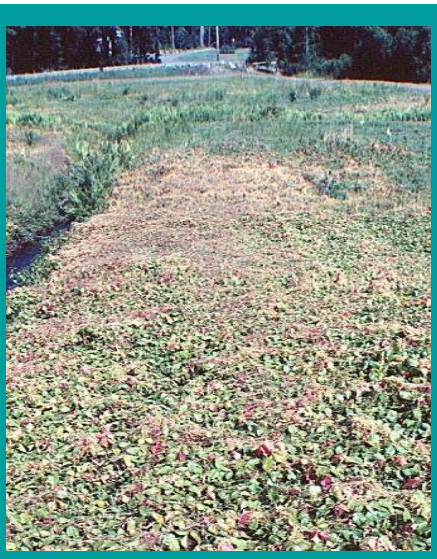
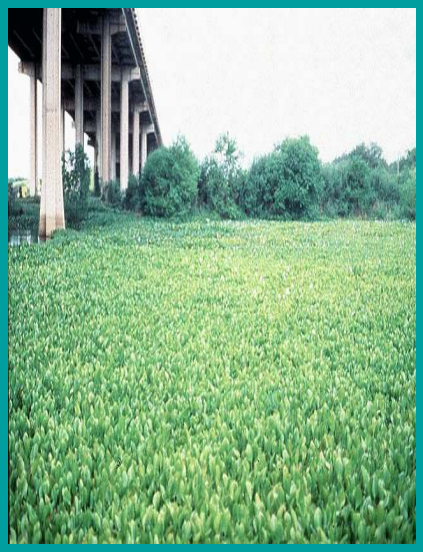
Biological Control of Weeds - It's a *Natural*!

Before





After

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The origins of biological weed control

In ancient times, the Chinese discovered that increasing ant populations in their citrus groves helped decrease destructive populations of large boring beetles and caterpillars. That use of a natural enemy to control a pest marked the birth of biological control.

Insects imported from Australia feed on the leaves of the Melaleuca tree. Combined with other agents, there is hope that Melaleuca trees can be controlled. (Photo provided by Gary Buckingham, USDA/ARS)

Biological control research and implementation is even more relevant today. Foreign and native organisms that attack weeds are being evaluated for use as biological control agents. As a weed management method, biological control offers an environmentally friendly approach that complements conventional methods. It helps meet the need for new weed management strategies since some weeds have become resistant to certain herbicides. Biological control agents target specific weeds. Moreover, this technology is safe for applicators and consumers.

By 1925, Australia was struggling with 60 million acres of grazing land heavily infested with prickly pear cactus. Hundreds of square miles were virtually impenetrable to humans or animals. A small moth from Argentina was imported and released. The moth larvae burrowed into the cactus, grew and multiplied, and within 10 years had decimated the prickly pear population. Today, the cactus covers only 1% of the area it occupied in 1925.

Caterpillars of the moth *Cactoblastis cactorum* bore into the pads of prickly pear. This damages the cactus and introduces a bacterium that causes the plant to die. (Photo provided by E. S. Delfosse, USDA/ARS)

The problem with weeds

Weeds can be defined as plants growing out of place. For example, waterhyacinth is beautiful in floating gardens but can rapidly clog waterways, making navigation impossible (cover, center-left photo). Similarly, morningglory is beautiful in the garden, but when it entwines corn stalks, it can destroy a farmer's crop.

Cover: *Top left*: Dodder, a parasitic plant, infects cranberry causing yield loss and plant death. *Top right*: Dodder controlled with applications of Smolder™, a fungus being developed as a bioherbicide by United Agri-Products (Photos provided by J. Porter, Univ. of Massachusetts Cranberry Experiment Station, Wareham, MA). *Middle left*: Waterhyacinth, an introduced invasive aquatic plant, choking a waterway in Mississippi. *Middle Right*: Waterhyacinth controlled by insects introduced from the area of weed origin (Photos provided by A. Cofrancesco, Army Corps of Engineers.) *Bottom left*: Northern jointvetch infests rice fields, lowering yields. Seeds mixed with harvested rice lower crop quality. *Bottom right*: This weed is controlled by aerial applications of the bioherbicide Collego® (Photos provided by D. Johnson, Encore Technologies, Inc.)

