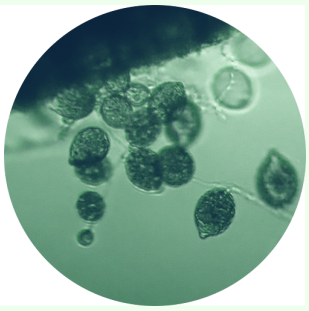
Phytophthora in nursery stock and restoration plantings



Using heat to eradicate soil-borne plant pathogens from nursery potting media ("soil sterilization")

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Many organisms pathogenic to plants reside in the soil and can contaminate even "soilless" mixes used to propagate plants in nurseries. Using pathogen-free potting media is an essential starting point for producing nursery container stock that is free of soil-borne plant diseases. Diseased plant material that is outplanted can introduce pathogens from the container into the new planting site. If conditions are suitable, these pathogens can affect not only the transplanted stock but may spread beyond the planting sites into the environment where thay can affect other vegetation.

Heat treament is often referred to as sterilization, but temperatures routinely used to heat soil will not result in completely sterile soil / potting media. The goal is to heat the potting mix to a point that kills the plant pathogens of concern.

FAQ

Q: What temperature is needed and for how long?

A:

Heat treatment of soil or potting mix involves reaching a target temperature for a specific minimum period of time. In general, lower temperatures require a longer heating time to achieve the same degree of kill of plant pathogens. Moist heat is also more effective than dry heat at any given temperature.

The entire mass of soil or potting mix needs to reach the desired temperature for the minimum treatment time. Begin timing when the coolest area of the treated mix reaches the target temperature. Uniformity of heating can be affected by a variety of factors, including variation in compaction, moisture, clods, bin shape, and method of heating. The coolest part of the heated mix may be at the center or near the edge, depending on these factors.

Target temperatures needed to kill specific organisms for moist soil or potting medium heated to the target for a minimum of 30 minutes:

Moist soil, 30 minutes at	Organisms killed
120F (49C)	watermolds (oomycetes)
145F (63C)	most plant pathogenic fungi, bacteria, and viruses, worms, slugs, centipedes
160F (71C)	plant pathogenic bacteria, soil insects
180F (82C)	weed seeds
212F (100C)	heat resistant plant viruses and weed seeds

Source: Baker, K.F., 1957.

Other recommended time / temperature treatments

- Maintain 140F (60 Celsius) for 30 min to pasturize nursery soil if using aerated steam Greisbach et al 2012.
- Maintain temperatures of 158°F or higher for 30 minutes, or 140°F or higher for one hour, to kill most pests in soil in containers through solarization UC publication 74145.

Q: How can I measure temperature?

A:

Greisbach et al 2012 recommend the use of button-style temperature probes, such as the linked product. Other manufacturers produce similar products. Make sure that the probe is rated for a temperature range that extends above your target temperature so the probe will not be damaged if the temperature exceeds your target. Place the temperature probe in the coolest portion of the treated soil or media. You may have to place several probes initially to determine which area is the coolest. Begin timing the heat treatment once the probe shows

you have reached the desired temperature at the coolest spot.

Q: How can I heat-treat my soil?

A:

Various types of equipment can raise the temperature of a mass of soil or potting mix to the necessary target temperature for the amount of time needed. Aerated steam is perhaps the most efficient means for supplying moist heat, but other heat sources may be used. An important point to consider is the scale that will be needed to handle the amount of potting mix used in production. A search on "steam generator nursery greenhouse"and similar related searches will identify primarily larger commercial grade equipment. For small scale operations using low volumes of soil, you may want to consider other types of equipment. Electric soil sterilizers are one option, but commercial moisture-proof heating equipment used in other industries (e.g., search "food warming equipment" and "towel warmer cabinet") may be low cost alternatives for small operations. In areas with sufficient solar exposure, a solar heater may be able to reach the target temperature or may at least be used to preheat soil to a temperature that will minimize heating costs. A custom-built apparatus that is specifically tailored to your specific needs and constraints may be the most economical over the long term.

Greisbach et al 2012 recommend pasturizing soil by the use of aerated steam. They illustrate several different types of steaming units (p.52).

Baker 1957 discusses the principles of heating soil in great detail in chapter 9 and compares a variety of heating units in chapter 10. Although this reference is old, the physics of soil heating have not changed. Practical tips and relevant data are provided.

Stapleton et al 2008 describe how to use solarization to heat treat soil in containers.

Q: How do I prevent re-contamination of heat-treated soil?

