Is Your Soil-Steaming Adequate?

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Most growers who have seriously tried soil sterilization are convinced that it pays real dividends. For soil sterilization in and near the greenhouse, steaming is still the best general method for destroying weed seeds, insects, nematodes, bacteria and fungi in the soil. If the steaming process is adequate, all pathogens and other pests present will be destroyed. Sterilized (pasteurized is a more accurate term since all organisms are not killed) soils may become recontaminated in a period of six weeks to six months. Hence, steaming gives the best results with crops growing in a soil for less than one year. Despite the temporary nature of pasteurization, the beneficial results more than repay the cost of treatment.

EXPERIMENTAL

Through the courtesy and cooperation of Oscar Maier, a carnation grower of North Bellmore, Long Island, New York, we obtained continuous temperature readings while soil steaming was in progress. Thermocouples placed at specified depths in the soil provided temperature readings which were recorded on a continuous chart on a Brown Potentiometer, manufactured by the Brown Instruments Division of the Minneapolis-Honeywell Company, Philadelphia, Pennsylvania.

Prior to steaming, the soil in both beds and benches was fitted with a rototiller. A single line of perforated pipe was laid on the surface down the center of the bed or bench and the bed then covered with a plastic cover. The steam was introduced at one end of the pipe when 125 foot lengths were treated. It was introduced at both ends when 165 foot lengths were steamed.

In the first trial two raised benches were steamed. One bench contained "moist" soil and the second "dry" soil. The "moist" soil could be formed into a ball which would readily crumble when dropped. The "dry" soil would not flow through the cracks in the bottom of the bench, but a hole dug in the soil would fill by crumbling and flowing in from the edge. A thermocouple was placed at a 4 inch depth in each soil. Steaming of the "dry" soil commenced at 7:30 a. m. while that of the "moist" soil commenced at 1:30 p.m. This accounts for the different initial temperatures of the two soils as shown in the temperature curves in figure 1.

This graph shows that the moist soil not only heated more rapidly but also reached in this trial a temperature 6°F higher than that in the dry soil.

In a second trial a moist soil in a ground bed was steamed. Thermocouples were buried at 4, 6, and 8 inch depths. The results of this trial are presented in figure 2.

DISCUSSION

Over the years a number of different types of equipment and methods of applying heat have been developed for steaming soil. Satisfactory results can be achieved with many of these when they are properly used. A grower should keep two points in mind: the equipment and the method used (1) must heat the soil to the desired temperature, and (2) maintain that temperature for the required length of time.

The amount of heat required to steam a soil adequately depends upon the moisture present, the physical condition of the soil, the initial temperature, and the volume or area to be treated at one time.

Fundamentally, the application of heat to a soil raises the temperature of the moisture in that soil. This moisture in turn conducts the heat to everything that it contacts. However, if a soil is saturated with water, a tremendous amount of heat is required to heat the excess water and consequently the temperature rise is slow. Conversely, if a soil is extremely dry, heat is not conducted through the soil mass, because the large amount of dead air space acts as an excellent insulator.

An adequate moisture supply for several days prior to steaming insures that the organisms present are in an active state of growth. Weed seeds, pests, and pathogens in an active state are killed more readily than those in a dormant state.

The physical condition of the soil is almost equal

in importance to soil moisture. Satisfactory steaming is dependent upon the rate of direct penetration of the steam into the soil. Large clods of soil will heat slowly and the center portion may never reach a temperature sufficiently high to kill pathogens or pests. A compacted soil likewise hinders the penetration of steam.

We have brought out the principal factors involved in doing a good job of steaming. Now let's translate this information into good greenhouse practice. The practical problem involves reaching all particles of the soil to be treated with required temperatures and exposures. To accomplish this we have to treat for periods far beyond those actually required for destruction of the various pests. In practice we heat the soil nearest the steam source to about 212°F and try to heat the soil 6 to 12 inches from the source to 140-175°F. Nematodes are killed almost instantly by exposure to temperatures around 140°F while fungi and bacteria normally are killed by exposure for 10 minutes to temperatures of 140-158°F or for 1 minute at 204-212°F. Weed seeds in the soil are killed by temperatures that kill fungi and bacteria. To allow an ample margin of safety we recommend 180°F for 30 minutes at the coldest spot in the bed or bench. This temperature and duration allows for considerable variation in soil moisture and physical condition, and for unknown cold spots. Use an accurate, easy-to-read thermometer to obtain the soil temperature at different places in the bed or bench.

