TREATMENT OF SOIL WITH AERATED STEAM

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When I started my nursery career, I was a bright-eyed lad of 15 and it was at the nursery that we are going to visit this afternoon. Among my first jobs was sterilizing or "cooking" the soil, as we called it in those days, and I can vividly remember putting many a load of soil and cow manure through the cooker. This cooker consisted of a waterproof steel tank roughly 6' long, 3' wide and 3' deep. It had some house bricks in the bottom of it, and it was built up so you could place a fire underneath. On top of the bricks it had a perforated steel plate. You filled this tank up with water to the top of the plate, then you filled it up with soil. To get the soil in you used to have a plank which came back about 15 feet. Then you loaded the barrow — they were big barrows in those days and I was only a little bloke then — and you used to make a terrific run up the plank and tip it in; the tank held about 3 yards of soil. You filled it and lit the fire, generating steam that moved upward through the soil. The key to the whole thing was a small potato; we used to religiously put this potato in the top inch of soil. When the "Murphy" was cooked, the soil was cooked. You might laugh, but it only cost about $20. Anyway, it was a good efficient sterilizer. You couldn't get Aquasol or Thrive or Rite-Gro Liquid Manure or anything like that in those days. When you treated a load of cow manure you used to drain the excess water out through the bottom — that was the best liquid manure you could get anywhere. We used to be able to dilute it considerably.

When I left the nursery here in the mountains I went to the "big smoke," then into the Air Force. I was lucky to come back, and then started my own nursery. I bought the tank out at Mascot for 120 and it served me as a sterilizer for 4 or 5 years.

In the meantime, from Sorenson's Nurseries here in the mountains I was fortunate enough to take the horticulture course down at Ultimo, 4 nights a week. One thing I learned at Tech. was to get a thermometer and put it in the soil. You could quickly find you were at the right temperature (212°F) — it would always come up — you couldn't control it.

About 1958 Dr. Lilian Fraser, who just retired from our Department of Agriculture, introduced our association to the University of California Manual 23(1) on growing healthy container plants. This started a revolution within our industry which has

spread throughout Australia and the world. By this time I had my own nursery about 8 years. At lunch today a chap said to me, "I never do any sterilizing or any fumigating or anything like that; I don't find it necessary." I said, "How long have you been in business in that place?" and he said, "7 years", and I said, "Watch out for the next year because it is usually about 8 years that things start to catch up with you in a nursery." Well, they caught up with us, and where we had put in about 100 *Aphelandra* cuttings, we might pot off and successfully sell 50 or 60. The rest would damp-off or otherwise fail. Now this is bad economics; even I could understand that you couldn't stay in business very long with this. The U.C. Manual was of great help to us in introducing hygiene into our nursery, and it started to pay off.

In 1960, Dr. Kenneth F. Baker, who was one of the authors of the U.C. Manual, came to Australia on a Fulbright Scholarship to study aerated steaming of soils at the Waite Agricultural Research Institute in Adelaide. I think this has been one of the greatest steps forward in successful nursery production on an economic basis that we have known in the last 30 to 100 years — ever since 1888 when soil was first steamed at 212°F in Germany. It was a major breakthrough when you treated soil mixtures at 140°F, whereas before you could only treat them at 212°F, creating a biological vacuum. Because you have created a biological vacuum with the 212°F steaming, any pathogen introduced into that soil can run riot, unchecked. Someone could put their hands into the soil in a bench and contaminate the whole lot; your losses, as they have been in the past, would be severe. It was the pleasure of 7 or 8 New South Wales Nurserymen to go down to Adelaide for a weekend with Dr. Baker; I think it was the most mementous weekend that any of us had ever spent. There are quite a few here in the room today who were there.

That weekend he introduced for the first time to a group of nurserymen this concept of aerated steam. He had been producing it there in the laboratory at the Waite Institute. To get aerated steam at 140°F, you mix 6-1/2 pounds of air to 1 pound of 212°F steam. In the laboratory he used a big air compressor but was concerned about the economics of it in commercial use. He gave us facts and figures and showed pictures of a venturi under test. When we returned home we started to work with the idea of how we could make steam at 140°F — "aerated steam."

