PP253

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Organic Management of Vegetable Diseases Part I: Soilborne Pathogens[1]

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Most methods of plant-disease control follow one of the six principles summarized by the acronym REPEAT: Resistance, Eradication; Protection, Exclusion, Avoidance, and Therapy. The following is an overview of these principles with an emphasis on methods acceptable in certified organic vegetable production for controlling plant disease caused by soilborne pathogens.

This review is not exhaustive, but is a generalized guide, intended to assist growers in selecting complementary strategies that will result in a more sustainable system. A separate review of organic control strategies for foliar pathogens is also available; see EDIS Publication PP254 *Organic Management of Vegetable Diseases Part II: Foliar Diseases* (http://edis.ifas.ufl.edu/PP170).

Regardless of the disease-control strategy employed, it is the responsibility of the grower to verify that all practices and products meet the principles established by the United States Department of Agriculture (USDA) National Organic Program (NOP); (http://www.ams.usda.gov/nop/NOP/NOPhome.html). The Organic Materials Review Institute (OMRI) (http://www.omri.org) provides an up-to-date list of products and providers for certified organic production, including a list of providers of organically produced seed.

Resistance: Using plant varieties that are genetically resistant to or tolerant to a specific pathogen for disease control.

Resistance is by far the easiest and most economic means to control plant disease. For example, many vegetable varieties have resistance to species of *Verticillium and Fusarium*, common soilborne pathogens that cause vascular wilts. However, the pathogen population can change with time, leading to a breakdown of plant resistance to the pathogen. Additionally, plant resistance to pathogens is limited to only a portion of the pathogen population, often called a race. Therefore, other disease-control methods are necessary to manage the pathogen population so as to minimize selection pressure and extend the usefulness of the resistant variety once it is used.

Eradication: Controlling disease by eliminating or reducing disease-causing pathogens in the environment.

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Eradication can include rotation with non-host crops, rogueing of infected plants, elimination of infested crop residues, use of biorationals, and any other physical/chemical method to destroy or reduce inoculum in the field.

Crop rotation is an effective means to control diseases since many pathogens have a strong crop preference. Rotation with a non-host crop breaks the disease cycle and over time reduces the inoculum in the soil. However, some pathogens have a broad host range, so proper identification of the pathogen is important in using the crop-rotation method effectively.

For information about proper methods for soil sampling and how to submit plant samples and/or digital images to the Florida Extension Plant Disease Clinic (http://plantpath.ifas.ufl.edu/pdc/default.htm) and the Distance Diagnostic Identification System (http://ddis.ifas.ufl.edu/) see these organizations' respective Web sites. Also refer to EDIS Publication RFSR007 *Sample Submission Guide for Plant Diagnostic Clinics of the Florida Plant Diagnostic Network* (http://edis.ifas.ufl.edu/SR007) and EDIS Publication PP185 *Guidelines for Submitting Plant Disease Samples Using the Distance Diagnostic and Identification System* (http://edis.ifas.ufl.edu/DDIS1).

Biorationals, including biological agents or secondary compounds extracted from plants, provide another means of eliminating pathogens**.** Some commercially available biological agents will parasitize various stages of the pathogen, reducing the viability of soil propagules or decreasing the overall aggressiveness of the pathogen. To locate an effective biorational based on the target pest/pathogen or to search for a biorational by trade name or active ingredient, consult the following ATTRA Web site: http://attra.ncat.org/attra-pub/biorationals/biorationals_main_srch.php.

The use of cover crops can also reduce inoculum by acting as a trap-crop to stimulate the germination of pathogen propagules in the soil in the absence of an appropriate host. Some cover crops release toxic secondary compounds into the soil during growth or decomposition. These compounds can be toxic to plant pathogens and, thus, help control plant disease. For example, many plants in the Brassicaceae (Mustard) family accumulate glucosinolates that breakdown during decomposition, releasing doses of isothiocyanates lethal to many soilborne pathogens.

Removing infected plants and debris can also help break the disease cycle and reduce the quantity of pathogens, thus slowing disease progress or eliminating the pathogen source for subsequent plantings.

Various hygienic approaches can eliminate the pathogen and exclude it from new environments. One example is applying surface disinfestants -- such as sodium hypochlorite solutions (household bleach) -- so as to clean work surfaces, propagation tools, gloves, boots and equipment, thereby eliminating pathogens and preventing or limiting their spread in greenhouse, shade house and field operations. Cleaning soil and plant debris from tractors and implements between fields, especially in fields with a disease history, can also greatly reduce the chance of spreading the pathogen to new areas. The use of a surface disinfestant or steam can aid in cleaning equipment.

