of the environment to retain and/or enhance naturally occurring biological control agents to increase the amount of damage that is done to weeds.

B. Inoculation or Classical Biological Control

Introduction of small numbers of a biological control agent that suppresses a target weed as the populations establish, increase and disperse. Applicable to invasive species. Introduced plants can become invasive when transferred to a new region without its natural enemies. Biocontrol agents are usually not native to the regions in which they are released to control an introduced host weed. Usually collected from the center of origin of the weed.

C. Inundation

Native or introduced species in large numbers to suppress the target weed quickly. Generally not expected to persist for long periods or to disperse over long distances.

Two Guiding Principles:

1. The use of a biological control agent should be integrated with other weed management practices to increase effectiveness.
2. Biocontrol agents must be thoroughly screened to properly assess their impact on target and nontarget organisms to avoid unintended consequences.

Biological Control of Weeds Using Arthropods

Conservation (system management, augmentative, facilitative):

Has remained largely a theoretical concept.

A better understanding of the ecology of resident herbivores may result in identification of management strategies that enhance their impact.

The use of both exotic and native insect herbivores to control environmental, rangeland and aquatic weeds can be divided into three general areas:

- population protection or the appropriate use of pesticides to maintain native or exotic biological control agents;
- habitat protection to preserve critical habitats or refugia; and
- plant community management to maintain and enhance the effectiveness of existing biological control agents.

Conservation and facilitation methods of biological control are especially well suited to promoting sustainable agroecosystems, in which weed control no longer aims at crop production in a weed-free environment but simply at a reduction in weed-induced crop losses (Muller Scharer et al. 2000)

Weed seed predation

Weed seeds on the soil surface are utilized as food by resident insects, birds, rodents etc (weed seed predation).

Carabid beetles can reduce weed seedling emergence through:

- Direct consumption of weed seed tissues
- Stashing seeds at depths from which the seedlings exhausted their resources prior to reaching the soil surface.

Defoliation

- Resident insects can defoliate weeds and reduce production of biomass considerably.
- Damage may be insufficient to limit crop yield loss.
- This may be due to damage occurring too late in the crop cycle to limit interference.

Methods are needed for enhancing weed suppression by natural enemies. 5 possible approaches:

1. Minimize or eliminate the use of pesticides with adverse effects on natural enemy populations.
   - Carabid beetle populations were reported to 2X as high in organic systems than conventional systems.

2. Delay postharvest tillage in order to increase the percentage of seeds that are destroyed by weed seed predators.
    - Seeds remain on the soil surface and are more susceptible to consumption by insects, rodents, and birds.

3. Use minimum tillage systems when possible.
    - Residues retained on the soil surface support higher levels of biological activity than systems with little or no residue.
    - 2-3 times higher carabid populations have been observed in no-till soybeans (with wheat residue) than in a conventional system with no surface residue.

4. Use complementary weed management tactics.
    - Includes inoculative or inundative releases or applications of other biological control agents.

5. Farmscape to enhance habitats for biological control agents.
    - Perennial grass strips planted at 200-m intervals within fields resulted in increased populations of carabid beetles.

Inoculative or Classical Biological Control

- Applicable to weeds introduced into new regions.
- Without their natural enemies herbivores and pathogens they can become invasive.
- Used primarily with insects - they are well-adapted to persist, disperse, and attack their hosts in noncrop situations.
- Tend to work slowly over a period of years.
- Suited to pastures, rangeland, and noncrop areas.

Annual weeds of row crops considered poor targets for inoculative biocontrol.
Introduction of *Zygogramma suturalis* F. (ragweed beetle) to control *Ambrosia artemisiifolia* L. (common ragweed) in Russia and, more recently, in Croatia, China and Australia. (Muller Scharer et al. 2000).

Prior to release – appropriate host range studies to ensure that nontarget species will not be affected.

1. Release of multiple species of biocontrol agents for control of a single weed species.

2. Introduction of multiple herbivore species attacking different life stages.

Unintended consequences:

"*C. cactorum*, native to South America, was introduced from Argentina into Australia in 1925 to control several North American and South American species of *Opuntia*. In Queensland 16 million acres of severely infested land were reclaimed for agriculture by the action of this insect. It has also been an effective control agent of *Opuntia* spp. in other areas including Hawaii, India, and South Africa.

In 1957 it was introduced into the Caribbean, in Nevis, where the control of *Opuntia curassavica* and other *Opuntia* spp. was rapid and spectacular. Eggs and larvae, or infested cladodes, were sent from Nevis to Montserrat and Antigua in 1962 and to Grand Cayman in 1970. By 1963 it had naturally spread from the Lesser Antilles to Puerto Rico. Currently also present in Haiti, Dominican Republic, and the Bahamas. In early 2009, the cactus moth was found and quickly eradicated in Mujeres, Mexico about 10 miles offshore from Cancun (LSU 2009). *Cactoblastis cactorus* has been introduced multiple times to Florida (Marisco et al. 2011). Based on genetic analyses, existing populations probably were likely founded from the introduced Caribbean moth populations (Marisco et al. 2011).

The moth's range continues to expand along both the U.S. Atlantic and Gulf coasts. It now is found as far north as Charleston, South Carolina and as far west as Louisiana (LSU 2009). *Cactoblastis cactorum* spreads more quickly along the coasts, but inland spread is occurring. The moth was found in Loxahatchee, Palm County, Florida in June of 1992 by the Florida Department of Agriculture and Consumer Services, 24 km inland from the Atlantic Ocean. In 2011, *Cactoblastis cactorum* was found at the Ordway-Swisher Biological Station in Putnam County, Florida (C.W. Miller).

Inundative approach (Microbial herbicide approach):

Used primarily with microorganisms