ALTERNATIVE PEST CONTROL
Microbial (Biological) and Biological Insecticides

Rick Besson, Entomologist

Pest is a sociological title. There is no such thing as an ecological pest. Species are only considered pests because they are a nuisance to us. In reality 99% of insects are innocuous, neither beneficial nor pests.

INTRODUCTION

Spraying with any insecticide, organic or not is a last resort. Effective pest management begins with prevention. Their are several good farming practices, which can prevent pest problems. These include using raised beds (control the spread of disease) and crop rotation (disrupts the cycles of insects in the soil).

STEPS TO SUCCESSFUL PEST CONTROL

1. **Detection** -- A key to successful pest control is early detection. Walk your fields regularly, keeping an eye on what's going on. This will help avoid getting caught in situations that require difficult decisions.
2. **Identification** -- Another necessary element is identification. You cannot manage your problem unless you know what the pest is. This can't be stressed enough.
3. **Evaluation** -- It is important to evaluate the significance of the pest. It is not simply the presence of a pest in the field that causes concern. Before it is considered a problem, populations have to be at a certain level and the crop at a vulnerable stage.
4. **Consider the alternatives** -- There will generally be several alternatives for dealing with most problems. Many of these begin back with prevention. When you know there is a problem, use all of the appropriate preventative tactics in the future to prevent it happening again.

PROPERTIES OF A DESIRABLE INSECTICIDE

1. Selective-- controls a certain pest but does not affect other beneficial or innocuous species.
2. Degrades rapidly

Q. Why is this important? Why not let the insecticide be present for the time the plant grows?

A. Constant presence (or frequent use) of an insecticide would encourage the development of resistance in the pest species. In addition, as there are no completely benign insecticides, this would greatly increase the possibility of harm to non-target species.

3. Low human and environmental toxicity

As we know, these qualifications are not totally met in any synthetic, biological or botanical insecticide.

This paper was produced through a grant from the Loretto Community Special Needs Committee, 3001 S. Federal Box 1113, Denver, CO 80236.

BIOLOGICAL INSECTICIDES

Biological or microbial insecticides are derived form microbes growing in the environment. They have some definite advantages:

1. non-toxic to humans -- in fact many are less toxic than coffee or aspirin
2. very specific -- they target a single species or a group of closely related species
3. degrade rapidly
4. can often be used right up to harvest without the required field entry intervals.

There are also several disadvantages:

1. very specific -- This can be a disadvantage if the plant is being affected by a complex of several species.
2. degrade rapidly
3. costly - There is a minimum of distributors and the cost can be expensive.
4. slow acting -- Some biological have a slow response time so their needs to be anticipated when deciding when to treat.

Common Types of Biological Insecticides

Bacillus thurgiensis -- There are over sixty recognized of this bacteria, but only four on the commercial market. Bt is actually just like a regular insecticide; by the time you spray it the bacteria has been killed and all that's left is the little protein, called a delta endotoxin. It is used like any other insecticide. Insects have the possibility of developing resistance to Bt like they would with synthetics.

Bacillus thurgiensis (Bt) var. kurstaki NOTE: All commercial brands of this strain are not the same. Some do work better than others.

Q. Do some work better because of additives?
A. Not in this case. When companies first started making the products they each had a certain isolate of the strain. Not all of those isolates are genetically identically. There are natural variations within the population, and differences in the proteins that Bt produces.

Kurstaki is the strain used to kill caterpillars, the larvae of moths and butterflies. It is not effective on other pests. Bt var. kurstaki is a stomach poison and must be ingested by the insect. It works by tearing up the paratrophic membrane in the insect's stomach. The insect stops feeding almost immediately and dies within a few days.

Bt var. Israelensis (Bti)

This strain kills fly larvae. It is used in greenhouses to kill fungus gnats. It is also used in the control of black fly larvae. Bti doesn't kill caterpillars or beetles, only specific types of fly larvae.