Alan Newport and I worked together on this problem and, after many frustrations, finally came up with the answer, a series of venturis. At the time we were getting close to success, Gavin Wilton from Adelaide joined us. However, with the advent of the venturi, we successfully developed aerated steam on a commer-

cial basis and Dr. Baker credits us with being the first nurserymen to use aerated steam at 140°F on a commercial basis. A venturi consists of a 1/2'' or 3/4'' steam line, comes into a 2 inch T pipe with a stainless steel orifice (around 1/4 or 3/16 inch). Steam at a pressure of 15 to 100 psi comes through the orifice and the actual location of it in relation to the inlet, if everything is right you get steam at 140°F very economically. The particular setting which draws in 6-1/2 lb of air to 1 lb of steam, regardless of any other factors gives steam at 140°F.

In our nurseries we used this type of venturi very successfully until about 2 years ago, when soil volume started to catch up with us. Many other nurseries also used these venturis for quite a few years. The most important thing, apart from the venturi was the treatment bin and the most important thing in the bin was the perforated plate at the bottom. For any type of bulk-soil treating bin for aerated steam the perforated plate is the most important part. This one had 3/16ths holes with 9/16ths staggered pitch, which we have used for quite a number of years, but we now find that one with 5/16ths, 1/2'' staggered pitch is much more successful. You would say the soil would fall through; it doesn't really, however; there is a tendency for clogging with the small holes.

You should have a steel or a wooden bin. With a steel bin it is desirable to insulate it on the outside; if the bin is in a breeze and it is not insulated the soil at the side of the bin can be down to 120°F, whereas further inside the temperature would be 140°F. For many years we used wooden bins made out of waterproof plywood; they lasted very well.

The area below the perforated plate is the plenum, which must be 3 to 6 inches in depth. This is where the steam develops the low back pressure necessary for uniform flow through the soil. The depth of the plenum is not very critical. One other thing — in any type of bin it is a good idea to put a triangular wooden filler in the corners so that you do not have a right angle.

With venturis you could only run round 12 to 15 inches of soil; this is the maximum depth because of the back pressure developed. When steam came from the venturi into the plenum then up through the perforated plate and soil, back pressure develops, increasing with the density and dampness of the mixture. With soil over 15 inches in depth there is difficulty in making a venturi work.

About 1963 another great breakthrough came with aerated steam. This occurred in Melbourne when a Shell engineer working with Ron Gross used a centrifugal blower which could cope

with much more back pressure than the venturis could, and put the system on a much bigger scale than the venturis could ever hope to do. Another thing, it made it a bit quieter because the venturis tend to scream as they are sucking in air.

Centrifugal blowers are usually the straight-bladed type. We use ones about 8" wide, 15" round, and to treat a batch of soil 24 inches deep, we need one having about a 6" water gauge capacity at 3,000 cu ft per minute (this is the capacity of fan required — a term used in measuring the output of the blower). A moveable damper over the blower intake provides excellent control of the air volume. There is no need for air under great pressure; you only need to get 6" water gauge from your centrifugal blower.

The centrifugal blower usually is portable — it can be on wheels since you have a flexible hose which hooks on the outlet of the blower. Steam is introduced into the slipstream of the blower so that it mixes there. The steam supply can be manually controlled. You can get excellent control with this equipment. Instead of the manually operated steam inlet, you can get a pressure-operated steam valve controlled by a thermostat. In other words, you can have a thermostat bulb in the mixing chamber or in the plenum of the soil bin, which controls the entry or the rate of steam which is mixing with this air. It is then possible to set this steam valve by trial and error at 140°F air-steam temperature and it will automatically keep the steam-air mixture going into your bin at 140°F without further adjustments.

