Selection and Use of Insecticides for Organic Production

Guide H-168

Tessa Grasswitz[1]

Cooperative Extension Service • College of Agricultural, Consumer and Environmental Sciences

INTRODUCTION

Organic farming and gardening place a strong emphasis on non-chemical methods of insect control, chiefly through measures designed to mimic natural ecosystems. These include growing a diversity of crops, using only plants that are well-adapted to the site, practicing crop rotation, building soil health, and encouraging natural predators and parasitic insects. Many of these tactics are also used by conventional growers practicing integrated pest management (IPM).

Well-established organic farms and gardens often have very few insect problems. However, pest issues can still arise. Along with native pests, new invasive species can pose fresh challenges. Additionally, growers transitioning from conventional systems may experience particular difficulties in the first few years of organic production. Under these circumstances, they may be forced to consider using a pesticide. There is a common misconception that because organically approved insecticides are derived from natural sources they are safer for non-pest insects. In fact, many of them are toxic to a broad spectrum of insects, including beneficial predators and parasitic species (Figure 1). Only a very few materials are highly selective, i.e., harmful to the pest but relatively safe for beneficials. Furthermore, since the range of chemical controls available to organic growers is much more limited than those available to conventional farmers, it is particularly important to use these products judiciously to prevent or delay the development of insecticide resistance.

Figure 1. **Consider potential effects on beneficial insects before spraying insecticides. Larval stages of predators (such as this ladybeetle) are often particularly vulnerable.**

Choosing an appropriate insecticide for use in organic production can be confusing. Bear in mind that **all** insecticides used in New Mexico must be registered by the New Mexico Department of Agriculture (NMDA) for use on the target pest and crop. Organic insecticides sold in other states (or on the Internet) may not be registered for use here, in which case they are not legal to use in New Mexico. A link to further information on pesticide regulations in relation to organic production is provided in the **Resources section** at the end of this publication.

[1]Urban/Small Farm Integrated Pest Management Specialist, Department of Extension Plant Sciences, New Mexico State University.

Certified (or transitioning) organic growers must also ensure that all the products they use meet the requirements of their certifying body and the National Organic Program Standards. If a product is **not** included on the list of approved products maintained by the Organic Materials Review Institute (OMRI), then producers should seek further advice from their certifier. Certified growers must also be able to demonstrate that they have first used all appropriate non-chemical means of control and documented the conditions justifying the use of an insecticide in their organic production plan. As with any other pesticide, all organic insecticides should be used only in strict accordance with the directions on the label.

Various types of organically approved insecticides are discussed below in terms of their active ingredients. The use of trade names has been kept to a minimum since they are subject to change.

BOTANICAL INSECTICIDES

The following insecticides are derived from plant sources.

i. Pyrethrum

Pyrethrum is the generic term for several insecticidal compounds ("pyrethrins") that are found in the flower heads of the pyrethrum daisy (*Chrysanthemum cinerariaefolium)*. Do not confuse natural pyrethrum with synthetic pyrethroids, which have similar chemical structures but which are not allowed in organic production.

Pyrethrum is a fast-acting contact poison that causes rapid "knockdown" of sprayed insects by disrupting their nervous system. This initial knockdown is followed by paralysis and eventually death. However, some insects can recover from the knockdown effect, and for this reason many commercial pyrethrum-based products include synthetic additives (e.g., piperonyl butoxide) that reduce the insect's ability to detoxify pyrethrum and hence increase mortality. Products that contain such additives, however, are not permitted under the National Organic Program Standards.

Pyrethrum is a broad-spectrum insecticide that kills insects (including beneficials) on contact; it is highly toxic to bees, and sprays directly contacting bees are likely to be lethal. Pyrethrum residues on plants, however, are rapidly broken down by sunlight so that residual activity is limited. For these reasons, highly mobile pests should be sprayed in the cool of the early morning when they are relatively inactive, taking care to avoid spraying flowering crops where bees might be foraging. Pyrethrum products are labeled for use against a variety of pests, including thrips, mites, aphids, various caterpillars, true bugs, and beetles.

ii. Neem

These products are based on extracts from seeds of the neem tree, *Azadirachta indica*, a species native to southern Asia. They may contain neem oil (sometimes formulated as a soap) or the purified active ingredient, azadirachtin.

