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Organic Insect & Disease Management

Successfully managing insects and diseases is often the most significant challenge for ‘conventional’ farmers who are switching to organic. Often these farmers’ first approach is to look for products, such as organically acceptable chemicals, to replace the pesticides they used in the past. Relying on this ‘input substitution’ approach generally does not provide satisfactory results in the long run. Successful organic pest management usually requires “re-designing” and managing the farm or field (i.e., agro-ecosystem) so that a variety of natural processes and specific actions by the farmer minimize pests and their damage.

I. Principles of Organic Integrated Pest Management

Ideally, integrated pest management for organic systems involves a thorough understanding of the farm ecosystem so that it can be manipulated in a way that it is self-regulating in terms of pests. The following principles are key to an integrated approach to organic pest management.

1. Know the organisms and ecosystem
   - organisms include: crop(s), key pests and beneficial plants, animals and microbes
   - know: life cycles; relationships among organisms; effects of physical environment on organisms
   - monitoring populations and keeping good records is important to understanding what is happening
2. Develop a healthy system
   - use the above knowledge to develop farming systems that favor crops and beneficials and disfavor pests
3. Maintain diversity
   - diversity generally promotes stability, resilience, and agro-ecosystem ‘health’
   - above ground and below ground diversity are important in regulating populations of pests that occur in these different environments (e.g., flying insects and foliar diseases in the above ground environment; nematodes and root diseases below ground)
   - there can be economic, as well as ecological, benefits to diversity
4. Multiple tactics - integrated approach
   - usually single tactic usually won’t suffice in either the short or the long run
   - “integrated” implies complementary approaches and tactics

II. Tactics

We can classify tactics into four broad categories:

Genetic Biological Control Cultural Controls Chemicals

Knowing the organisms involved as potential pests and beneficials informs our decisions about which tactics we may employ in a given situation. The first three categories are generally compatible with one another (with a few specific exceptions) and with a truly ecological approach to pest management. However, chemical pesticides are generally less compatible with and ecological approach. While some organically acceptable chemicals are quite safe, not all of them are. Because of their potential negative impacts on beneficial insect populations, the environment and human health, many organically acceptable chemicals should be used sparingly and as a last resort.

1. Genetic

- there are genetic differences within a crop species for susceptibility to diseases, nematodes, insects
- plant breeders, including farmers, can select strains or varieties that are less susceptible
- the resulting genetic resistance or tolerance is most commonly used with diseases
- completely compatible with other tactics
- usually increased seed cost to grower for improved varieties.

2. Biological Control (BC)

Definition: BC = using organisms to control other organisms

A. *BC of arthropods (e.g.,insects and mites):*

- More common than BC of plant pathogens or weeds
- Three broad groups of "beneficial organisms" are the "good guys"
    - Predators (individual predators consume more than 1 prey individual),
    - Parasitoids (parasitize not more than 1 host {alone or with other individuals}),
    - Pathogens (microbes which infect hosts and cause disease)
- "Natural BC" is BC that results from "naturally present" beneficial organisms
- Two main approaches to *managing* BC of arthropods:
    - enhance environment to favor (e.g., insectary plants, artificial foods, no harmful sprays)
    - purchase (or collect or rear yourself) and release
- Economics: may be "free" (e.g., "natural BC") or quite costly (e.g., multiple purchases/releases)
- May be "renewable" (i.e., self reproducing) or not
- Doesn't interfere with other tactics, but chemicals may damage beneficial organisms

B. *BC of plant pathogens:*

- Primarily of soil borne pathogens. Soil microbial diversity is key (rotation helps here)
- Composts: may contain many beneficial microbes to help control disease; esp. in potting mixes
- Commercialized microbial products: relatively rare, but seem to be increasing

3. Cultural Controls

- wide variety of management tactics that disfavor pests and favor crops &/or beneficial organisms
- generally compatible with all other tactics
- may cost extra money, but worth the "investment" in later costs being averted

A. Sanitation

- *prevent* initial contamination
- *clean up* contaminated areas, plants, equipment, etc.
- e.g.s: clean seed, clean transplants, no "cull piles", compost well

B. Physical Exclusion

- e.g., greenhouse - keep pests out of greenhouse (once inside certain pests may thrive)
- e.g., field - row covers protect from insects and diseases they transmit (e.g., viruses), and some vertebrate pests (e.g., rabbits)

C. Crop Rotation

- pest related objective is to breaks pest life cycle (this is one reason to know life cycles)
- most commonly used with *soil borne* diseases and nematodes
- may be only good control for many soil borne pests
- make sure rotation crops are "non-hosts" (and host weeds are not allowed to grow)
- rule of thumb: rotate to "crops of different families" (more specific info may help)
- crop rotation harder to implement on very small scale, with intercropping schemes, etc.

