



Sanitation Practices for Disease Management in Commercial Specialty Crop Production

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IMPORTANCE OF SANITATION

Plant diseases pose a significant risk to fruits, vegetables, and ornamentals. Whether grown in fields, greenhouses, high tunnels, landscapes, or nurseries, specialty crops can be affected by diseases that result in premature leaf drop, fruit decay, dieback, decline, and plant death. When disease becomes apparent, it is often presumed that fungicides are the best management option. However, a thorough sanitation program can help to reduce the need for fungicides and improve the effectiveness of other disease management practices.



FIGURE 2. CROP DEBRIS LEFT BEHIND IN FIELDS CAN PROVIDE A SOURCE OF MICROSCOPIC DISEASE-CAUSING ORGANISMS THAT INFECT FUTURE CROPS.

Sanitation is the process of removing crop debris (FIGURE 1) and cleaning to remove disease-causing pathogens. This disease management tool reduces pathogen propagules (such as fungal spores, bacterial cells, virus particles, and nematode eggs; FIGURE 2) that can ultimately lead to infections and disease losses. During the growing season, actively growing plants provide host tissue for pathogen multiplication, resulting in disease spread. Dead plant material (foliage, stems, roots, and fruit mummies) can harbor overwintering pathogen propagules for months or years (FIGURE 3). Disease-causing propagules can travel via air/wind currents, stick to shoes or tools, or move with contaminated soil or water droplets. Sanitation through selecting disease-free materials, cleaning tools, surfaces, and structures, and the removal of affected plants or plant parts can reduce disease incidence and spread.

SANITATION PRACTICES

The following sanitation practices can reduce the amount of infectious pathogen propagules present in plantings. The most successful disease management programs include a combination of several sanitation practices. Not all sanitation practices are applicable for all crops or growing environments. The practices described below are summarized by crop and growing environment in TABLE 1.

Use new potting media

- Do not reuse soil or potting media.
- Do not collect soil from outdoors for use as greenhouse potting media.

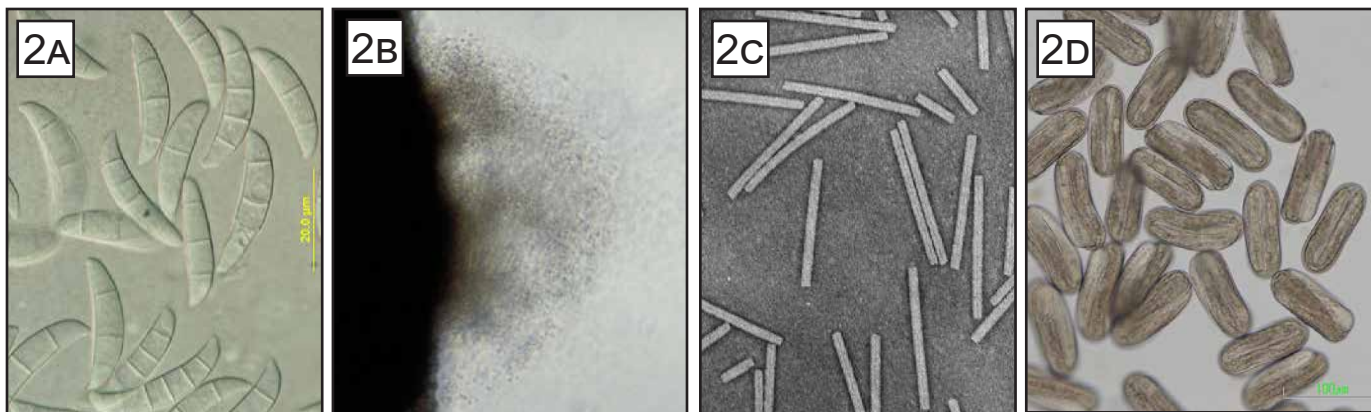


FIGURE 2 SANITATION PRACTICES HELP ELIMINATE MICROSCOPIC PLANT PATHOGENIC PROPAGULES SUCH AS **(A)** FUNGAL SPORES [*FUSARIUM* SP. CONIDIA], **(B)** BACTERIAL CELLS [BACTERIAL STREAMING MAGNIFIED 100X], **(C)** VIRUS PARTICLES [TMV AS SEEN UNDER THE ELECTRON MICROSCOPE], AND **(D)** NEMATODE EGGS [SOYBEAN CYST NEMATODE]. PROPAGULES ARE SHOWN UNDER HIGH MAGNIFICATION.