Azadirachtin acts mainly as an insect growth regulator, i.e., it disrupts normal growth and development when applied to immature insects. For some pests (particularly Lepidoptera [butterflies and moths]), it also has anti-feedant and anti-oviposition properties, i.e., it deters them from feeding or laying eggs on treated surfaces. When neem oil is formulated as a soap, it acts mainly by disrupting the waterproof layer of the insect's cuticle.

Products based on neem work on contact and/or through ingestion. On leaf surfaces, neem is rapidly broken down by sunlight or washed away by rain. As with most insecticides, neem should be applied when target pests are in their early life stages and before populations have reached high levels. Even then, repeat applications may be necessary before effective control is achieved.

Neem products have been shown to affect over 200 insect species, including various species of thrips, leafminers, aphids, scales, caterpillars, beetle larvae, and some true bugs. Neem is generally considered safe to most adult beneficial insects, but immature stages (e.g., larval ladybird beetles) are more susceptible.

iii. Other botanical insecticides

A variety of commercial products are based on botanical oils or extracts (such as those from garlic or thyme). In many cases, the modes of action of these ingredients and their effects on beneficials have been little researched and are poorly understood. Some of these products are intended for use as repellents rather than control agents, and some of them contain other ingredients that are not permitted under the National Organic Program Standards. If the product is not OMRI-approved, producers are advised to check with their certifying body prior to use.

MICROBIAL INSECTICIDES

The following insecticides rely on various microorganisms or microbial by-products to control insects.

i. *Bacillus thuringiensis* ('Bt')

Bacillus thuringiensis is a naturally occurring bacterium that is common in soil, in dead insects, and on plants. It produces both spores (resting stages) and a crystalline protein (endotoxin). When eaten by a susceptible insect, the endotoxin is activated and creates holes in the gut wall that allow the gut contents to enter the insect's body cavity and bloodstream. The insect soon stops feeding and in a few days dies of septicaemia; affected insects typically soften and darken as they die.

Worldwide, there are an estimated 50,000 different strains of Bt, and the toxins they contain selectively affect different groups of insects. Commercial products based on Bt typically contain one of the following subspecies: *B. thuringiensis kurstaki* (for Lepidopteran larvae, i.e., caterpillar pests), *B. thuringiensis aizawai* (also for Lepidopteran larvae), *B. thuringiensis tenebrionis* (for beetle larvae; also known as *B. thuringiensis san diego*), and *B. thuringiensis israelensis* (for fly larvae such as fungus gnats, mosquitoes, and blackflies).

Not all species of caterpillars, beetles, or flies are susceptible to Bt, but the key to successful use is to choose a product containing the subspecies of Bt that is appropriate for the target insect. Since Bt (like most insecticides) is most effective when applied to young larvae, early detection of the pest is necessary. Achieving good coverage of treated plants is also important, especially since many insects feed on the underside of leaves where they are more protected from sprays. Bt products are broken down fairly rapidly by sunlight (within a few days) and, because of the specificity of the toxin, are very safe for beneficial insects.

Some Bt products may contain additional ingredients that are prohibited under the National Organic Program Standards; make sure the product you use is OMRI-listed and check with your certifier if in doubt. Crop plants that have been genetically modified to produce Bt toxins are also prohibited.

ii. *Beauveria bassiana*

Beauveria bassiana is a soil-dwelling fungus, different strains of which are found throughout the world. As with Bt, different insects differ in their susceptibility to different strains, but only a few strains are currently used in commercial products. Commercial strains are produced by a fermentation process in which the fungal spores are extracted and formulated into a sprayable product.

Insects become infected with the fungal spores either by walking on treated surfaces or through direct contact with the spray. When the fungal spores contact the insect's outer surface (cuticle), the spores germinate and send out structures (hyphae) that penetrate the insect's body and proliferate, typically killing the insect in about 3 to 5 days. The dead insect then becomes a new source of fungal spores, further spreading the infection. Unfortunately, since the spores are rapidly killed by high temperatures and sunlight, these products are most effective under cool conditions and relatively high humidity. They may be suitable for early-season use in hoop houses and similar structures, but are unlikely to work well outdoors in New Mexico in the heat of summer.

