Soil Steaming*

A Review of Fundamentals

Kenneth F. Baker and Carl M. Olsen

Steam is the best method of treating soil because: it is quick, and the soil may be planted as soon as it cools; it destroys all pathogens, weeds, etc. whereas some chemicals do not; no toxic after effects result from treatment of inert-type soils; it can be used without injury to nearby plants or humans. Even including the prorata cost of a boiler, steaming cost is lower than treatment with chemicals.

While there are many methods of applying steam to soil its diffusion in each case is through the continuous pores of the soil to the cold area where it condenses, releasing a large quantity (b. t. u.) of heat at low intensity (a maximum of 212°F). It moves at an advancing front (212° on one side and unheated on the other) which varies from 1 inch or less in width and efficient high flow rates or proximity to the input, to several inches wide with low flow rates or greater distance from the input.

In this zone of heating, the steam mingles with the pore air, producing an even richer mixture as the temperature rises and the air is pushed out. *A ready escape for this expelled air must be provided.*

Steam moves about twice as fast upward through soil as downward or sideways. A given soil has a maximum condensing rate for steam, and once this is exceeded "blow outs" occur. Once a "blow out" of steam from the soil occurs, steam is bled from the rest of the treatment area and heating is greatly reduced. Greatest efficiency is obtained just below this point, through balancing the steam flow rate and the quantity of soil treated. It is best to pipe the steam to the soil, so that no spot is more than 6 inches from a steam outlet.

Since steam penetrates very poorly into compacted soil, thorough cultivation to the desired treatment depth is required. Soil moisture beyond that required for good planting tilth decreases efficiency because of the increased heat capacity and diminished pore size.

Line pressure is lost when steam is released into soil. There is actually no worthwhile advantage in heat transfer from the use of either high pressure or superheated steam over that of very low-pressure (free-flowing) steam. A temperature of 180°F for 30 minutes provides adequate treatment. The problem is to efficiently distribute the large volume of high pressure steam from the lines in such a way that it may condense on a large number of soil particles.

Subsurface steaming—Some of the oldest and most efficient methods apply steam to soil through buried perforated pipes or tiles. These pipes should be placed so that the distance from the pipe to the top is at least twice that from the pipe to the bottom or to the plow sole. The bottom corners usually heat slowly, and these should be either blocked off with triangular pieces of wood or the treatment continued until they are heated. The soil should be covered with a tarp for heat retention only after the soil is heated. [For practical reasons the cover usually is put in place before steaming. It should be loose in several places to permit escape of air.]

Surface (Thomas) Steaming—Steam is applied to a covered area of the soil surface, and diffuses downward through the pores. This method has a natural disadvantage in that steam moves less rapidly downward than upward through the soil. For this reason, conditions must be optimal for effective surface treatment of more than 8 inches of soil. It is not recommended for field use.

Because the air is displaced downward by steam as the temperatures rise, there must be provision for its escape. This is provided by open cracks in the bottom of raised benches or by open tiles in ground beds. In ordinary ground beds the air must be pushed downward, outward, and then up again. In loose soil this definitely restricts steam diffusion; if soil is not deeply tilled or the area outside the beds is a compacted walk or pavement, downward steam flow is almost prevented, and the inefficient heating is from percolation of condensed hot water. The method is almost worthless on benches with tight bottoms or on beds with inadequate bottom drains, but is excellent to 10 inches depth in beds with loose soil and relatively open bottoms.

Vault Steaming—Containers of soil are placed in a closed vault into which steam is released without pressure. Steam is released into the top or bottom of the vault and mixes with the air, which is pushed out with about equal efficiency through cracks around the door or around the bottom, or through a valve at the top. The air displacement is very slow and reasonably uniform. Because there are usually some unpredictable areas of very slow heating the time should extend somewhat longer than necessary to heat the soil at test points. Furthermore, the containers should be separated about ½ inch in each direction to permit ready flow of steam.

Heating of soil in the containers results from the diffusion of steam into the open top and through openings in the bottom and sides and from the very slow transmission of heat through the container walls. For this reason the last point to heat in a clay pot, metal can, wood box, or flat is in the center about two-thirds of the distance down from the top. In an unperforated can of soil the point of slowest heating is the center about three-fourths of the distance from the top. Probably no container should hold more than ½ cu. ft. of soil (about 9½ x 9½ x 9½ inches) for efficient or dependable vault steaming. [1 bushel=about 1 cu. ft.]

Steam Rake—The steam rake is a harrow-like device which consists of a series of vertical chisels mounted on a

(*Continued on page 3*)

* Reprinted from: "The California State Florists' Assoc. Magazine," Vol. VIII, No. 9, April, 1959.

Soil Steaming

(*Continued from page 2*)

hollow steam header pipe; it is drawn slowly through the *soil by* a powered winch. Steam is released from short pipes trailing behind the chisels, as well as from the header pipe under the trailing tarp. Thus, a combination of moving subsurface and surface treatment is applied. Because steam is released at points 11 inches or more apart, the rake must not be moved forward so fast that the expanding spheres of steam do not have time to meet, or else strip treatment will result. Practically, this means moving only 6-8 inches per minute. The large volume of steam is injected into a small volume of soil and the condensing capacity of the soil is frequently exceeded, with consequent "blow outs." In clay soils the trailing pipes tend to form mud tubes which conduct the steam to the rear and away from the area to be heated. It is impractical to increase forward speed by decreasing the distance between chisels, because this would increase the mechanical drag and cause soil to pile up ahead of the header pipe. This device, although presently much used, is likely to be dropped because of its deficiences.

These difficulties seem largely to be eliminated by a steam blade now being developed in California and in The Netherlands. Steam is released from the trailing edge of a horizontal flat blade which is moved through the soil just above the plow sole or bench bottom. The surface is heated by steam released under a trailing surface tarp. Because of the large area of contact between soil and steam, the forward speed can be greatly increased over that of the steam rake. The thermal efficiency of these units is high.

Both the steam rake and steam blade may be used on beds or benches as well as in the field. It is essential in either case that the soil be well tilled to the depth of treatment desired, and that there be no clods remaining.