Use pathogen-free irrigation water

- Utilize either municipal or sterilized water.
- Install a water-treatment system if using surface water or recycled water.

Begin with disease-free stock

- Purchase certified disease-free seeds, transplants, and plugs.
- Consult suppliers regarding information on production practices.
- Inspect plants prior to installation to ensure they are disease-free and healthy (FIGURE 4).
- Small-scale producers should treat any saved vegetable seeds prior to planting. Information on best practices for seed treatments can be found in *Disease Management Practices for Saved Vegetable Seeds* (PPFS-VG-09).



Clean & sanitize materials, equipment & tools

- All planting materials (pots, stakes, trellising, etc.), equipment, sprayers, and tools should be cleaned and sanitized prior to each use. Tools such as pruners and hoes should be cleaned and sanitized between fields; if disease is present (especially bacterial diseases), sanitize pruners after each cut.
- Before sanitizing, clean thoroughly to dislodge soil and debris that may contain disease propagules.



FIGURE 3. DEAD PLANT MATERIAL CAN HARBOR LONG-TERM SURVIVAL STRUCTURES, SUCH AS SCLEROTIA (*e.g.*, TINY, ROUND, BROWN FUNGAL STRUCTURES WITHIN THE WHITE CIRCLE), THAT CAN SURVIVE FOR MONTHS OR YEARS. REMOVAL OF CROP DEBRIS CAN HELP REDUCE DISEASE INCIDENCE IN LATER PLANTINGS. [SOUTHERN BLIGHT ON LETTUCE DUE TO *SCLEROTIUM ROLFII*]

FIGURE 4. INSPECT PLANTS CAREFULLY, INCLUDING ROOTS, BEFORE TRANSPLANTING TO ENSURE ONLY HEALTHY PLANT MATERIAL IS USED. [WATERMELON TRANSPLANTS WITH *PYTHIUM* ROOT ROT (*left*) AND HEALTHY ROOTS (*right*)]



FIGURE 5 CLEAN EXCESS SOIL AND PLANT DEBRIS FROM GREENHOUSE FLOORS, INCLUDING AREAS UNDER BENCHES, TO REMOVE INFECTIVE PROPAGULES SUCH AS SURVIVING FUNGAL SPORES OR BACTERIAL CELLS.



FIGURE 6. WEEDS AND VOLUNTEER PLANTS NOT ONLY COMPETE FOR WATER AND NUTRIENTS, BUT THEY CAN ALSO HARBOR PATHOGENS AND CREATE ENVIRONMENTAL CONDITIONS CONDUCIVE TO DISEASE.

Clean & sanitize materials...(cont'd)

- Sanitation methods
 - Use a commercial disinfectant such as quaternary ammonium (Green-Shield®, Quattro, Physan), 10% bleach (1 part household bleach to 9 parts water), hydrogen peroxide (Oxidate, Terraclean), or 10% Lysol® concentrated disinfectant to sanitize surfaces, equipment, and tools.
 - Bleach and peroxide are corrosive, so tools must be rinsed with clean water within 5 to 10 minutes of exposure.
 - Heat treatments, such as steam or solarization, can also be effective. Ensure that temperatures reach between 250°F and 350°F (depending on pathogen). Additional information on solarization can be found in the research report publication *Effects of High Tunnel Soil Solarization on Sclerotinia sclerotiorum in the Temperate Climate of Central Kentucky* (PPRR-13).
- Additional information about cleaning equipment and tools can be found in the publication *Cleaning and Disinfecting Hand Tools and Planting Supplies* (PPFS-GEN-17).

Clean & sanitize structures

- Clean excess soil and plant debris from floors and benches (FIGURE 5). Gravel, concrete, or landscape cloth can be used to cover dirt walkways. Gravel and woven landscape cloth do not block upward movement of water and soil and may have to be cleaned more frequently.
- Clean and sanitize benches and floors with the same method as described in **Clean & sanitize materials, equipment & tools** (previous section).
- Woven landscape cloth and groundcover can be sanitized with a quaternary ammonium disinfectant (some formulations do not require rinsing).

- Flush irrigation lines before and after each cropping season using products described in **Clean & sanitize materials, equipment & tools** (previous section).
- Avoid dragging hoses that may move soil and debris to cleaned surfaces.
- Additional information about cleaning greenhouse surfaces and structures can be found in the publication *Cleaning and Sanitizing Commercial Greenhouse Surfaces* (PPFS-GH-07).
- Heat treatments, such as steam or solarization, can also be effective. Ensure that temperatures reach between 250°F and 350°F (depending on pathogen). Additional information on solarization can be found in the research report publication *Effects of High Tunnel Soil Solarization on Sclerotinia sclerotiorum in the Temperate Climate of Central Kentucky* (PPRR-13).