Bt var. tenebrionis

This is used to kill some types of beetle larvae, including the Colorado potato beetle and elm leaf beetle. There is evidence of some resistance developing in the Colorado potato beetle in the Northeast where large potato production occurs. It has only taken about two years to see resistance in the beetle. To be effective Bt var. tenebrionis requires a high pH in the gut. Most

beetles, such as the lady beetles and other beneficials are unaffected because of the low pH in their stomachs. This strain is used in control of about six beetle species. NOTE: The Colorado potato beetle is somewhat unique among insects. It has an amazing ability to adapt to just about anything humans develop to kill it.

Bt var. aizawai

This strain was marketed years ago and has recently been reintroduced. In this area it is sold under the trade name XenTari. It is more effective than the kurstaki on some pests. As with kurstaki it kills only caterpillar larvae. It is used in the control of some of the most troublesome species including the diamondback moth and the beet armyworm.

Q. How long after spraying is it effective?
A. Bts have a short half-life. Depending upon the crop they are usually effective for 2 - 3 days after spraying. There are ways to enhance their performance. The best time to spray in the evening. This is true for just about anything. Most microbial insecticides and botanicals degrade rapidly in sunlight. Many have to be ingested to work, so spraying at night allows for a greater period of activity.

To use Bts or other microbial correctly

1. identify the pest correctly -- If you can't make a good identification you can't use these tools effectively.
2. remember that Bts only attack certain life stages. They are not effective against adults, only larvae. Also keep in mind that the smaller the instar the smaller dose it will take to kill it. NOTE: Instar -- A small number of insect species, (grasshoppers, for example) develop in a pattern called incomplete metamorphosis. This pattern involves a succession of molts. After the embryo develops into a nymph, which is a small version of the adult, it feeds, molts and continues this sequence several times. The periods between these molts are called instars. Usually after about six instars the fully mature adult emerges. These insects do not have radically different life behaviors between the immature and adults, as do those undergoing complete metamorphosis (e.g. butterflies).
3. remember that although the Bts may not instantly kill the insect, they will almost immediately stop feeding.
4. All biologicals are subject to UV degradation so spray in the evening.

Encapsulation -- There are new types of Bt available, which have been encapsulated (MVP-kurstaki). The gene is placed in the bacteria *pseudomonas fluorescence*. The bacteria produces the Bt protein crystal. The bacteria is then killed. When it dies it forms an envelope around the crystal. This helps reduce the UV degradation. There is some uncertainty about the organic restrictions on genetically altered bacteria With this particular strain, while there is a small improvement in its performance, there is a large increase in the cost.

Q. Does rain decrease the effectiveness ?

A. More than an inch of rain will cause runoff. With broccoli, cabbage and other cole crops you need to add a sticker spreader, otherwise it will run off without the rain.

Q. What is a good sticker/spreader?
A. Baby soap or shampoo. Also, Safer's insecticidal soap.

Nematodes

Nematodes are tiny roundworms. These sucking organisms feed with a small stylet. When they are inside the insect they fit the stylet into various organs.
Beneficial nematodes are classified as entomophagus (ento - insects, phagus (feeding). They are very selective and only feed on certain types of insects. They are typically effective against insects that occur in the soil or bore into plant material. This is because nematodes are extremely sensitive to desiccation. They need to be in a very moist environment, such as soil or in a tree or shrub.

NOTE: Many packages of commercial nematodes have a short shelf-life. You need to make sure you're getting fresh nematodes. Most advertised brands are guaranteed for two months after purchase. In tests there was no viability after three months. Try to buy them from the manufacturer.

Nematodes are effective against many insects including cutworms and white grub species.

Viruses

There is a naturally occurring virus which is used in control of the beet armyworm. The bee armyworm is a relatively new pest in Kentucky. It comes from the South, where it is a major pest on cotton. With cotton acreage moving north, combined with the unusual weather patterns during 1993 it showed up in several Kentucky counties.