As with other insecticides that work on contact, good spray coverage is essential, particularly if the target insect feeds on the undersides of leaves or in other protected locations. Multiple applications may be needed to achieve suppression. Pests that bore into the plant are not controlled with this type of product since they are unlikely to pick up a lethal dose.

iii. Insect viruses

Insects are vulnerable to various naturally occurring viral infections that often cause lethal disease outbreaks when pest populations are high. Such viruses are generally very specific to the target insect (and hence are safe for beneficial insects), and some have been commercialized as insecticidal products that can be applied with standard spray equipment. Insect viruses are typically covered with a natural protein coat that to some extent protects them from rapid environmental degradation when outside a living host. To become infected, insects must eat the virus particles; once inside the highly alkaline environment of the insect gut, the protective coating is broken down, releasing the virus, which then penetrates the cells of the gut wall where it replicates and gradually spreads to other internal organs.

Typically, infected insects stop feeding within a few days, become increasingly inactive, and eventually die. At that point, the body of the insect often turns black and soon liquefies, the outer integument (skin) disintegrating to release large numbers of new virus particles, each one of which is capable of starting a new infection if eaten by another host insect. Generally, the younger the insect, the more susceptible they are to infection and the more quickly they will die. Keep in mind that death can take several days, so large larvae may still cause considerable damage before succumbing to infection. In some cases, a sub-lethal infection in a mature larva may persist into the adult stage, and females may then transmit the infection to their offspring in their eggs. In other cases, mortality from a latent infection may be delayed until the insect is stressed in some way, for example by lack of food or overcrowding, or during overwintering.

Virus particles may persist in protected environments (such as the soil) for some years, and may be spread by rain, wind, cultivation, and accidental movement by animals. Host-specific sprayable formulations of viruses are currently available for codling moth (Cyd-X) and corn earworm/tobacco budworm (Gemstar); however, correct spray timing is critical to ensure success since the larval stage of these insects will bore into their respective host plants soon after hatching and will then be out of reach of subsequent sprays (Figure 2). Monitoring with pheromone traps and correct use of temperature data and development models is recommended for these pests. Consult your county Cooperative Extension agent for details.

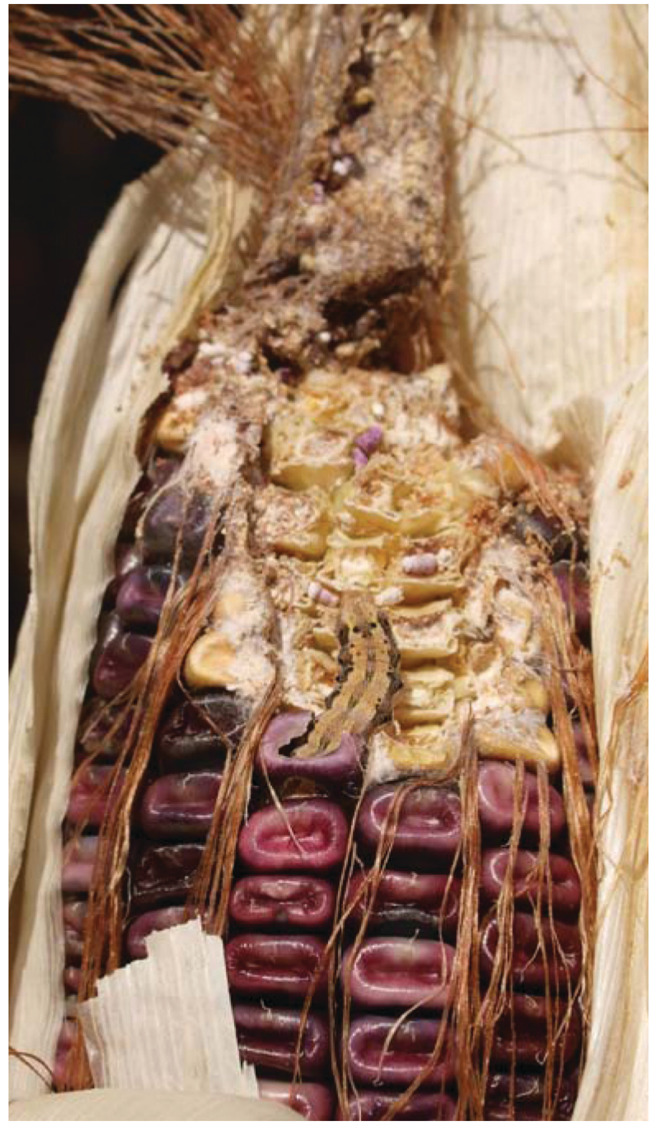

***Figure 2.* Careful monitoring is needed to time insecticide applications correctly—particularly for pests such as corn earworm that feed within the plant.**

iii. Spinosad

The active ingredients in spinosad are derived from the fermentation of a Caribbean actinomycete (soil bacterium) called *Saccharopolyspora spinosa*. Products based on spinosad disrupt the insect nervous system, leading to loss of muscle control and eventually paralysis and death. Insects pick up a lethal dose by eating treated plants or by direct contact with a spray droplet or the residue on newly treated surfaces. Affected insects are killed in 1 to 2 days.