FIG. 1. RATE OF TEMPERATURE CHANGE IN MOIST AND DRY SOIL IN RAISED BENCHES DURING SOIL STEAMING.

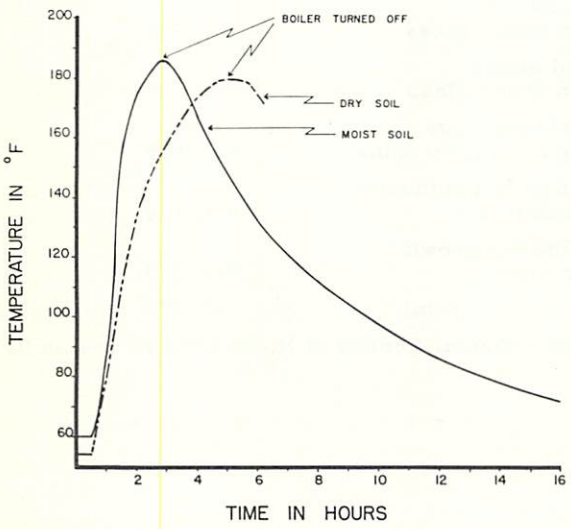
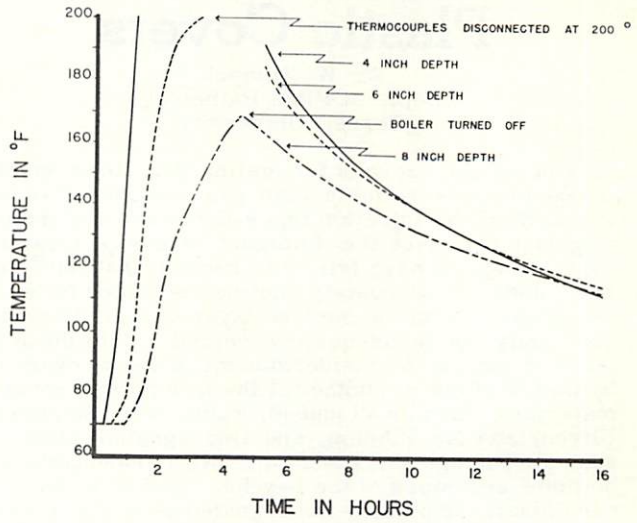


Figure 1 shows a big difference in rate of temperature rise in the moist and dry soils. This difference in rate of heating is important from the standpoint not only of fuel and time saved but also of the thoroughness of the soil sterilization job.

The temperature curves in Figure 2 indicate that we should not expect complete eradication of disease organisms or pests in a ground bed at depths below 8 to 10 inches. For plants whose roots penetrate well below the 6 to 8 inch depth, a disease or pest may become serious within a period of months after replanting. Such reinfestation would be possible for symphilids, nematodes, and certain fungi such as Fusarium and Verticillium. In a ground bed live weed seeds below

FIG. 2 RATE OF TEMPERATURE CHANGE AT 4, 6, AND 8 INCH DEPTHS DURING STEAMING. MOIST SOIL IN GROUND BED.



the treated layer will not germinate unless brought up close to the surface.

Reinfestation from below can be prevented with solid bottom beds. The possibility of reinfestation in ordinary ground beds can be reduced by thorough steaming or by changing the structure of the bed. Some growers have had excellent results by digging out the soil to a depth of 16 to 20 inches, laying one or two permanent lines of tile for steaming, covering these with a 3-4 inch layer of gravel, then replacing the soil. The layer of gravel allows the steam to move quickly and evenly across the width of the bed. The steaming process starts from the bottom of the soil layer and prevents pests such as symphilids from moving down in the soil and escaping the heat.

Weeds growing on a steamed soil indicate either a poor job of steaming or reintroduction of weed seeds. If large numbers of weeds appear within a week or two after steaming the grower should suspect that a poor job of sterilizing was done. To supplement the steaming of soil in beds and benches the grower should eliminate weeds from the walks and under the benches by chemical or mechanical means.

SUMMARY

1. A satisfactory job of steaming may be done with many types of equipment and with various methods if the soil can be heated to the necessary temperature and maintained at that temperature for the required length of time.
2. A few man-hours spent in providing the proper amount of moisture and in preparing the soil will pay dividends in fuel and time savings during the actual steaming process and insure a better job.
3. Weed control alone pays for the cost of steaming. Disease and pest control is a bonus.
4. Adequate steaming may depend only upon the proper use of a thermometer and a clock. It is so simple and easy that you may be lulled into feeling a false security. Why not check up on yourself and see if your soil steaming is adequate?

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