4 Taylor, F W 1962-63 A method for the heat treatment of soils using steam and air mixtures at 140°F (The Shell Company of Australia, Ltd.)
5 Ferguson, J F and Paul Ecke, Jr 1962 Steam-Air Mixtures For More Efficient Soil Treatment Unpublished
6 McCain, A H and R H Sciaroni 1964 Steam, Chemical Soil Treatment. FLORISTS REVIEW CXXXV (3492): 21-22
7 Griffin, Richard and Richard Maire 1965 Sterilizing Nursery Soils With Steam — A new method PUBLICATION AXT — 177 THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXTENSION SERVICE.

MODERATOR TICKNOR: Thank you, Fred, for a most stimulating discussion. Now we will have Dr. Falih Aljibury speak to us on controlled-release fertilizers.

CONTROLLED-RELEASE FERTILIZERS

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In recent years there has been considerable interest in the use of the so-called "slow-release" or "controlled-release" fertilizers. The use of such products has offered several advantages:

(1) They can be applied at the rate required by the plants without causing excessive loss by leaching.
(2) The nature of the release allows for reasonable mistakes and over-application without burning the plants.
(3) Frequent application of fertilizers will not be required.

The characteristics of the slow-release and long-lasting fertilizers described in this paper are attributed to the following techniques:

A. *Membrane Coating.* Fertilizers are coated by membranes of various sources and thickness. When the fertilizers are in contact with moist soils, water enters through the membrane and dissolves some of the fertilizers in the capsule. The dissolved fertilizers diffuse out of the membrane into the surrounding soil. The rate of release is manipulated by the thickness of the membrane. This technique may provide a release rate of one to two per cent per day.

B. *Metal Ammonium Phosphates* — Divalent metals such as magnesium, ferrous iron, zinc, manganese, and copper can be found in slowly soluble compounds. When the fertilizer comes in contact with water, it dissolves until saturation. When the nutrients are used up by plants, the equilibrium is upset and thus more fertilizer is dissolved. The rate of release is influenced by pH and the degree of soil wetness. The rate of release is also influenced by the size of the particles and the method of application. Incorporating the fertilizer into the soil releases more nutrients than if applied on the surface.

C. *Synthetic Organic Nitrogen* — Kaempffe of UCLA showed that under best environmental conditions, nitrogen in urea-formaldehyle is mineralized at the following rates:

25 — 35%	in in three weeks
35 — 50%	in four weeks
50 — 75%	in six months
6 — 10%	free urea available at once

Temperature, aeration, moisture and pH affect the rate of mineralization.

D. *Natural Organic Nitrogen* — Most of these materials mineralize in about four to six weeks. Since they don't mineralize immediately, their use has been considered by many to be safe. In recent years, it has been observed that these materials have become more expensive and less available.

MODERATOR TICKNOR: We can now start in with the questions. Who has the first one?

VOICE: In treating the soil chemically, is the equipment flow-rate timed with the tractor speed so that the application is not guess work?

JERRY HANES: Yes, that's right. Our method now is to use a flow regulator that is related to the speed of the tractor so that if the speed is increased because of the soil being hard or slowed down because it's fluffy, the metering device is regulated so the fumigant flows through at a desired rate. Then we can have different rates; we can apply anything from 100 lbs. per acre to 600 lbs. per acre.

VOICE: That's done manually —

JERRY HANES: Yes, that's all done manually.

VOICE: Then, the next question is, what is the cost per acre?

JERRY HANES: Well, that depends on the proportion of methyl bromide and chloropicrin used and the rates of application. An average treatment of two parts methyl bromide and one part chloropicrin, at 300 lbs. per acre, in a ten-acre field, runs about $300 per acre applied.

RON HUROV: How long do you treat the soil with air-steam?

FRED PETERSEN: Thirty minutes. A three cubic yard load of peat moss reached uniform temperature in 18 minutes and the treatment temperature was held for 30 minutes and the cool-down was approximately 45 minutes to get it back to ambient — so we figure in this system we have about 1½-hour to a 2-hour "turn around" time. That is fill, treat, cool-down, and pot, which offers some advantage. This cool-down phase has been neglected by others but is quite important both in preserving the biological community as well as enhancing the economics of it.

JIM HINES: I have another question for Mr. Petersen; two or three questions, actually. You have criticized us for not using this air-steam. You've passed this problem along to us and blamed everybody.