Manage weeds & other unwanted plants

- Remove weeds, volunteer plants, or other non-cultivated species (FIGURE 6) to limit movement of diseases.
- Remove above and below ground plant parts to discourage regrowth.

Avoid moving pathogen propagules

- People can often be responsible for moving pathogen propagules to healthy plants. The following strategies can help to limit this movement.
 - Work with healthy plants first and then scout/inspect unhealthy or less vigorous plants.
 - Change clothing, coveralls, or outerwear after working in diseased fields or greenhouses. Launder clothing daily.



FIGURE 7. PATHOGENS MAY BE CARRIED INTO PLANTING AREAS ON SHOES AND BOOTS. USING FOOT BATHS TO DISINFECT FOOTWEAR CAN HELP MINIMIZE MOVEMENT OF SOME DISEASE PROPAGULES BETWEEN GREENHOUSES OR BETWEEN PLANTING ZONES.

FIGURE 8. COLLECT DISEASED FRUIT AS SOON AS SYMPTOMS ARE OBSERVED. THIS ELIMINATES A SOURCE OF INOCULUM THAT CAN SPREAD TO OTHER FRUIT, AND IT REMOVES A POTENTIAL SOURCE OF OVERWINTERING PROPAGULES IF LEFT ON TREES OR ON THE GROUND [BITTER ROT OF APPLE].

FIGURE 9. REMOVE AND DESTROY WHOLE PLANTS WHEN HEAVILY INFESTED. FOR IN-GROUND PLANTS, THIS MAY ALSO REQUIRE REMOVING AS MUCH OF THE ROOT SYSTEM AS POSSIBLE, ALONG WITH SURROUNDING SOIL [RHIZOCTONIA WEB BLIGHT ON CHRYSANTHEMUM].

Avoid moving pathogen propagules (*cont'd*)

- Utilize footbaths between greenhouses or zones to prevent movement of propagules on shoes (FIGURE 7).
- Do not work with plants when wet. Avoid working during periods when dew is present or right before, during, or after a rain event.
- Pathogens can move long distances via infected plants and plant materials (whole plants, seeds, fruits, stems).
 - Avoid introducing diseased plants into fields; never purchase or accept diseased plant material. Diseases cannot be cured, even using fungicides.
 - Discard prunings and culled plants. Never leave cuttings or diseased plants in fields or greenhouses. See **Discard diseased plant material** section (*next page*) for additional information.
 - Nursery exports may require a phytosanitary certificate for certain states. County Extension agents can assist growers in contacting the Office of the State Entomologist (nursery inspector).

Remove diseased plants or plant tissues

- Prune cankered and galled branches several inches below the point of infection. Cuts should be made at an intersecting branch, when possible.
- Collect rotting or diseased fruit as soon as symptoms develop (FIGURE 8).
- Prune or remove infected tissue (flowers, fruit, stems, leaves) when disease symptoms appear.
- Remove whole plants when heavily infected (FIGURE 9), or when plants are infected with non-treatable diseases (e.g., root rots, viruses, and vascular wilts). When practical, remove as much of the root system as possible along with infested soil.
- At the end of the growing season, remove and discard all plant material and debris. To the extent possible, rake and remove fallen buds, flowers, fruit, twigs, and leaves.
- All diseased plant materials should be collected and discarded. Never leave debris or clippings on the ground. See **Discard diseased plant material** section (*next page*) for additional information.

Discard diseased plant material

- Bury, burn, or completely remove diseased plant material (fallen leaves, prunings, dropped buds, fruit mummies, and culled plants). Prune directly into a cart or onto a tarp whenever possible. Never leave debris or clippings on the ground.
- Commercial orchardists may mow fallen leaves and apply nitrogen to promote the breakdown of leaf tissues. This technique is only effective for tissues that decompose easily. Rigid leaves and woody tissue do not respond to this treatment.
- Vegetable and strawberry growers may deep till residual debris at the end of the season to encourage decomposition. Large debris should be removed from the field before tilling.
- Avoid saving limbs and trunks from diseased trees or shrubs to be used as firewood.
- Do not compost diseased plant material or infested soil because incomplete composting (temperatures below 160°F) may result in survival of propagules.