Keep in mind, however, that most detergents are not allowed in certified-organic vegetable production because they include a synthetic surfactant. Soaps generally are permitted. Prior to using any cleaning products, check that they meet NOP standards (http://www.omri.org).

Manipulation of the physical environment -- such as increasing the air or soil temperature or limiting oxygen exchange -- is another means of eradicating soilborne pathogens. These practices can be employed in greenhouse and field settings prior to planting. While these approaches are promising, they require additional research for reliable field applications.

Soil solarization uses a plastic mulch to trap solar energy, thereby raising soil temperature to levels lethal for many soilborne pathogens. For a more detailed discussion of this method, see EDIS Publication ENY052 *Nematode Management for Bedding Plants* (http://edis.ifas.ufl.edu/IN470) and EDIS Publication ENY032 Nematode Management in Tomatoes, Peppers and Eggplant (http://edis.ifas.ufl.edu/NG032). Increasing soil temperature in this way can be especially effective during the long, hot summers typical of Florida. Results can vary greatly, however, depending upon environmental conditions, so this approach needs to be evaluated on a case-by-case basis.

Soil steaming, long used to sterilize potting mixes for greenhouse production, is another use of heat to eradicate soilborne pathogens.

Biological soil disinfestation uses the action of decomposing vegetative materials -- whether from cover-crop debris, green manure or immature compost -- in combination with a nearly airtight plastic film (ensilage plastic with low oxygen permeability) to create an anaerobic environment that is lethal to many soilborne pathogens. However, this approach, like soil solarization, needs to be evaluated on a case-by-case basis.

Protection: Using NOP-approved materials, including biorationals, to interfere with a pathogen's ability to infect susceptible plants.

This approach requires the application of materials prior to the rise of conditions favorable for disease development or, to prevent rampant spread of a disease, immediately following the appearance of the first symptoms of the disease.

In foliar applications, these materials provide a protective barrier on plant surfaces. The barrier interferes with the pathogen. But repeat applications are required with subsequent rain/irrigation that wash materials off foliage and fruit or with the emergence of new foliage.

Similar strategies are possible for protective agents applied to seeds, roots or soil. These materials can provide temporary protection to roots, but results can vary depending on the crop, the pathogen and the environment. Subsequent root growth or rain/irrigation can wash materials away from the root zone. And many biological agents can grow within the root zone and persist longer than chemicals. However, because these biological agents are unable to compete with native soil microorganisms, they tend to persist at levels ineffective for control. Biological agents are generally most effective in the control of root rots associated with seed germination and seedling/transplant establishment.

Exclusion: Controlling disease by preventing the introduction or establishment of a pathogen in an environment.

In theory, this is the best management strategy. But in practice, it is often the most difficult. For practical purposes, preventing the pathogen from entering the production system begins with the use of disease-free seed, transplant, or propagation material.

Many diseases are seedborne, so using seed that is tested and certified to be free of certain diseases is wise. For more information on organic seed production, please refer to EDIS Publication HS981 *Seed Production and Seed Sources of Organic Vegetables* (http://edis.ifas.ufl.edu/HS227). To locate commercial suppliers of organic seed, consult OMRI databases (http://seeds.omri.org/) and the database made available by Appropriate Technology Transfer for Rural Areas (ATTRA) (http://attra.ncat.org/attra-pub/altseed_search.php).

In addition to careful selection of seed, exclude disease from the field by screening seedlings for any symptoms of disease and removing these sources before the disease spreads. Following a disease outbreak, especially in a transplant facility, be careful to clean all tools, transplant flats and work surfaces (including floors) with a surface disinfestant to eradicate the pathogen and exclude it from subsequent production of transplants.

These methods do not provide any guarantee against subsequent disease since some pathogens can remain in a dormant state on the plant until specific conditions occur. However, the use of disease-free planting materials and good production hygiene will limit the amount of pathogen introduced into the environment and, thereby, control the incidence and severity of a disease outbreak. And limiting the size of an initial disease outbreak provides an opportunity to manage the disease successfully.

Avoidance: Controlling plant disease by maintaining healthy growing conditions for the plant and growing the plant under environmental conditions not favorable for the pathogen or for the development of disease.

Avoid conditions that compromise plant health. Poor soil structure or bed preparation is likely to lead to poor drainage, which not only stresses the plant, but also creates conditions favorable for many soilborne pathogens. Poor water quality and nutrient management can also compromise plant health. Amend soils with composted plant residues and manures to improve soil structure and create a nutrient source that supports the activity of soil microorganisms to promote crop health.