FRED PETERSEN: Including myself, you know. First of all, I listed ourselves.

JIM HINES: I may not be up on these things, but how do you treat 100-cubic yards a day?

FRED PETERSEN: Fumigation would undoubtedly be the fastest method. As a matter of practice, I don't think there are equipments available for air-steam. I think the technique could be modified for a continuous flow system. However, an increasing number of nurserymen concentrate their highest level of sanitation at the liner, seedling or propagation phase and depend upon other methods, such as fumigation, for treating soil in the magnitude of 100 cubic yards a day. We only work for one client, I think, that has capability of producing soil-mix in that quantity. In his soil stock pile, a self-generating heat process is used; tests were run — that is, biological plating was done of material removed from the bottom of this pile. It was, disturbingly, too clean! That is, it had essentially cooked itself out. In our repertoire of clients I know of only one container nurseryman who is still steam sterilizing his soil. I know of one, up north, who is still steam-sterilizing every bit of soil; that is, from the liner, flat, seedling, propagation stage. I think, if the demand for a system such as you require is made, it's simply a matter of enough steam and of enough air and a moving system; it would be practical. I think Dr. Baker has covered this quite thoroughly. One system which he originally stressed was a continuous-flow; it would just be a matter of mechanics.

JIM HINES: Would the mechanics get out of proportion — in cost — to what you're doing?

FRED PETERSEN: Well, I think it has been a matter of economics which has kept people from steaming large volumes of soil initially. That is, neither a vault nor a tarp method lend themselves particularly well to efficiency, in time. The only client, again, that I know is steaming is doing it in the back of a truck, which is a bit unwieldly. If a person was presently steaming 100-cubic yards of soil a day, all I can say is that he would be expending substantially fewer dollars to convert to this system. Can you give me some idea, for example, of how a person is steaming 100-cubic yards a day?

JIM HINES: We're using methyl bromide.

FRED PETERSEN: I think it would be prohibitive to convert to a steam process for that quantity of soil simply because you've already decided, I think, to use fumigation, rather than steaming, for the reason of economy.

JIM HINES: Then the other question, what is the cost of dry heating versus steam?

FRED PETERSEN: I do not know if you have reference to heating cables or to a conduction rotating kiln, type heating: such conductive heating is strongly discouraged by most qualified plant pathologists and is felt to be quite hazardous from a standpoint of toxicity because you lose the basic value of steam when you go to conductive heating. Steam has the unique ability to flow to a cold point, then condense, so you are actually heating only the particles which requires heating as opposed to a conductive method. For example, in a rotating kiln — as in used in asphalt production — there is a heated surface; a popcorn cooker I guess would be a good analogy. Here the particle has to be physically heated by contact. Aside from the toxicity standpoint of charring, the biological problem is very real because the pathologists would tell us that most organisms are best controlled in the moist condition and conductive heat would not work well because we have to heat so much water.

JIM HINES: One last question, you brought up the idea concerning a nursery that is using a composting effect, or storage pile, and is building up this heat. What temperature does it get to?

FRED PETERSEN: It was over 170°F.

JIM HINES: How does he sterilize the outer edges of the pile?

FRED PETERSEN: Fumigation.

JIM HINES: There's no way to capture the heat that so the whole pile will be sterilized?

FRED PETERSEN: Attempts have been made by tarping, but unfortunately the piles were 30 to 40 feet tall and in a windy area. Repeated attempts to get an economical tarp were pretty difficult, that is a tarp that would stay in place long enough to conserve and trap this heat. A tarp such as Jerry suggests was satisfactory for the overnight period for surface fumigation.

I think the greatest value of aerated-steam in a container nursery is in the propagation phase. In general, experience suggests that this is where most people are placing most emphasis on sanitation. That is, the old secret of let's get a clean, healthy, vigorous- growing, liner. By the time a liner reaches a gallon can, it has been handled many times mechanically. The likelihood is that it has been infested to some degree. even under the strictest levels of sanitation; so to put that liner into something aseptic is breaking one of the cardinal rules of pathology. This is why I make the remark about the stockpile soil. In the opinion of an eminently qualified pathologist, that soil was too clean. It had no biological antagonists.

JIM HINES: Now then, you've brought up another question. I think your company recommends methyl bromide for fumigating large piles of soil and at the rate we're required to put it on, we are ending up with a sterile medium with infected liners.