If you are using a continuous flash steam generator, which produces steam a lot moister than that from an orthodox boiler, you should put it through a steam drier. This is a 44-gallon drum with a basal tangential steam inlet. The steam goes around the walls and exits through the outlet at the top, centrifugally expelling water drops, which drain out at the bottom of the drum through a tap. This provides dry steam to your bin. We have never found it necessary when steam is introduced through a bottom plenum, and I haven't seen many units used. Another big advantage with the blower is the ability to rapidly cool the mixture after treating; venturis do not have this feature.

The idea of aerated steam pasteurization of soil is to bring the mixture up to 140°F as quickly as possible, hold it at 140°F for 1/2 hour, and then cool it as quickly as possible. At 140°F, harmful pathogens such as nematodes, pythium, water molds, *Rhizoctinia*, and most weed seeds (of course, clover and very hard-coated seeds, even 212°F steam won't kill) are killed, but helpful saprophytes remain. In the lighter type mix, weed seeds usually are no problem.

As soon as the soil attains the desired temperature you can throttle back the steam because you are not using as much heat. If you have one of these automatic valves it may throttle itself back, or you can do it manually. As soon as treatment is finished the steam is cut off completely, the blower air intake opened; with the air intake you have an adjustment so that you can adjust your air through the fan to get that 140°F, regardless of the steam, as well. It is desirable to put a filter over the intake because you are going to drive air, and perhaps contaminating pathogens, from within the area up through your treated soil. It is desirable to use a fiberglass filter — we don't do it; I don't think we have had any problems through not doing it; but it is the right thing to do.

With this rapid cooling you can use Osmocote or urea-formaldehyde or other types of slow-release fertilizer; without the rapid cooling from the fan it is dangerous because you would then have no advantage from the slow-release feature in your mixture.

The use of the blower was a big step forward and it is catching on over the world. What are the advantages that you can expect from using aerated steam?

(1) Buffering against disease. At 140°F, instead of the biological vacuum created by 212°F treatment, the harmful pathogens are killed but the saprophytic micro-organisms increase because of reduced competition. Instead of a biological vacuum you could finish with more "goodies" in the soil, less the "baddies." If contamination develops later, as is likely, there is a buffering effect of good soil microorganisms which can decrease the growth of pathogens.

(2) Less or even no phytotoxicity. Seedling growers have known ever since 212°F steam was started that they had trouble with different plants. They would damp-off and wouldn't grow; this was caused by ammonium toxicity. With 140°F there is practically no ammonium toxicity in the soil, and you can steam soil with plenty of humus, even fertiliziers in it. I mentioned slow-release fertilizers which you could never use at 212°F because it would burn the roots.

(3) We are all interested in this one — lower cost. You use 6-1/2 lbs of air to every lb. of steam. You can virtually do with a boiler twice as much soil, economically, and better and more efficiently than you could with 212°F.

(4) Ready for immediate use. With steamed soil at 212°F it can be up to 10 hours before you could use that soil. Steam-air

treated soil, even uncooled, can be used immediately after treatment to pot up. With the blower, you can cool soil in 10-15 minutes, bringing it down to 90 or 80°F, depending on the outside temperature.

(5) Suitable for treating plastic pots without deforming their shape. This is important. The bin can be loaded up with plastic pots and you can steam them at 140°F, kill all those harmful pathogens that I mentioned, and at the same tend to re-plasticize your plastic. Plastic starts to get brittle from ultra-violet radiation. By heating the plastic to 140°F it tends to plasticize again and become more pliable; this will give them a bit of extra life and save a considerable amount of labour.

In conclusion, you cannot afford not to use aerated steam. I firmly believe that part of our success has been this great breakthrough in the commercial treatment of soil. Instead of sterilizing you are pasteurizing, and I think this development has been one of the great things in horticulture in this century. I have told you in layman's terms about aerated steam. But there is a document (2) written by Ken Baker which provides practical, down to earth, but up-to-date scientific information on aerated steam and even chemical treatment of soil. I don't think you would use chemical treatment of bulk soils if you knew the advantages of aerated steam.

LITERATURE CITED

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