A:

Heat-treated soil can readily become recontaminated with soil-borne plant pathogens in numerous ways, including:

- placing treated soil into contaminated equipment, vehicles, bins, or pots

- handling treated soil with contaminated implements or hands

- planting pathogen-contaminated propagules or seed

- introducing contaminated water via irrigation or splash from contaminated soil

- placing treated soil on the ground directly or in pots that have been on the ground or on contaminated surfaces

The key to avoiding soil-borne pathogens is to start clean and stay clean. One way to help reduce the chances for contamination is to heat treat the nursery mix in the containers that plants will be grown in. More details about the role of sanitation as a part of clean production practices are discussed HERE

Q: Will heat treatment produce toxic compounds in the soil?

A:

Heating soil or nursery mix to excessively high temperatures will use more energy than is required and can have adverse affects on beneficial microorganisms. Excessive soil heating may also increase chance of phytotoxicity due to soluble salts, manganese toxicity, and toxic organic compounds. It is safe to treat a UC type soil mix (fine sand and sphagnum peat moss or hypnum peat moss) to a temperature of 212F (100C) without developing soil toxicity to plants. Soil mixtures high in readily decomposable organic matter (manure, leaf mold, compost) are most likely to give injury when exposed to excessively high temperatures (Baker 1957 p129). Note that composting facilities, depending on their size, are subject to regulations concerning minimum temperatures and duration LINK.

Q: What happens to mycorrhizal fungi and other beneficial microorganisms when soil is heat treated?

A:

As noted above, typical heat treatment temperatures (e.g., 140F (60 C) for 30 min) do not kill all microoganisms in the soil, though they are lethal to most plant pathogenic fungi and oomycetes.

Spores of fungi known to form mycorrhizal associations with plant roots are ubiquitous in soil. Studies have shown that container plants form mycorrhizal associations either in the nursery or after transplanting (for example Meyer et al 2005). Experiments with soil heat-treated by solarization found that plants growing in recently solarized soil were well colonized by arbuscular mycorrhizae (Stapleton and Devay 1986). In general, saprophytic fungi can colonize heat treated soil more readily that pathogenic watermolds or fungi, which often have limited saprophytic ability. Hence, destruction of fungi which might have the ability to form mycorrhizae in potting mix by heat treatment of soil is not likely to have a negative affect on plant growth.

Another point to consider: a typical soilless potting medium does not have a soil microbial community that has much in common with a planting site in native habitat

or elsewhere. Some native plant nursery growers have expressed concern about losing benefical microbes by heat-treating their soil mix, but have no real knowledge of what organisms are actually in these mixes. Adding field soil to a soil mix is a risky practice unless the soil has been thoroughly tested to ensure that it is free of pathogens. If desired, documented clean inoculants can be added after heat treatment, though there are little data to support the need for such inoculants in most situations.

Q: Are some components of soil mix "clean" enough that heat treatment is not needed?

A:

Vermiculite and **perlite** are manufactured using very high temperatures and will be free of soil-borne pathogens as long as they haven't been contaminated after manufacture.

Commercial compost produced according the California standards may be free of most pathogens, but depending how the material is handled at the composting facility and afterward, has a high risk of being recontaminated. California composting facilities, depending on their size, are subject to regulations concerning minimum temperatures and duration LINK.

Sand, especially quarried from rivers, is commonly contaminated with soil-borne pathogens. Sand from clean sources can also become contaminated.

Bottom line: Clean soil mix components do not look any different from contaminated components. Components that are produced and moved in bulk can easily become mixed with contaminated material in storage and transport.

References

Baker, K.F. Editor. 1957. **The U.C. System for Producing Healthy Container Grown Plants, Manual 23.** University of California, Division of Agricultural Sciences, Agricultural Experiment Station Extension Service. LINK

Griesbach, J.A.; Parke, J.L.; Chastagner, G.A.; Grünwald, N.J.; Aguirre, J. 2012. **Safe procurement and production manual: a systems approach for the production of healthy nursery stock.** Wilsonville, OR: Oregon Association of Nurseries. 98 p. LINK

Meyer, AH.; Botha, A., Valentine, A.J. Archer, E., Louw, P.J.E. 2005. **The Occurrence and Infectivity of Arbuscular Mycorrhizal Fungi in Inoculated and Uninoculated Rhizosphere Soils of Two-year-old Commercial Grapevines.** Meyer, AH.; Botha, A.,

Valentine, A.J. Archer, E., Louw, P.J.E. S. Afr. J. Enol.Vitic., 26(2):90-94. LINK

University of California Solarization webpage LINK

Stapleton, J.J., DeVay, J.E. 1986. **Soil solarization: a non chemical approach for management of plant pathogens and pests.** LINK

Stapleton, J.J., C. A. Wilen, and R. H. Molinar. 2008. **Soil solarization for gardens and landscapes.** Pest Notes Publication No. 74145, University of California Agriculture and Natural Resources. LINK