FRED PETERSEN: I seriously doubt whether you're winding up with sterile media. With methyl bromide, it's my understanding that it is a good herbicide, a terrific nematocide, but there are a lot of disease organisms, a lot of fungi, that it will skip.

JIM HINES: This is one of the reasons for adding chloropicrin, is it not?

FRED PETERSEN: Right. So it would appear that if you are fumigating with methyl bromide alone, you are leaving a substantial fungus population. You would have to.

ROBERT BODDY: This is another question for Fred Petersen. Has any determination been made on the size of a boiler — BTU capacity — that would be required for a small scale operation, say one cubic yard a day, or five cubic yards a day, or a continuous operation that might build up to five cubic yards a day?

FRED PETERSEN: Yes. The numbers, Bob are well defined. We use the factor: 200 times the cubic yards — if you want to jot this down — 200 x yards, cubed = pounds of steam per hour required. This is a good safe ball-park figure, probably a bit on the high side; pounds of steam, of course, can be translated back into the capability of any boiler system. In general, it works out that for something around 10 cubic yards, as I recall without referring to notes, it is around 25 to 30 "boiler horsepower"; "boiler horsepower" is not a particularly efficient way to gauge a boiler.

ROBERT BODDY: You mentioned this one party converted to air-steam for $500. That is assuming he already had his boiler.

FRED PETERSEN: Yes, he had the boiler.

ROBERT BODDY: A 25-horsepower boiler would be worth about $5000.

FRED PETERSEN: Oh, yes. In fact we have recently been in the process of looking at flash steam generators, and the price is no small item. This particular one, I believe, was a 50-horsepower — with all the goolie-bobbers on it — for around $7000. However, it's the same old question — what does it cost per liner?

PETER VERMUELEN: Dr. Aljibury, have you found a direct relationship between rate of release of your slow-release fertilizers and soil temperature?

DR. ALJIBURY: Yes. This would be particularly true for urea-formaldehyde. It has been reported that there is not much correlation between release from the capsule, or from the coated materials, and temperature — but with a urea-formaldehyde type and with metal-ammonium-phosphate, there is such a correlation between increasing temperature and greater release.

PETER VERMUELEN: We had a sad experience with some azalea crops in 2¼ - inch pots. We lost quite heavily on the crop with a product that you mentioned. This was attributed to a higher soil temperature than is normally experienced outside. This happened to be in a greenhouse and has been acknowledged by the company.

VICE-PRESIDENT ISHIDA: Our final session this afternoon is on tissue, or meristem, culture and the moderator will be Mr. Richard Maire, Farm Advisor from Los Angeles County. Dick —

MODERATOR MAIRE: Thank you, Henry. I think if we have anything new or exciting in the field of plant propagation, this topic is one of the most exciting. We have two people who are well qualified to cover this subject. Dr. Toshio Murishige from the University of California at Riverside and Dr. Wes Hackett from UCLA. Dr. Murishige, who will speak first, was at the University of Hawaii before he came to Riverside. He has been working in the field of tissue culture for quite some time. OK, Toshio, let's amaze them with some of this "space-age" propagation.

PRINCIPLES OF IN VITRO CULTURE

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Introduction

Increasing use of the *in vitro* approach in botanical investigations and the expanding store of information prohibit a thorough coverage of the subject. This article is intended to simply acquaint the unfamiliar with some highlights of principles. Citations to original research should be viewed only as examples for illustration. More extensive coverage, including the historical development, can be obtained from several reviews and symposium publications now available (4,5,8,11, 13,21,27,28,34,35,39,42,43).

The term "plant tissue culture" has been popularly used indiscriminately to denote cell, tissue and organ culture. It is desirable to distinguish between cell and tissue on one hand and organ on the other, since their behavior and requirements in culture are markedly different. The preferred term which encompasses each of these cultures is "*in vitro* culture" and it is therefore used in this article.

Fundamentals which apply to any *in vitro* culture shall be examined first. This will be followed by some of the more specific aspects of cell, tissue and organ cultures. Finally, we shall consider some applications of the *in vitro* approach in plant propagation.

General Considerations

Whether it be cell, tissue or organ culture, these aspects demand fundamental consideration: asepsis, nutrition, physical environment, and the *in vitro-in vivo* relationship.