Spinosad is relatively safe to many important predatory insects, but is toxic to bees and parasitic wasps if they are contacted directly by spray droplets; once the residues dry, their toxicity is reduced. Spinosad-based products are principally used against caterpillar pests (Lepidoptera), thrips, fruit flies, sawflies, and some pest beetles (e.g., the larval stages of Colorado beetles). Spinosad is not fully systemic (able to move within the plant), but penetrates leaves well enough that it can be used against some species of leafminers. Spinosad products have been widely used by organic growers against codling moth, but the risk of developing resistance makes it inadvisable to use it every generation. If possible, use correctly timed applications of Bt-based products (or Cyd-X) against at least the first generation, which tends to be less numerous than the later ones.

OTHER ORGANICALLY APPROVED INSECTICIDES

i. Insecticidal soaps

Insecticidal soaps are sprayable liquid formulations of potassium salts of fatty acids that are specifically intended for insect control. They work by degrading the outer waterproof layer of the insect cuticle so that the pest dies from desiccation. Soaps work best against soft-bodied pests such as aphids, mites, mealybugs, and the immature stages of other pests; predatory mites and the soft-bodied larval stages of beneficial insects such as ladybird beetles ("ladybugs") and hoverflies are also likely to be affected. Soaps are ineffective against insect eggs and harder-bodied adult insects. Some soap-based products are formulated with neem oil, and these tend to have a broader range of action (see previous section on neem).

Target pests must be directly contacted by the spray; once the residue dries on the plant, it is no longer effective. For this reason, it is more effective to spray in the early morning when the insects are becoming active but temperatures are still relatively cool so that drying is less rapid. Repeat applications may be necessary to achieve control.

Be aware that although insecticidal soaps are formulated to be non-toxic to plants (unlike dish soaps), they may still disrupt the waterproof layer of leaves (particularly those with a dense layer of wax); check the label recommendations for susceptible crop types and, if in doubt, spray only a portion of the plant and wait for several days to check for adverse effects before proceeding further.

ii. Horticultural oils

OMRI-listed horticultural oils are based either on vegetable products (such as canola oil) or light mineral oils. They are combined with emulsifiers to help disperse them in water for spraying. These oils work by physically clogging the insect's breathing pores (spiracles), and good coverage to directly contact the pest is therefore essential. There may be a risk of phytotoxicity (damage to the plant) if these products are applied when temperatures are high. Check product labels for details.

Figure 3. **Tomato plant treated with kaolin clay.**

iii. Kaolin clay

Kaolin is a naturally occurring clay mineral that is finely ground and processed to produce a sprayable material that dries to a fine white film after being applied to leaves, stems, and fruits (Figure 3). It acts against insects in several ways: it can form a physical barrier that prevents them from reaching the plant tissue, act as a repellant (deterring feeding and egg-laying), mask the attractant properties of treated plants, and act as an irritant. In regions with high summer temperatures and light intensity, it is also used to protect tree fruits (e.g., apples) from sunburn and to reduce plant stress by reducing water loss through transpiration. In some regions, kaolin clay has been shown to be effective against some orchard pests (e.g., apple maggot) and to give fair control of codling moth; however, heavy use has been found to be harmful to some beneficial species and in some cases this has resulted in outbreaks of scale and mite pests.