D. Timing

- grow crop during optimum season allows rapid healthy growth; pests have less impact
- may time planting, harvest to avoid pests (e.g., many pest populations build late in season)
- (may conflict with trying to extend season, e.g., get good early season prices)

E. Planting Methods

- use transplants to avoid very vulnerable seedling stage in the field
- "overplant" and take some seedling losses

F. Water and Soil/Plant Nutrition Management

- many diseases (soil and foliar) are favored by water: avoid irrigation practices that favor disease
- good soil management favors crops & beneficial microbes; therefore disfavors soil diseases
- 'balanced plant nutrition' helps crops resist pests
  - e.g., avoid excess N; Ca, K nutrition of crop are important
  - soil nutrition and foliar sprays (e.g., sea products, compost teas) may be used

Compost Teas: Depending upon the method used to produce them , compost teas contain a diverse mix nutrients and microorganisms; many farmers use compost teas to disfavor pests by improving the nutrient balance of the crop, modifying the microbial community dynamics of plant surfaces (e.g., leaves), or other mechanisms. Results may vary widely, depending upon the compost.

4. "Pesticides" (including insecticides, acaricides, fungicides)

A. *Last Resort:* Pesticides should be used only as last resort; even organically acceptable chemicals may be detrimental to workers, consumers, beneficial insects and "the environment."

B. *Regulations:* Organic farmers must be concerned with two ***distinct*** regulatory criteria:

1. *Is the product* ***registered*** *for the intended use?*

All pesticides must be registered with the Federal (and, in California, the State) Government. All registered pesticides must be sold with a *label*, which is a legally binding document that indicates, among other things, on which crops, and at what application rates, the pesticide can be used.

2. *Is the product and its use* ***allowed in organic production****, according to the USDA's National Organic Program Standards?*

The USDA Standards indicate a long list of methods, including cultural and biological controls, for managing insect pests and diseases. If these methods are insufficient to prevent or control a pest, the Standards allow the use of non-synthetic biological, botanical or mineral pesticide products.
In addition, a few synthetic substances may also be used, if they are on the National List of allowed synthetic substances (see section 205.601). This list includes soaps, horticultural oils, pheromone insect attractants, sticky traps/barriers, elemental sulfur, copper sulfate, "fixed coppers," hydrated lime, streptomycin (only for fire blight control in apples and pears) and some other products. On the other hand, section 205.602 includes a list of non-synthetic, but prohibited substances. This list includes arsenic, lead salts, strychnine (a plant-based compound), and tobacco dust (nicotine sulfate).

C. *Main groups:* The main groups of organically allowed pesticides are:
For insects: Microbials (e.g., *Bacillus thuringiensis* - "Bt"), Soaps, Oils, Botanicals
For diseases: Minerals (e.g., S, Cu compounds)

Types of organicially acceptable pesticides:

Microbials: Microbial pesticides include bacteria, fungi and viruses that cause disease and death of pests. One of the most commonly used organic pesticides in organic farming is "Bt" (*Bacillus thuringiensis*) in its various formulations. Bt is a naturally occurring bacterium (although it has been used in genetic engineering work and genetically modified crops with "Bt genes" are not allowed in organic production). The strains that are most common used in organic farming are those that affect the larvae (caterpillars) of certain lepidoptera (moths and butterflies). Commercial Bt formulations contain Bt spores and crystals of Bt toxin. When ingested, the toxin makes the caterpillars sick and usually causes death. Bt is quite safe for beneficial organisms, humans and the environment. In order to be effective, the Bt must be consumed by the caterpillar. Therefore, good coverage of the crop is important for effective control with Bt.

Soaps: Soaps are also used fairly commonly used in organic farming. They are used primarily to control aphids and other soft bodied insects. They do this by breaking down the waxy cuticle on the outside of the insect. Therefore, the insect must be directly hit by the soap spray for it to be effective. Since plants also have waxy cuticles, soaps may also damage some plants (in fact, some soaps may be used as organically approved herbicides). When in doubt, spray a small area and see if the plants are damaged.

Oils: Oils are not widely used. They are used primarily as dormant season sprays on woody crops, such as fruit and nut trees. Oils coat the bodies of immobile insects (e.g., scale insects) and prevent them from getting oxygen, so they suffocate.

