

Managing Greenhouse & High Tunnel Environments to Reduce Plant Diseases

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INTRODUCTION

Greenhouse and high tunnel environments, which tend to be warm and humid, often create ideal situations for disease development. Environments favoring infection and spread of many disease pathogens include one or more of the following: high relative humidity (90% or above), free moisture (e.g., leaf wetness, wet soil), and/or warm temperature. Because diseases can cause extensive damage, their management is essential to production of high quality, marketable products. While challenging, these environments can be managed to simultaneously encourage plant growth and discourage pathogen spread.

MANAGING RELATIVE HUMIDITY & TEMPERATURE

High relative humidity promotes development of many leaf, flower, and fruit diseases, including powdery mildew and gray mold (FIGURE 1). Daytime relative humidities of 25% to 70% are often low enough that pathogen infection is inhibited. However, when humidity rises above 90%, especially for long periods, disease incidence can also increase. The following practices help manage humidity and temperature.



FIGURE 1. MANY PLANT PATHOGENS, (SUCH AS *Botrytis*, SHOWN HERE) ARE FAVORED BY THE WARM, HUMID CONDITIONS THAT CAN DEVELOP IN GREENHOUSES AND HIGH TUNNELS. PATHOGENS ALLOWED TO MULTIPLY ON DISEASED TISSUES SERVE AS SOURCES OF INFECTIOUS MATERIAL FOR FURTHER DISEASE SPREAD.



FIGURE 2. VENTILATING HIGH TUNNEL (LEFT) AND GREENHOUSE (RIGHT) STRUCTURES IS IMPORTANT TO REDUCING INTERNAL RELATIVE HUMIDITY. HIGH HUMIDITY ENCOURAGES THE DEVELOPMENT OF MANY DISEASES, SUCH AS POWDERY MILDEW AND BOTRYTIS GRAY MOLD.

Air Circulation

Fan-jet or horizontal air flow systems should operate continuously in greenhouses during periods of high humidity, which often occur at night and during rainy days. Exhaust fans, when present, can be used to circulate air in greenhouses and in high tunnels when sides are closed.

Ventilation

Exchange air in greenhouses and high tunnels with fresh outdoor air (FIGURE 2) in order to reduce internal relative humidity.

Heated greenhouses

Most winter evenings are cool enough to raise humidity to 100% and result in considerable condensation in greenhouses. Condensation can be reduced significantly with late afternoon ventilations. Ventilation fans exhaust warm moist air from the greenhouse, replacing it with cooler outdoor air. When this fresh air is heated, it becomes much drier and less favorable for disease development.

High tunnels

Ventilation in high tunnels is manipulated by opening sidewalls, endwalls (FIGURE 2), and/or ridge vents, if applicable. For new construction, choose a site with good air drainage and gentle

breezes to facilitate ventilation. Prevailing winds will dictate orientation of a ridge vent.

Plant Spacing

Closely-spaced plants and overlapping canopies can create microclimates different from the rest of the structure. These microclimates are often higher in relative humidity than surrounding air and are typically the first place disease develops. Plants should be adequately spaced to allow for air movement during all stages of development. This facilitates drying of foliage and makes it easier to obtain good spray coverage when fungicides are required. Hanging baskets placed overhead also reduce normal water evaporation and contribute to high humidity in crop canopies. Bushy or suckered ornamentals should have wider spacing, especially if plants are not pruned regularly. On determinate tomatoes, suckers and old leaves (up to first bunch of fruit) should be removed to facilitate air flow.

For specific recommendations on vegetable spacing, see *Vegetable Production Guide for Commercial Growers* (ID-36).

Air Temperatures

Temperatures outside the normal range of growth induce stress on plants, and stressed plants are generally more susceptible to



FIGURE 3. PUDDLING WATER ON GREENHOUSE AND HIGH TUNNEL FLOORS INCREASES RELATIVE HUMIDITY, ENCOURAGES WEEDY GROWTH, AND CAN SERVE AS SOURCES OF PATHOGEN INOCULUM. HOSES LEFT ON THE GROUND MAY BECOME CONTAMINATED WITH PLANT PATHOGENS.

infection by disease-causing pathogens. Rapid temperature fluctuations in structures should also be avoided to reduce plant stress. Consult literature and production guides (e.g., *Vegetable Production Guide for Commercial Growers*, ID-36) for optimal temperatures for specific greenhouse or high tunnel crops.

Avoid Standing Water

Water that collects or puddles under benches or in walkways (FIGURE 3) increases humidity. Standing water also encourages growth of weeds and volunteer plants, which can harbor plant pathogens. Gravel, concrete, or landscape cloth covering dirt walkways reduces the overwintering (or overseasoning) capability of plant pathogens.

