Steam Sterilization of Growing Media

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Abstract—With the removal of methyl bromide over the next few years as a treatment agent for soils and growing mixes, other methods will have to be found. Steam offers a good alternative for greenhouse and nursery operations both indoors and in field beds.

The technology has been developed over many years and equipment is available from several manufacturers. The use of aerated steam can reduce energy requirements and speed the sterilization process.

INTRODUCTION

The Environmental Protection Agency (EPA) has added methyl bromide to the Clean Air Act -Class 1 as an ozone depleting substance. This freezes U.S. production and imports from 1994 to 2000 at 1991 levels. By the year 2001, all production will be phased out and other alternatives will have to be used.

Steam has long been considered the best treatment agent for growing media. It will destroy fungi, bacteria, nematodes, insects and most weeds. Its effectiveness is evaluated simply by measuring the medium temperature and the length of contact time.

Steam is also non-toxic so that the soil can be worked immediately after treatment. There is no danger to the workers handling the mix. It can also be used next to living plants without any danger.

The lethal temperatures necessary to eradicate soil pests are shown in Table 1. Good results can be obtained with a temperature of 160 to 180 deg. F. for 30 minutes. A probe-type thermometer works well for measuring temperature.

HEAT REQUIREMENT

The amount of heat needed to raise the temperature of a given volume of growing media depends on the components, its moisture content and the difference between the cold soil temperature and the desired treatment temperature. The heat flow rate needed per minute depends on how quickly the mix must be brought up to the desired temperature. A comparison of the amount of steam needed for different growing mixes is shown in Table 2. For most applications, 30 minutes heating time and 30

Table 1. Temperature necessary to kill soil pests.

115 deg.F.	Water molds (pythium and phytophthora)
120	Nematodes
135	Worms, slugs, centipedes
140	Most plant pathogenic bacteria
160	Soil insects
180	Most weed seeds
215	Few resistant weed seeds & plant viruses

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minutes of contact time is desirable.

Soil moisture is best at near field capacity. Because it takes about 5 times as many Btu's to heat one pound of water as compared to one pound of soil, very wet soil should be avoided. Real dry soil should also be avoided as it acts like an insulator and restricts heat flow.

When water is heated and turned to steam, 970 Btu's of heat are absorbed in the phase change. The volume also increases 1600 times. When steam is injected into the medium, the 970 Btu's of heat are released as the steam condenses back to water. This is what makes steam a much better sterilizing agent than water. Unless the soil has very good porosity, a water treatment system would wet the soil too much.

TYPES OF SYSTEMS

There are two common methOds of steam treatment: free-flowing and aerated.

When steam leaves the boiler it is under slight pressure (5 to 15 psi). As soon as it is released into the growing mix it drops to atmospheric pressure giving up its heat. At this point it is considered free-flowing. As the temperature drops, it creates a heat zone that advances as the surrounding soil is heated. When one soil particle reaches 212 deg.F, then the steam moves past it to heat the next particle until the whole area is brought up to temperature.

Table 2. Amount of steam needed for growing media treatment*.

Growing Media	Free-Flowing Steam	Aerated Steam
Soil	10.8 lb/cu ft	6.3 lb/cu ft
Soil/peat/sand	7.5	4.4
Soil/peat/perlite	6.8	4.0
Peat/perlite	9.7	5.7
Peat	11.2	6.5

*Assumes:
Soil - silty clay loam
Field capacity moisture content
Saturated steam - 230 deg. F.
Aerated steam - 160 deg. F.
Soil temperature - 60 deg. F.
Air - 70 deg. F. - 50% RH
Efficiency of boiler/piping system - 50%

As long as the injection rate does not exceed the condensation rate (about 18 lbs/hr/sq ft of exposed medium surface), blow-out, the free escape of steam to the outside does not occur. The medium should be well mixed without clumps, have uniform moisture and be level in the container, bed or bench. Disadvantages of free-flowing steam include over-kill of the micro-flora because of the high temperature, increase in total soluble salts and changes to the soil structure.

In the aerated steam method, steam from a boiler is combined with air from a high pressure fan to create a 140 to 180 deg. F. mix that is forced through the growing media. Radial or backward curved fans with a water static pressure of 20 in. to 25 in. are commonly used.

Advantages to the aerated steam system include:

1. Up to 40% less steam is needed as the soil doesn't have to be heated as much.
2. More rapid, even heating because the blower forces the steam through the soil.
3. Microflora survive at the lower sterilization temperature.
4. By turning off the steam and continuing the air flow, the temperature of the soil can be lowered rapidly.

With proper design, the system can be adapted to treat batches or continuous flow. For batch treatment, the air/steam mix is typically exhausted into a chamber below a perforated floor of a bin, cart or truck body. A fabric cover is used to hold in the heat but allow the air to escape.

Bed or bench treatment can be done in several ways:

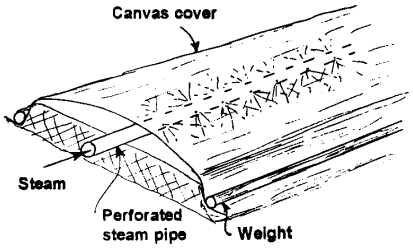
The easiest system to set up but

the least effective is to lay perforated pipe on top of the bed. Aluminum, canvas or high temperature plastic pipe is used. The bed or bench is covered with a canvas cover to retain the steam. Steam injected on the top of the soil only penetrates to about 8" deep which may not be adequate for some crops.

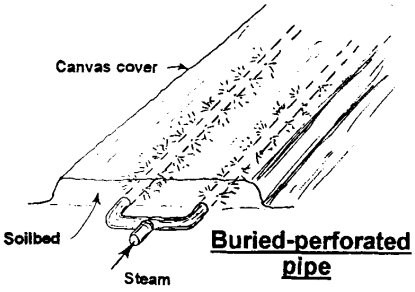
A better system uses perforated poly pipe buried 12" or deeper under the top of the bed. This allows the bed to be rototilled or cultivated without disturbing the pipe. Steam injected in the pipe rises toward the surface and gives uniform control throughout the bed.

Steam rakes and blades have been used since the 1950's. Original development was done in Europe but the technology never was common in the U.S. as chemical sterilants came in about that time. Research on this system is under development at the USDA Forest Service, Missoula, Montana.

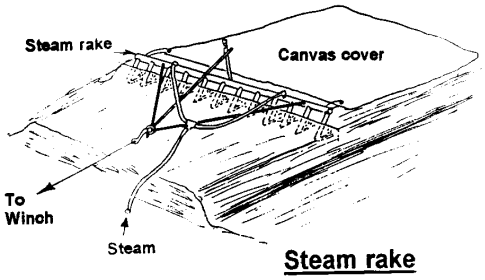
With this system the rake or blade is pulled slowly through the soil bed by a winch. Depth is controlled by the angle and length of the tines. Uniformity of treatment is good. A mobile boiler and aerator are needed.



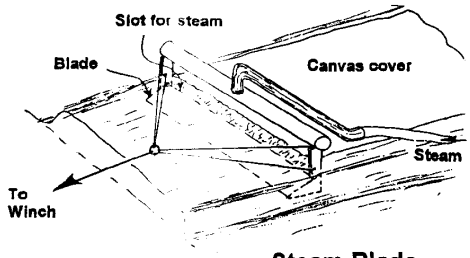
Surface Steaming



Buried-perforated pipe



Steam rake



Steam Blade