Having been a pest on cotton (heavily treated with chemicals for years) the beet armyworm is resistant to all synthetic insecticides. There are encouraging results with the virus *nuclearpolyhedrosus* (NPV). It only kills one species and has no effect on closely related varieties in the same genus. It took 10 - 17 days to effect 70% control. There two strains of the virus.

Q. If virus occurs normally within populations of beet armyworms wouldn't bug juice be effective?
A. If you happen to have some beet armyworms infected in the field, you could catch them at the right stage. At that point, however, if you're starting to find the virus out there it will probably control them on its own.

Q. Is the virus contagious?
A. It's virulent once it gets going. There are problems getting it started in the field.

The virus has two definite good points:
1. very selective -- It is non-toxic to almost everything but the target species.
2. very low use rates -- Typical application is 5 grams of the virus to the acre.

Q. Have you used Nosema locustae (a protozoa) against grasshoppers?
A. No
Grower's response -- It is very effective on grasshoppers and blister beetles, which feed on grasshopper larvae. There was some activity in the first year but it was very effective in the second.

Bacillus popillae

This bacteria is used against white grubs. It is not recommended anymore, because Ringer the company that marketed it tested the product they were selling and found it had no active ingredient. These bacteria are produced commercially by loading vats full of insects and fermenting them with the bacteria. Ringer found they were fermenting some non-pathogenic species.

BOTANICAL INSECTICIDES

Botanicals are used almost as much as biological. They are derived from plants.

There are several advantages to using botanicals:

1. degrade rapidly --They are not as selective as biological, so it is necessary that they degrade quickly.
2. fast acting -- Some work very quickly to stop feeding or kill the insect.
3. low human toxicity -- This is true for some of them. Others need to be handled carefully to avoid unnecessary risk.
4. low phyto-toxicity -- They are safe to plants.

There are also disadvantages:

1. degrade rapidly -- This helps beneficials, but shortens the length of time the pest population is exposed.
2. toxicity -- Some types are very toxic to the applicator. As with all insecticides they need to be handled carefully with no unnecessary risks.
3. cost/availability -- Most are available through mail order, but can be expensive. Some can be difficult to obtain. When ordering by mail it would be good to find out if the product is registered for use in your state.
4. lack of test data -- Unlike synthetics there has been a minimum of research into the most effective dosages and frequency. There is still a lot of experimentation in organic gardening and farming.

Types of Botanicals

Pyrethrum/Pyrethrins

These products are derived from the pyrethrin daisy flowerhead. Pyrethrum is a fast acting nerve poison, which has an immediate knock down response (KDR). It is a contact poison so it must touch the target species. There is little residual activity so be sure to spray underneath leaves. Pyrethrum is synergized by piperonyl butoxide (PBO). Synergism makes a product more effective. In mixtures the synergist is ten times more concentrated than the insecticide. As of yet synergists are not approved for organic certification, so be careful where you purchase your product. With the pyrethrins most companies sell a mix. One advantage is that these products have a low mammalian toxicity. However, all pyrethrins are very toxic to fish. They should not be used around streams, ponds, etc. They should also not be sprayed if there is a danger of runnoff.

NOTE: This is different from pyrethroids, which are synthetic analogs. They are similar but the pyrethroids are more persistent and much more toxic. They are not used by organic growers.

Rotenone

Rotenone is derived from the roots of several tropical legumes (the cuberoot). It is a muscle poison, which must be ingested to work. After ingesting the poison the target insect species stops feeding activity quickly. It was used for years with the Colorado potato beetle, but they have developed a resistance. It is synergized by PBO, but is marketed unmixed. Rotenone is toxic to humans (and fish) so precautions should be taken when using it. It is used for control of some leaf feeders. Rotenone has a longer residual life than most botanicals and is effective for about a week.