Postharvest disease prevention

- Clean and sanitize all storage equipment and containers prior to use.
- Minimize wounds and bruises during harvest, handling, and packaging.
- Move produce to storage conditions as soon as possible. Avoid leaving produce in the sun.
- If fruits and vegetables must be washed, they should be completely dry before storage.
- Maintain appropriate storage temperature and humidity.
- Inspect stored produce regularly and discard damaged and diseased material immediately.
- Additional information on postharvest disease losses can be found in the publication *Postharvest Disease Losses in Fruit and Vegetable Crops* (PPFS-GEN-24).

TABLE 1. APPLICATION OF SANITATION PRACTICES BY CROP OR PRODUCTION ENVIRONMENT

	Crop / Production System						
	Sanitation Practice	Tree Fruit	Small Fruit & Berries	Vegetables	Container Nursery	Greenhouse	High Tunnel
Prior to growing season/between crops	Clean and sanitize pots, stakes, trellising, or other cropping materials			X	X	X	X
	Clean and sanitize all tools such as pruners, shovels, trowels, hoes	X	X	X	X	X	X
	Clean and sanitize irrigation lines		X	X	X	X	X
	Clean and sanitize all equipment such as harvesters, planters, and sprayers	X	X	X		X	X
	Clean and sanitize all structures including floors and benches				X	X	X
Planting	Do not reuse soil or potting media			X	X	X	
	Purchase disease-free seed/transplants	X	X	X	X	X	X
	Treat saved seed			X		X	X
	Plant only healthy plants; Do not introduce diseased plants	X	X	X	X	X	X

TABLE 1. APPLICATION OF SANITATION PRACTICES BY CROP OR PRODUCTION ENVIRONMENT (CONT'D)

Crop / Production System							
	Sanitation Practice	Tree Fruit	Small Fruit & Berries	Vegetables	Container Nursery	Greenhouse	High Tunnel
During growing season	Use pathogen-free irrigation water	X	X	X	X	X	X
	Work healthy plants first, then work unhealthy plants	X	X	X	X	X	X
	Do not work with plants when wet	X	X	X	X	X	X
	Manage weeds	X	X	X	X	X	X
	Remove volunteer plants or wild plants of cultivated species	X	X	X	X	X	X
	Avoid dragging hoses across floors				X	X	X
	Change clothing after working with diseased plants	X	X	X	X	X	X
	Use footbaths with a disinfectant					X	X
	Remove diseased plant tissues throughout the season	X	X	X	X	X	X
	Remove whole plants when highly infected or infected with non-curable diseases	X	X	X	X	X	X
	Remove diseased fruit throughout the growing season	X	X	X		X	X
	Discard prunings and culled plants away from production areas	X	X	X	X	X	X
End of growing season	Clean-up of plant material and debris	X	X	X	X	X	X
	Burn, bury, or remove diseased plant material from site	X	X	X	X	X	X
	Deep till residual debris to encourage decomposition		X	X			X
	Do NOT compost diseased materials	X	X	X	X	X	X
	Mow and apply nitrogen to promote breakdown of fallen leaves	X					
	Avoid saving diseased wood for firewood	X			X		
	Clean and sanitize all storage containers prior to re-use	X		X		X	
	Minimize wounds and bruises during harvest, handling, and packaging	X	X	X		X	X
	Move produce to storage conditions as soon as possible	X	X	X		X	X
	If fruits and vegetables must be washed, allow to dry before storage	X	X	X		X	X
	Maintain appropriate storage temperature and humidity	X	X	X		X	X
	Inspect stored produce regularly and discard damaged and diseased material immediately	X	X	X		X	X

ADDITIONAL RESOURCES

Additional information can be found on the UK Plant Pathology Extension Publications webpage:

<https://plantpathology.ca.uky.edu/extension/publications>.

- *Cleaning and Disinfecting Hand Tools and Planting Supplies* (PPFS-GEN-17)
- *Cleaning and Sanitizing Commercial Greenhouse Surfaces* (PPFS-GH-07)
- *Disease Management Practices for Saved Vegetable Seeds* (PPFS-VG-09)
- *Effects of High Tunnel Soil Solarization on Sclerotinia sclerotiorum in the Temperate Climate of Central Kentucky* (PPRR-13)
- *Postharvest Disease Losses in Fruit and Vegetable Crops* (PPFS-GEN-24)

DISCLAIMER

Chemicals listed here include a few of the most common products available and were selected to simplify information in this publication.

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