Yellow starthistle infests millions of acres in the western U.S. It out-competes native grasses and forbs, reducing grazing quality, and its sharp thorns injure livestock. (Photo provided by Bill Bruckart, USDA/ARS)

Melaleuca spreads over hundreds of thousands of acres in the Everglades, one of the most fragile ecosystems in the continental U.S. (Photo provided by Gary Buckingham, USDA/ARS)

This purple loosestrife, growing in Minnesota, can be controlled with insects introduced from Europe. (Photo provided by Roger Becker, University of Minnesota)

Weeds degrade native ecosystems.

Invasive, noxious weeds such as leafy spurge and yellow starthistle infest millions of acres of rangeland and wilderness areas in the northern plains and are estimated to cost tens of millions of dollars annually in lost grazing and associated economic effects. For example, leafy spurge and yellow starthistle spread and form dense stands competing with native plants, reducing plant diversity, and degrading wildlife habitats.

Melaleuca, the paperbark tree from Australia, was deliberately introduced on several occasions into South Florida in the early 1900's, and later planted in mass to stabilize levees along lake Okeechobee. It is now on the national list of noxious weeds. At an invasion rate of 15 acres/day, it currently infests hundreds of thousands of acres in the Florida Everglades, threatening this fragile ecosystem. Melaleuca infestations grow into impenetrable stands, competing with native plant species and displacing native wildlife.

Weeds foul waterways.

Purple loosestrife has run rampant in U.S. waterways and natural wetland ecosystems, choking out cattails and other native aquatic plants that provide food and shelter for fish, mammals, birds, and reptiles. Many believe that purple loosestrife seeds arrived in the United States during the early 1800's in soil used as ship ballast.

Weeds lower property values.

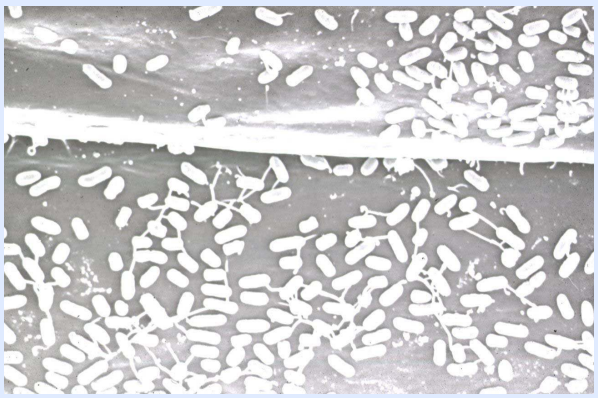
Knowledgeable people avoid buying land infested with invasive weeds. Much time and money will probably be required to convert weed-infested fields to more productive or aesthetically pleasing land.

Many troublesome weeds in the United States are natives of other countries. These weeds were brought to North America accidentally or deliberately and arrived without the living organisms that infect or feed upon them. Without their natural enemies, these exotic plant species rapidly populate new ecosystems that are favorable for their growth.

There are many methods of destroying weeds. We have tried burning them, pulling them out or chopping them down, and treating them with herbicides - all with mixed results. A combination of control methods is generally required to best manage these nuisance plants. Biological control holds much promise for long-term, economical, and environmentally sensitive weed management.

What is biological control of weeds?

Biological weed control involves using living organisms, such as insects, nematodes, bacteria, or fungi, to reduce weed populations. In nature, plants are controlled biologically by naturally occurring organisms. Plants become pests - and are labeled "weeds" - when they run rampant because their natural enemies become ineffective or are nonexistent. The natural cycle may be interrupted when a plant is introduced into a new environment, or when humans disrupt the ecological system. When we purposefully introduce biological control agents, we are attempting to restore or enhance nature's systems.



Bacteria that live in association with plant roots are called rhizobacteria. Some that live on the surface of weed roots release chemicals that reduce weed growth. These are called deleterious rhizobacteria, or DRB's. (Photo provided by Bob Kremer, USDA/ARS, University of Missouri, Columbia)

How does it work?

Roots provide plants with water and nutrients. Some biological control agents attach to roots and thereby stunt plant growth. Some bacteria live on root surfaces and release toxins that stunt root growth. Many fungi infect roots and disrupt the water transport system, which reduces leaf growth. Beneficial insects and nematodes feed directly on the weed roots causing injury which allows bacteria and fungi to penetrate.

Plant leaves capture energy from the sun and store it as sugar. Insects that feed on leaves reduce the leaf surface available for energy capture. Fungi and bacteria that infect leaves reduce the ability of the leaf to make sugars. In either case, there is less energy available for weed growth. Whether through damage on roots or leaves, severe infestations of biological control agents can actually kill weeds, reducing their adverse effects on desirable plants.