SANITATION

Sanitation practices aid in eliminating sources of infectious plant pathogens and minimizing their spread. For more information on this topic, refer to *Greenhouse Sanitation* (PPFS-GH-04).

The following practices can help reduce active and dormant pathogen inoculum levels.

Surface Sterilize Benches, Pots, & Tools

Disease-causing pathogens are often spread through used pots, dirty tools and work surfaces, unswept floors, contaminated hoses (FIGURE 3), and even on human hands and clothing. Avoid any introduction of natural soil from dirty boots. Surface sterilize all work benches and tools regularly to prevent spread of pathogen inoculum. A dilute solution of household bleach (9 parts water to 1 part bleach) or commercial disinfectant will eliminate most pathogens. If using landscape cloth, thoroughly sweep it between cropping seasons and clean by spraying with high pressure water. Landscape cloth should be replaced as soon as it begins to wear. Plastic liners in float beds should be replaced each year.

Clean Up Plant Debris

Most plant diseases cannot be cured, so it may be necessary to discard diseased plant material. Bedding plants and vegetables with root rots, vascular wilts, and viruses should be removed immediately after a positive diagnosis. This prevents pathogen spread to neighboring healthy plants. Diseased parts of woody plants, such as cankers, may be pruned. Plants with a few foliar leaf spots or powdery mildews may be salvaged if diseased material is removed and plants are treated; however, any leaf removal on vegetables should be conservative in order to maintain production levels.

Diseased plant material and debris should be bagged and discarded (trashed or burned) as soon as possible; do not compost. Tobacco mowing should be completed with a sharp blade to minimize plant injury, and then clippings should be removed and discarded; do not dispose of clippings directly outside the greenhouse. Develop a regular schedule to clean-up plant debris on and under benches, in ground beds, and on walkways. Immediate debris removal is important because fungal pathogens can readily produce and disseminate spores on these materials.

Manage Weeds

Remove and discard weeds and volunteer plants inside and outside of growing structures. Excessive weeds outside greenhouses reduce airflow through vents, thus increasing relative humidity in these structures. Weeds in ground beds can increase canopy density and result in higher relative humidity. Additionally, weeds may harbor pathogens and insects that can transmit disease to greenhouse and high tunnel crops; insect-vectored viruses are a particular concern. Gravel or landscape cloth may be used to create a weed-free zone 5 to 10 feet around the outside of structures; herbicides should be used with caution.

Wash Hands Thoroughly After Using Tobacco Products

Tobacco mosaic virus (TMV) is a physically hardy virus particle that can persist on hands after greenhouse workers use cigarettes and other tobacco products. To prevent introduction of this virus to commercially grown crops, workers should wash their hands thoroughly with soap and water after using tobacco products.

Do Not Bring in Soil from Outdoors

Natural soil can harbor many soilborne pathogens that may become serious problems if introduced into greenhouses; non-sterile natural soil should not be allowed into these structures. Sterilize any natural soil used in growing mixes or use a commercial soilless medium. Do not reuse potting media. Remove mud from boots and use foot baths (FIGURE 4) to prevent tracking natural soil.

WATER MANAGEMENT

Many pathogens require free water to infect and reproduce. Wet plant surfaces are often at risk for foliar or fruit diseases, and overly-wet growing media favors development of damping-off and root rot diseases. Additionally, many pathogens are spread from plant to plant by splashing water or flooded soil. The following practices will aid in management of moisture in greenhouse and high tunnel systems.

Avoid Wetting Foliage

Whenever possible, opt for drip irrigation instead of overhead irrigation; this keeps plant surfaces dry. If using overhead irrigation, water early so foliage dries by midday.

Water Only As Needed

Monitor plants closely and water judiciously, but only as needed. Variations in light levels, temperature, and humidity affect plant requirements for water. For example, plants require less water during periods of cloudy weather. In addition, plants arranged beneath overhead hanging baskets (FIGURE 5) do not dry as quickly as those exposed to bright light or full sun. Plants with similar water requirements should be grouped together to maximize irrigation efficiency.

Test Water to Ensure Fungicide Efficacy

Water used for tank-mixing or injecting fungicides should be tested for pH and alkalinity for maximum fungicide efficacy, as well as maintenance of application equipment. For more information on water quality, see *Understanding Irrigation Water Test Results and Their Implications on Nursery and Greenhouse Crop Management* (HO-111) and *Fungicide Tank-Mixes and Incompatibilities* listed in Additional Resources.



FIGURE 4. USE FOOT BATHS TO PREVENT TRACKING NATURAL SOIL (AND POTENTIAL PATHOGENS) INTO GREENHOUSES.