If possible, produce the crop in an environment unfavorable for disease development or where the pathogen is not found. Manipulate the planting date to favor times when the pathogen is either inactive or at a lower level in the environment. For example, seedling diseases are often favored by moist, cool soil conditions. However, keep in mind that modifying planting dates can in some cases have negative consequences. For example, planting later, when soils are warmer, might circumvent seedling diseases, but expose the crop to conditions more favorable for foliar diseases.

Therapy: Controlling disease by treating infected plants through chemical or biological agents or by manipulating the environment to eliminate or limit pathogen growth and subsequent disease.

While various choices are available for the therapeutic treatment of foliar diseases, there are few therapeutic treatments for root and crown diseases. Once a pathogen has colonized tissues of the root or crown, it is nearly impossible to treat since the pathogen is then protected within plant tissues from the effects of most treatments. Few chemicals or biorationals approved for organic production are systemic. However, reducing irrigation or fertilization will often slow the progress of the disease.

Integration Is the Key to Sustainability

The most sustainable approach to disease control is one that integrates several of the methods summarized above. And because successful integration of these methods requires knowledge of the pathogen and the disease cycle, correct diagnosis of the disease is critical.

The principles of plant-disease control outlined in this paper are reviewed in Table 1, below, along with strategies and specific examples.

The premise of organic agriculture is to produce a crop through use of biological and ecological approaches that are in synchrony with the natural environment and, in so doing, to manage plant fertility, pests and diseases in the absence of synthetic compounds.

While any commercial grower or backyard gardener can apply the principals of organic production, growers certified in organic production are obligated to adhere to these principles as established by the USDA's NOP. Information about these standards is available at the following URL: http://www.ams.usda.gov/nop/NOP/NOPhome.html. Failure to comply with NOP guidelines could result in fines or even loss of organic certification.

It is the responsibility of the grower to check that all products comply with NOP standards for certified organic production.

Other Useful Sources of Information on Organic Crop Production

Organic Farming Research Foundation (http://ofrf.org)

Consortium/Scientific Congress on Organic Agriculture Research (SCOAR) (http://www.organicaginfo.org/)

Appropriate Technology Transfer for Rural Areas (ATTRA) (http://attra.org/)

Cornell University Organic Resource Guide (http://www.nysaes.cornell.edu/pp/resourceguide/)

Table 1. Strategies for controlling plant diseases caused by soilborne pathogens, following the REPEAT disease-control principles and including some specific examples.

Principle	Strategies	Notes
Resistance	Select disease-resistant/tolerant vegetable varieties.	Resistance to wilts caused by species of *Fusarium* and *Verticillium* is common among vegetables.
Eradication	Rotate crops.	Never double-crop a field with crops of the same plant family, i.e., tomato and pepper.
	Rogue diseased plants.	Scout early and often to quickly identify and eliminate disease problems in the greenhouse and the field.
	Eliminate plant debris.	Do not leave or spread culled fruit in production fields. Incorporate all remaining crop residues into soil to ensure rapid decomposition.
	Employ biological control agents.	*Coniothyrium minitans* is a parasite of *Sclerotinia sclerotiorum* and will colonize and destroy the pathogen. Many products contain species of *Trichoderma,* another mycoparasite that can eliminate or weaken other fungal pathogens.
	Plant cover crops.	Many members of the Brassicaceae (mustard) family release during decomposition isothiocyanates that are lethal to many soilborne pathogens.
	Solarize soil.	Success depends on elevating subsurface soil temperatures over an extended period; often requires weeks.
Protection	Apply biological control agents.	Many products are based on strains of *Bacillus, Pseudomonas,* or *Streptomyces.* These microorganisms often produce antibiotics that thwart root pathogens, and they compete for sugars and amino acids, which are produced by roots and would otherwise benefit the pathogen.
Exclusion	Use disease-free plant material.	Use seed or transplants that have been tested for seedborne pathogens. Do not introduce unhealthy/diseased transplants into the field.
Avoidance	Select an appropriate site.	Avoid planting in areas with drainage problems or with a history of disease.
	Select an appropriate planting date.	Coordinate planting dates to avoid troublesome growing periods.
	Use composted residues and manures.	Amending soils with composts or manures can improve soil structure and fertility and promote crop health.
Therapy	Manipulate crop inputs.	The severity of many root/crown diseases can be lessened by reducing water and nutrient inputs.