Canada thistle is native to Eurasia. Those pictured here are being attacked by a bacterium. Research trials offer hope that this invasive weed can be controlled with this organism. (Photo provided by Dave Johnson, Encore Technologies, Inc., Plymouth, Minnesota)

Many weed species survive from year to year by producing seeds. Fungi or insects that attack seeds can reduce the number of weed seeds stored in the soil, which in turn can reduce the size of future weed populations. This lowers the effort needed to control the remaining emerging weeds.

This poison ivy plant is infected with a fungus. Scientists are evaluating several strains of fungi as biological control agents of this troublesome weed. (Photo provided by Tom Bewick, USDA/CSREES)

Biological control is worth the effort.

It is well demonstrated that weeds can be controlled biologically. Deleterious rhizobacteria have been used to stunt weed growth in wheat fields in the Pacific Northwest. A rust fungus has been used to eliminate rush skeletonweed from thousands of acres of rangeland in the West. A complex of introduced insects has also cleared alligatorweed from waterways, rice fields and lakes in the South.

Two applications of a bacterial pathogen of Canada thistle completely controlled dandelion (pots on the right) in greenhouse trials. (Photo provided by John Porter, Univ. of Massachusetts, Amherst)

Some bacteria and fungi applied as biological control agents do not survive from year to year. These organisms must be applied on an annual basis. This technique is called the "**bioherbicide**" strategy. With this tactic, biological agents are used a in manner similar to chemical herbicides.

Weeds introduced from foreign countries often require a different strategy. Insects and pathogens are collected in the area of origin and evaluated for release in North America. Insect agents often require a number of years to become fully effective. Their growth is often hindered by adverse climatic conditions. Long-term monitoring is needed to determine their effectiveness. The release of biological control organisms in this manner is termed the "**classical**" approach to biological control. Fungi that naturally spread and infect weeds can also be used in a classical biological control strategy.

The alligatorweed fleabeetle is one of a complex of insects that successfully controls this floating aquatic weed. (Photo provided by Jim Cuda, Univ. of Florida, Gainesville)

The cost of developing and conducting a biological control program varies with the target weed and the strategy selected. On average, a biological control program will cost about $4 million. But every dollar spent in development returns at least $50 in benefit.

Biological control of weeds will not eliminate the need to use chemical herbicides. Both of these tools need to be integrated with cultural practices, such as tillage and crop rotation, in the battle against weeds. By using Integrated Weed Management, the development of weeds that are resistant to biological or chemical agents can be slowed.

Stranglevine grows on top of citrus trees and limits their productivity. DeVine® is a fungus-based product that controls this weed for years with one application. (Photo provided by the late William Ridings, Division of Plant Industry, Florida Dept. of Agric. & Consumer Services)

Why isn't everyone using biological control?

Despite the fact that scientists have demonstrated that biologically based herbicides can be effective, there are currently (2000) only two products (DeVine® and COLLEGO®) being sold in the U.S. and Canada. There has been little incentive for companies to become involved in the development of these products and it is often difficult to protect the use of these agents with patents.

Although some insects have been successfully introduced into North America to control exotic weeds, the process is very time consuming. A single agent is rarely able to completely suppress a target weed and multiple agents require additional time for research and development.

The Animal and Plant Health Inspection Service (APHIS) regulates the introduction of biological control agents for weeds. There are very stringent requirements to insure that non-target plants are not damaged in an attempt to control weeds. It can take 20 scientist-years to take a single project from initial exploration through testing and introduction, to establishment and monitoring.

Biological control of weeds needs your support.

If the continued development of biological weed control is important to you, the time to act is now. Ask your Senators and Representatives to support funding for research and development of both classical and bioherbicide agents. Encourage them to require government agencies to implement sensible, economical biological control regulations that facilitate, rather than impede, the research and development of weed biocontrol agents. Request lawmakers to establish a policy for the Patent Office that facilitates patenting of biological agents so that commercial interests can protect their investment.

With public support, solutions to weed control problems can be achieved. But we should all understand also that how soon biological solutions to weed control are available is a function of the amount of financial support that the research receives. When used in an integrated approach, property owners and farmers will benefit from this method of weed management.

These lodegepole pine saplings have been released from competition with sitka alder by applications of the fungus *Chondrostreum purpeum*. (Photo provided by Raj Prasad, AG Canada)

Who's responsible?

