INUNDATIVE CONTROL USING BIOHERBICIDES

What is a bioherbicide?

Plant pathogens can be used to control weeds in a similar way to chemical herbicides. The term bioherbicide is used to refer to herbicides based on any living organism (e.g. fungi, bacteria, viruses, protozoans). When the active ingredient used is a fungus, the product is called a mycoherbicide. Bioherbicides can be applied in many ways, e.g. as aerial sprays, through 'cut and paste' application or in a powder applied to the soil.

In contrast to the fungi typically used in classical biological control, the pathogens exploited as mycoherbicides are often native to the area where they are utilised, and do not need to be specially imported. Under natural conditions disease epidemics occur and damage plants from time to time, but the potential of these fungi is frequently limited. For example, the environment is not always conducive to good disease development and the pathogen may be limited in its dispersal capabilities. The inundative approach, where these fungi are turned into mycoherbicides, allows people to overcome some of these constraints and create disease epidemics when and where they want.

After application the fungi do not usually persist at high levels for long and have often returned to background levels 1–2 years later. This means that, like other herbicides used to kill plants, bioherbicides often need to be reapplied.

An example of a commercially available mycoherbicide

The pathogens used in inundative control often need not be as highly host specific as classical biological control agents because their use can be restricted to certain areas.

What is the history and current status of bioherbicides?

Mycoherbicide research to control agricultural and environmental weeds began in the 1940s. The earliest experiments simply involved moving indigenous fungi between populations of target weeds (e.g. the fungus *Fusarium oxysporum* used against prickly pear cactus (*Opuntia ficus-indica*) in Hawai'i, before the release of the *Cactoblastis cactorum* moth).

In the 1950s the Russians mass-produced the spores of *Alternaria cuscutacidae* and applied them to the parasitic weed dodder (*Cuscata* spp.). In 1963 the Chinese mass-produced a different fungus (*Colletotrichum gloeosporioides* f. sp. *cuscutae*) for the same weed. They called their mycoherbicide 'LuBao' and an improved formulation is still in use today.

Landcare Research
Manaaki Whenua
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Bioherbicides that have been registered and their current status, October 2008

Where and When	Product and Pathogen	Target weed	Status
USA: 1960	*Acremonium diospyri*	Persimmon (*Diospyros virginiana*) trees in rangelands	Status unknown
China 1963	Lubao: *Colletotrichum gloeosporioides f. sp. cuscutae*	Dodder (*Cuscata* spp.) in soybeans	Probably still available
USA:1981	DeVine®: *Phytophthora palmivora*	Strangler vine (*Morrenia odorata*) in citrus orchards	Status unknown, may no longer be marketed
USA: 1982	Collego™: *Colletotrichum gloeosporioides f. sp. aeschynomene*	Northern joint vetch (*Aeschynomene virginica*) in rice & soybeans	Not produced or distributed since 2003, but rice producers are showing renewed interest
USA: 1983	CASST™: *Alternaria cassiae*	Sickle pod & coffee senna (*Cassia* spp.) in soybeans & peanuts	No longer available due to lack of commercial backing
USA: 1987	Dr BioSedge: *Puccinia canaliculata*	Yellow nutsedge (*Cyperus esculentus*) in soybeans, sugarcane, maize, potato & cotton	Product failed due to uneconomic production system & resistance in some weed biotypes, no longer available
Canada: 1992	BioMal®: *Colletotrichum gloeosporioides f. sp. Malvae*	Round-leaved mallow (*Malva pusilla*) in wheat, lentils & flax	No longer commercially available but made on request
South Africa: 1997	Stumpout™: *Cylindrobasidium leave*	Acacia species in native vegetation & water supplies	Still available for sale, though demand has declined due to lack of advertising. May be taken up by "Working for Water"
Netherlands: 1997	Biochon™: *Chondrostereum purpureum*	Woody weeds, e.g. black cherry (*Prunus serotina*) in plantation forests	Available until end of 2000. Marketing/production stopped due to low sales & regulatory concerns
Japan: 1997	Camperico™: *Xanthomonas campestris pv poae*	Turf grass (*Poa annua*) in golf courses	Probably commercially available
South Africa: 1999	Hakatak: *Colletotrichum acutatum*	*Hakea gummosis* & *H. sericea* in native vegetation	Never registered, but will be produced on request
USA: 2002	Woad Warrior: *Puccinia thlaspeos*	Dyers woad (*Isastis tinctoria*) in farms, rangeland, waste areas, & roadsides	Registered, but never commercially available due to lack of commercial backer. Once registered, the fungus was spread by researchers.
Canada: 2004	Chontrol™ = Ecoclear™: *Chondrostereum purpureum*	Alders, aspen & other hard-woods in rights of way & forests	Commercially available
Canada: 2004	Myco-Tech™ paste: *Chondrostereum purpureum*	Deciduous tree species in rights of way & forests	Commercially available
USA: 2005	Smolder: *Alternaria destruens*	Dodder species: in agriculture, dry bogs & ornamental nurseries	Only just registered. Company planning to do more field trials & then market it in 2007
Canada: 2007	Sarritor: *Sclerotinia minor*	Dandelion (*Taraxacum officinale*) in lawns/turf	Commercially available