Minerals: Minerals are used primarily for disease control. Some minerals (e.g., Copper) may be quite toxic to various organisms, including aquatic species, and they should be used with caution.

- *Sulfur* is used to control various fungal diseases and certain arthropods, including some mites, such as russet mites. (Largely because of its extensive use in controlling powdery mildew in grapes, there is more sulfur used in California agriculture than any other pesticide.)
- *Copper* is used to control fungi and bacterial diseases. It's environmental hazards need to be considered when using copper.

Botanicals: There are a variety of botanical insecticides that may be used in organic farming. The following list has information on the major botanical insecticides.

Pyrethrins
source: *Chrysanthemum cinearifolium*
LD_{50} (oral): 1500 mg/kg
Action: "rapid knock down" & exciter (insects may come out of "hiding")
contact, stomach and fumigant action
UV sensitive: last only about 1 day - short residual activity
Broad spectrum: chewing insects, sucking insects, flies, thrips, mosquitoes, household pests,
some beneficials, fish.

notes:
1. Pyrethroids are synthetic analogs of pyrethrins and not organically acceptable
2. PBOs (piperonyl butoxides) are commonly added to pyrethrins because they decrease insects' ability to detoxify pyrethrins. Although PBOs are derived from sassafras, they are chemically altered and, therefore, organically unacceptable.
Thus, neither pyrethroids nor pyrethrin formulations containing PBOs are allowed in organic farming.

Rotenone
source: *Derris spp.* & *Lonchocarpus spp.* roots
LD_{50} (oral): 130 - 350 mg/kg
Action: contact, stomach and repellent action; slow acting
UV sensitive: last only about 1 to a few days - short residual activity
Broad spectrum: chewing insects, sucking insects, fish.

Pyrellin
a fairly commonly used mix of Rotenone and Pyrethrin
broad spectrum
lasts about 2 days

Sabadilla
source: *Schoenocaulon officianale* seeds
LD_{50} (oral): 4000 mg/kg (eye irritant)
Action: contact, stomach action

UV sensitive: best if used in cool, moist weather
Broad spectrum: chewing insects, sucking insects, honey bees

Ryania
source: *Ryania speciosa* stems
LD_{50} (oral): 750 - 1200 mg/kg
Action: contact, stomach action; slow kill, but feeding arrested quickly
Lasts 1 - 2 weeks; best in hot, dry weather; washes off with water easily
Relatively narrow spectrum: some caterpillars, thrips; "easy on beneficials"

Quassia
source: *Quassia spp.* bark
LD_{50} (oral): "high"
Narrow spectrum: generally soft-bodied insects; "easy on beneficials"

Neem
source: *Azadirachta indica* seeds
LD_{50} (oral): >13000 mg/kg
Action: surface and systemic activity in plants; toxic to many insects; also repellent and inhibitor of feeding and ovipositing
Broad spectrum: many insects, fungi and bacteria, although reportedly fairly easy on beneficials

III. Issues of Diversity and Scale

In practice, approaches to organic pest management can be quite different on different organic farms. Operations that are highly diversified tend to be smaller in scale; these farms often can not afford to expend much time and other resources monitoring pests. Additionally, because there are so many crops grown, the economic value of each individual crop is generally quite small. Therefore, individual crops are occasionally lost to pests, but, within the context of the overall operation, the cost of such losses may be less than cost of preventing them. In addition, because most diseases and insect pests have fairly limited host ranges, a crop in one row can be devastated by a particular pest while other crops growing in adjacent rows can be completely unaffected. Finally, high levels of plant (e.g. crop and other species) diversity tend to promote higher levels of insect diversity, particularly beneficial insect diversity, so levels of "natural" biological control may be quite high, although the farmer is not spending any time or money specifically to promote this. Thus, the high level of diversity on these farms tends to have both ecological and economic consequences which promote an apparently laissez faire approach to pest management. However, overall farm design, the use of resistant varieties, various cultural practices, and some level of direct intervention usually are combined on such farms to result in satisfactory levels of pest management.

In contrast, organic farming operations that specialize in a smaller number of crops tend to be larger in size and have significant amounts of resources invested in each crop. Therefore, they tend to invest more in monitoring pests (as well as other factors, such as nutrition, water, etc.) on a field by field basis and are more likely to use interventions such as releasing beneficial insects or applying organically acceptable pesticides. These fields also tend to be less diverse ecologically and, in general, levels of 'natural' biological control are low. However, some larger scale organic farms do incorporate the use of insectary plants of various types on field margins, or even within the field, to try to increase levels of beneficial insects in their fields.