FIGURE 5. MONITOR PLANT WATER NEEDS AND IRRIGATE ACCORDINGLY. VARIATIONS IN GROWING CONDITIONS AFFECT PLANT WATER REQUIREMENTS. FOR EXAMPLE, PLANTS PRODUCED UNDER HANGING BASKETS MAY NOT NEED TO BE WATERED AS FREQUENTLY AS THOSE EXPOSED TO MORE DIRECT SUNLIGHT.

SOIL MANAGEMENT

Soiless Growing Media

Commercially prepared soilless media are usually free of plant pathogens and are recommended for commercial production in flats and pots. To avoid contamination, bags of media should be stored where they will not become excessively wet or have direct contact with natural soil.

Ground Beds (Natural Soil)

Growers should invest effort into maintaining pathogen-free soils in ground beds by following the recommendations below.

Crop and soil bed rotation

Rotate crops and soil beds to plants that are non-hosts of prevalent diseases in order to prevent buildup of populations of soilborne plant pathogens. Moveable high tunnels on rails allow alternation of the cropping site, which can reduce soilborne pathogens through natural weathering, fallow periods, or by using a non-host cover crop.

Salt buildup

Salt buildup in soils that are intensively cropped can stress plants and predispose them to disease. Monitor nutrient and salt levels with regular soil testing and follow nutrient recommendations. For more information on nutrient management, see *Vegetable Production Guide for Commercial Growers* (ID-36).

Fumigation

Fumigation is broadly effective in reducing a number of soilborne pathogens (e.g., root knot nematode, *Fusarium*, and *Verticillium*), but can also reduce populations of beneficial soil microorganisms. Only applicators with specialized Category 1b licenses may utilize fumigants. As of the date of this publication, grower access to commercial fumigators in Kentucky is limited and costly.

Non-fumigant products

Non-fumigant products have more specific modes of action against soilborne plant pathogens, and their efficacy relies on accurate disease

diagnosis. These products are usually applied to soils via drip irrigation systems. Non-fumigants suppress disease rather than broadly eliminate soilborne pathogens, so regular applications are necessary to realize yield benefits. These are most effective when combined with resistant or tolerant varieties. For specific non-fumigant options for vegetables, see *Vegetable Production Guide for Commercial Growers* (ID-36).

Soil solarization

Soil solarization is another broadly effective approach used to reduce soilborne plant pathogen levels. For more information about soil solarization, see *Soil Sterilization for High Tunnels* (Hort Fact-7003).

ADDITIONAL RESOURCES

- Greenhouse Crop Diseases and Disorders (Plant Pathology Extension Publications)
<http://www2.ca.uky.edu/agcollege/plantpathology/extension/pubs.html#GreenD>
- Herbaceous Ornamental Diseases and Disorders (Plant Pathology Extension Publications)
<http://www2.ca.uky.edu/agcollege/plantpathology/extension/pubs.html#OrnamentalHerbaceous>
- Burley and Dark Tobacco Production Guide (ID-160)
<http://www2.ca.uky.edu/agc/pubs/id/id160/id160.pdf>
- Foot Baths for Animal Facilities: Easier Than You Think! (University of California Division of Agriculture and Natural Resources)
Note: While this publication was written for animal facilities, the foot bath design it describes could also be used in greenhouses.
<http://anrcatalog.ucanr.edu/pdf/8281.pdf>
- Fungicide Tank-Mixes and Incompatibilities
<http://nicolewarduk.blogspot.com/2014/04/fungicide-tank-mixes-and.html>
- Greenhouse Sanitation (PPFS-GH-04)
http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-GH-4.pdf
- High Tunnel Crop Profiles (Center for Crop Diversification)
<http://www.uky.edu/ccd/production/system-resources/gh-ht>
- High Tunnel Webinar Series (Center for Crop Diversification)
<http://www.uky.edu/ccd/training/webinars/ht>
- Soil Sterilization for High Tunnels (Hort Fact-7003)
<https://www.uky.edu/Ag/CCD/HortFact7003.pdf>
- Understanding Irrigation Water Test Results and Their Implications on Nursery and Greenhouse Crop Management (Hort-111)
<http://www2.ca.uky.edu/agc/pubs/HO/HO111/HO111.pdf>
- Vegetable Production Guide for Commercial Growers (ID-36)
<http://www2.ca.uky.edu/agc/pubs/id/id36/id36.html>

March 2016

Acknowledgements—The authors are grateful to Shubin Saha, Extension Horticulture Specialist, for his review of this publication

Photos—Emily Pfeufer (1), Cheryl Kaiser (2, left), Nicole Ward Gauthier (2, right), Steve Berberich (3), and Matt Barton (5), University of Kentucky; and Swen Halverson, Halverson Greenhouses, Jackson County, Kentucky (4)

Revised from the original fact sheet, *Managing the Greenhouse Environment to Control Plant Diseases*, by Brian Eshenauer and Robert Anderson

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