Since then more than 100 bioherbicide projects have been undertaken worldwide, but only a small percentage of these have resulted in commercially available, registered products. It should be borne in mind that the chemical industry routinely screens thousands of inorganic compounds to find a single commercially feasible new chemical herbicide.

Formulation is often the stumbling block when developing bioherbicides. It can be extremely difficult to get living organisms to behave predictably and reliably in the field given the variety of conditions they encounter. Mixtures that look promising in laboratory trials often prove unsatisfactory in the field. It can take many years of experimentation to develop a workable formulation.

Each country has its own rules regarding registration, and meeting the requirements can be an expensive and complex process (e.g. it took 5 years to register BioMal®).

Commercialisation can also be difficult, especially if the target market is small and the product extremely effective (if the product does not need to be reapplied, its market gets smaller).

What benefits do bioherbicides have over other herbicides?

Because the plant pathogens used in bioherbicides usually occur naturally in the areas where they are utilised, they tend to be less harmful to the environment than chemical herbicides. The fungi are often more selective in their mode of action so the risk of damage to other plants is reduced. Bioherbicides are, as a rule, less toxic to people and animals than chemical herbicides.

What's happening in New Zealand?

At Landcare Research the main target weeds so far have been gorse and broom. Work to date has focussed on the fusarium blight (*Fusarium tumidum*) which works best on young plants up to 2 months old. However, after extensive

Mycoherbicide field trials in New Zealand

Silver leaf fungus

Steps in developing a bioherbicide

1. Check that a bioherbicide product is needed and that there is sufficient industry and commercial backing to proceed.
2. Look for suitable pathogens (if not already known).
3. Identify highly pathogenic (disease- causing) isolates that produce no or few toxins, and are unlikely to damage non-target species.
4. Develop an efficient way of mass-producing the pathogen and ensuring stability and shelf life.
5. Determine the optimum conditions for infection and disease development.
6. Check that the pathogen can be used in a manner that will minimise any harmful effects.
7. Develop an appropriate formulation and application technology.
8. Test in the field and improve formulation if necessary.
9. Obtain registration for the product, and market and distribute product.

testing it appears that this fungus is not likely to yield a high performance cost-effective mycoherbicide so effort has been switched to another fungus, *Chondrostereum purpureum*. Landcare Research, Scion and AgResearch have begun looking at the feasibility of using this fungus against not only gorse and broom but a range of woody weeds, but funding needs to be found to be able to continue with this work.

C. purpureum has a wide host range and grows on the dead logs and stumps of many tree species. It causes silver leaf disease of fruit trees such as plum and cherry so its common name is silver leaf fungus. Only trees that have fresh, open wounds are at risk. Research has been carried out in the Netherlands and Canada to develop *C. purpureum* into a mycoherbicide against woody weeds (e.g. black cherry, *Prunus serotina*). A 'cut and paste' mycoherbicide has been developed called 'BioChon' in Europe and 'Chontrol' in Canada/USA (was ECOclear). These products have successfully completed their registration process and are available in western Canada and the USA.

AgResearch has been working for a number of years to try to develop white soft rot (*Sclerotinia sclerotiorum*) as a product for controlling Californian thistles (*Cirsium arvense*), but because of formulation difficulties other more promising fungi are now being explored for Californian thistles instead. AgResearch are still working to develop white soft rot as a mycoherbicide for giant buttercup (*Ranunculus acris*).

Currently it is difficult in New Zealand to secure sufficient funding to develop bioherbicides, as this research may take 10 years or even longer and the market here is small.

The Future

It is likely that in future that the impetus to develop bioherbicides for New Zealand will increase. Intensive research to develop alternatives to synthetic pest control products is being undertaken in many countries overseas for a number of reasons. As well as the problem that satisfactory herbicide solutions are not available for all weeds, and some weeds are increasingly developing resistance, there has also been a shift in public attitudes towards the use of synthetic pest control products. People are increasingly uncomfortable with the use of synthetic pest control products and increasingly want to be able to produce or purchase organic food. As a result legislation is now in place in many countries that has restricted the use of herbicides, for example they may not be used in urban areas. Also products are being re-evaluated and often subsequently banned from further usage. All of these factors are likely to increasingly apply to New Zealand in the near future too.

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