Sabadilla

This insecticide is made from the seeds of a tropical lily plant and is available by mail order. It is a contact nerve poison, which acts very quickly and breaks down quickly in the environment. It readily degrades in UV light. In some cases it may act as a stomach poison as well. Sabadilla is extremely toxic in higher concentrations, so most commercial products are very dilute, usually 1-2% active ingredient. Be careful when using it. Sabadilla is synergized with PBO, but it too is sold unmixed. A note to the applicator __ the product irritates skin and mucus membranes. Sabadilla is effective against true bugs (e.g. stink bugs, etc.) NOTE: Several true bugs are among the predaceous beneficial insets. They feed on insect pests. Keep this in mind if you are considering Sabadilla. It is non-selective among these species.

Ryania

This is derived from the woody stems of Ryana speciosa, a South American shrub. Ryania is a slow acting stomach poison. It too is synergized with PBO but is sold unmixed. The insecticide is moderately toxic to humans and has low residual activity. Ryania is used to treat pests affecting corn, apples and pears.

Nicotine

Although nicotine is considered a botanical its use is strongly discouraged. Currently federal regulations allow its use as a pesticide in organic growing but it is extremely toxic to mammals. It is also non-selective, killing most anything it contacts. It is a fast acting nerve poison. It is frequently used in greenhouses for control of some soft-bodied insects. It does degrade rapidly. There are usually much better alternatives to its use.

Neem

Neem is developed from the seed of the tropical neem tree Azadrachta indica. Its active compound is azadirachtin and has been used for thousands of years in India. Neem has several modes of action: it is a feeding deterrent and some feel an ovipositional deterrent as well. It also acts as an insect growth regulator, messing up the internal hormone system thus preventing insects from molting in their usual procession.

Q. Does it work for all insects?
A. It was tested against a few different insects and performed well. It has been used effectively against the beet armyworm, diamondback moth, cabbage looper and greenhouse whiteflies.

Align is a commercial form of neem, which is new on the market. It has full food crop label. Bioneem, the more familiar brand is only approved for ornamentals.

NOTE: Always read the labels of the products you intend to use. They should list all pertinent warnings, as well as necessary application equipment and restricted entry intervals. Another

NOTE: According to new federal safety regulations, even if you apply something as innocuous as water, if you call it an insecticide you cannot enter the field for four hours after application. This is the absolute minimum re-entry period for any pesticide regardless of its effect. Some highly toxic chemicals may have extended intervals.

Limonene and Limanool

These are citrus peel extracts, which cause insect paralysis. Both insecticides are synergized by PBO and have the EPAs GRAS (Generally Regarded as Safe) classification. They evaporate fairly quickly in the environment and are used to control aphids, mites and fleas.

RESOURCES

Ellis, Barbara W. and Fern Marshall Bradley (Editors), 1992, The Organic Gardener's Handbook of Natural Insect and Disease Control. Rodale Press, Emmaus, PA.

Henn, Tess and Rick Weinzierl, 1989, *Botanical Insecticides and Insecticidal Soaps*, Alternatives in Pest Management, Circular 1296. University of Illinois at Urbana-Champaign, College of Agriculture, Cooperative Extension Service.

Ware, George W., 1988, Complete Guide to Pest Control (with and without chemicals), 2nd Edition. Thomson Publications, P.O. Box 9335 Fresno, CA 93791.

Weinzierl, Rick and Tess Henn, 1989, *Microbial Insecticides*, Alternatives in Pest Management, Circular 1295. University of Illinois at Urbana-Champaign, College of Agriculture, Cooperative Extension Service.

Williams, Greg and Pat, *Safe and Simple Bug Controls*, in BackHome, Summer 91, No. 4. Mountain Home, NC 28758. pp. 24-25.

The information on Alternative Pest Control was presented at a Kentucky Organic Growers Workshop held March 19, 1994 in Edmonton, KY.

EDITOR: Robyn Arnold PROJECT DIRECTOR: Al Fritsch