To be effective, complete coverage of the plant is necessary, which can be difficult to achieve with backpack equipment and home garden sprayers. Bear in mind, too, that actively growing plants will soon produce new (unprotected) leaves and that heavy rain will reduce the clay deposits. Furthermore, residues remaining on the crop at harvest are likely to reduce marketability if not removed.

iv. Diatomaceous earth

Diatomaceous earth is a fine powder formed from the silica-rich "skeletons" of tiny marine plants (diatoms). This material acts by absorbing the waxes from the waterproof layer of the insect's cuticle so that the pest eventually dies through desiccation. Although there are organically approved products based on this material, their registered uses are limited mainly to control of ants and similar pests around dwellings. Very few plant-feeding pests are included under present product registrations.

v. Sucrose esters

At present, there is only one product based on sucrose esters; sold under the brand name SucraShield, it is used as a foliar spray to control or suppress soft-bodied pests such as aphids, mealybugs, leafhoppers, mites, thrips, caterpillars, and some scale insects. It acts by creating minute holes in the insect's waterproof coating so that the pest eventually dries out and dies through desiccation. As with other pesticides targeted at soft-bodied insects (e.g., insecticidal soaps), it will affect beneficial insects that are in a vulnerable stage (e.g., ladybeetle larvae) if they are directly contacted by the spray. The residues are broken down to sugar, fatty acids, carbon dioxide, and water.

***Figure 4*. Increasing diversity in the farm and garden can help reduce pests and hence the need for insecticides.**

USE OF ORGANIC INSECTICIDES

Pesticides should only be used as part of an integrated pest management (IPM) strategy. This is particularly true in organic growing systems where the primary emphasis should be on adopting a holistic approach to pest prevention that includes building soil health and organic matter, careful choice of crops and cultivars to suit the site, crop rotation, sanitation, and conservation biological control (Figure 4). Certified organic producers (or those seeking certification) should consider all available options for managing the pests they are likely to encounter and include this information in their organic management plan; if they wish to use a product not included in their management plan, they must first seek approval from their certifying body and must ensure that the product chosen is both registered for that purpose with the New Mexico Department of Agriculture (NMDA) and either approved by the Organic Materials Review Institute (OMRI) or their certifier. Both OMRI and the NMDA maintain searchable, online product databases (see **Resources** section for links).

SAFE USE OF INSECTICIDES

If it becomes necessary to use insecticides, use them wisely and safely. The following tips will help you make better use of these products.

- Try to monitor for pests at least once per week. Pay particular attention to the undersides of leaves where mites, whiteflies, aphids, and many insect eggs are often found. It is important to apply insecticides at the right time—preferably when the pest is in the immature stages (Figure 2). Be sure that you have correctly identified the insect. If in doubt, consult your county Extension agent.

- With many organically approved insecticides, good plant coverage is essential to achieve control. Do not apply insecticides to wilted plants or during the hottest part of the day, or if wind speed is more than 5 to 10 miles per hour. Repeated application may be necessary after heavy rain; check product label for details.

- Apply insecticides only at the dosages recommended on the product label. Larger amounts can be dangerous, cause plant damage, and leave harmful residues without improving insect control.

- The length of effective control provided by an insecticide varies widely, not only with the active ingredient and its formulation but also with the pH of the water used for mixing and with environmental conditions. Temperature, humidity, wind, and sunlight can all affect insecticide residues on the plant; the greater the extremes, the sooner the insecticides will be degraded.

- The time interval required by the Environmental Protection Agency between treating a crop and harvesting that crop (the "pre-harvest interval") varies with both the product and the crop. This interval is stated on the product label and is set at a level that ensures that any residues left at the time of harvest will be within acceptable limits.

- Always read and follow all instructions on the product label for safe and effective insect control.

RESOURCES

New Mexico Department of Agriculture (NMDA). Searchable database of pesticides registered for use in New Mexico: http://state.ceris.purdue.edu/doc/nm/statenm.html

Organic Materials Review Institute (OMRI). Searchable database of products and generic materials currently approved for organic production: http://www.omri.org/omri-lists

Caldwell, B., E.B. Rosen, E. Sideman, A.M. Shelton, and C.D. Smart. 2005. Understanding pesticide regulations. In *Resource guide for organic insect and disease management* [Online]. Available from http://web.pppmb.cals.cornell.edu/resourceguide/appendix/appendix_e.php

Tessa Grasswitz *is NMSU's urban/small farm integrated pest management specialist. Her research interests include integrated control of insect pests, conservation of native pollinators, and the interactions between soil heath, plant pests, and biological control agents. Her Extension program provides research-based pest management information to small-scale commercial growers, home gardeners, and landscape professionals.*

DISCLAIMER:

Brand names appearing in publications are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Please be aware that pesticide labels and registration can change at any time. By law, it is the applicator's responsibility to use pesticides ONLY according to the directions on the current label. Use pesticides selectively and carefully, and follow recommended procedures for the safe storage and disposal of surplus pesticides and containers.

May 2012 **Las Cruces, NM**