Federal government agencies are responsible for:

* Identifying those weeds that threaten native habitats, agriculture, or the economy, and are potential candidates for biological control;
* Funding research efforts;
* Conducting national and international research;
* Checking documentation and research results before allowing potential biological control agents into the country;
* Keeping records of the location and effects of biological control agents after their release;
* Publishing results and communicating biological control results to the public;
* Implementing the biological control of weeds on federal lands as part of an Integrated Pest Management program mandated by Congress;
* Writing and implementing effective biological control regulations.

State Departments of Agriculture are responsible for:

* Identify target weeds for biological control research;
* Keeping records of releases of biological control agents within the state;
* Coordinating biological control efforts within the state.

Universities and other research organizations are responsible for:

* Identifying weeds for biological control research;
* Conducting overseas and domestic research, sometimes in partnership with federal agencies;
* Distributing and monitoring biological control agents;
* Publishing results;
* Educating the public about biological control processes.

Professional organizations are responsible for:

* Supporting biological control research;
* Publishing research results;
* Encouraging and coordinating interagency research projects;
* Educating the public about research progress and needs.

Private industry is responsible for:

* Funding facets of biological control research that may result in commercial products;
* Helping to educate the public about proper use of biological control agents;
* Redistributing commercial biological control agents.

Farmers/Growers are responsible for:

* Helping with field assessments;
* Integrating Biological control agents into pest management and production practices;
* Assisting on cost effectiveness estimates.

WHERE TO FIND MORE INFORMATION

Books:

Biologically Based Technologies for Pest Control (1995), a 216-page report by the Office of Technology Assessment. Available for $14 from the Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. (Phone: 202-512-1800). Request document S/N 052-003-01449-1.

Ecologically Based Pest Management (1996), a 260-page book published in 1996 by the National Academy of Science; available for $37.95. Phone 1-800-624-6242 to order. National Biological Control Institute.

Emerging Technologies for Integrated Pest Management: Concepts, Research and Implementation (2000), G.G. Kennedy and T.B. Sutton, eds. APS Press, St. Paul, MN. 526 p.

Microbial Control of Weeds (1991), D.O. TeBeest, ed. Chapman and Hall. New York. 284 p.

Use of Plant Pathogens in Weed Control (1999), E.N. Rosskopf, R. Charudattan and J.B. Kadir. In: *Handbook of Biological Control*, Academic Press, San Diego, CA p. 891-918.

Biological Control of Weeds: A Handbook for Practitioners and Students (1992), K. Harley and I.W. Forno. Inkata Press, Melbourne, Australia. 74 p.

Biological Control of Weeds: Theory and Practical Application (1997), M. Julien and G. White. ACIAR Monograph No. 49, Australian Centre for International Ag. Research, Canberra, Australia. 192 p.

The leafy spurge flea beetle is one of a number of agents introduced to control this rangeland pest. (Photo provided by Tony Caesar, USDA/ARS)

Journals:

Biological Control, Academic Press, San Diego, CA - http://www.elsevier.com/wps/find/journaldescription.cws_home/622791/description?navopenmenu=1

Biocontrol Science and Technology, Carifax Publishing Co., UK. - http://www.tandf.co.uk/journals/titles/09583157.asp

BioControl, Kluwer Academic Publishers, Dordrecht, The Netherlands - http://www.kluweronline.com/issn/1386-6141/contents

Plant Pathology - http://www.blackwellpublishing.com/toc.asp?ref=0032-0862&site=1

Molecular Plant Pathology - http://www.blackwellpublishing.com/toc.asp?ref=1464-6722

Weed Science - http://ws.allentrack.net/cgi-bin/main.plex

Weed Technology - http://wt.allentrack.net/cgi-bin/main.plex

Internet sites:

Association of Natural Bio-control Producers - http://www.anbp.org/

Biological Control Programs for Weeds In Victoria - http://www.thereef.com.au/biocontrol/semi2she.htm

Biological Control News - http://www.entomology.wisc.edu/mbcn/mbcn.html

Biological Control of Weeds, Inc. - http://www.bio-control.com/

Biological Control Virtual Information Center - http://cipm.ncsu.edu/ent/biocontrol/

Cornell Bio-control Web Site - http://www.nysaes.cornell.edu/ent/biocontrol/

National Agricultural Pest Information System - http://www.ceris.purdue.edu/napis/

National Invasive Species Council - http://www.invasivespecies.gov/

NRCS Plants Database - http://plants.usda.gov/

Pest CABweb Biocontrol News & Information - http://pest.cabweb.org/Journals/BNI/Bnimain.htm

Plant Pathology Internet Guidebook - http://www.bspp.org.uk/ppigb/