Modern Methods of Disease Control in Florist and Nursery Crops

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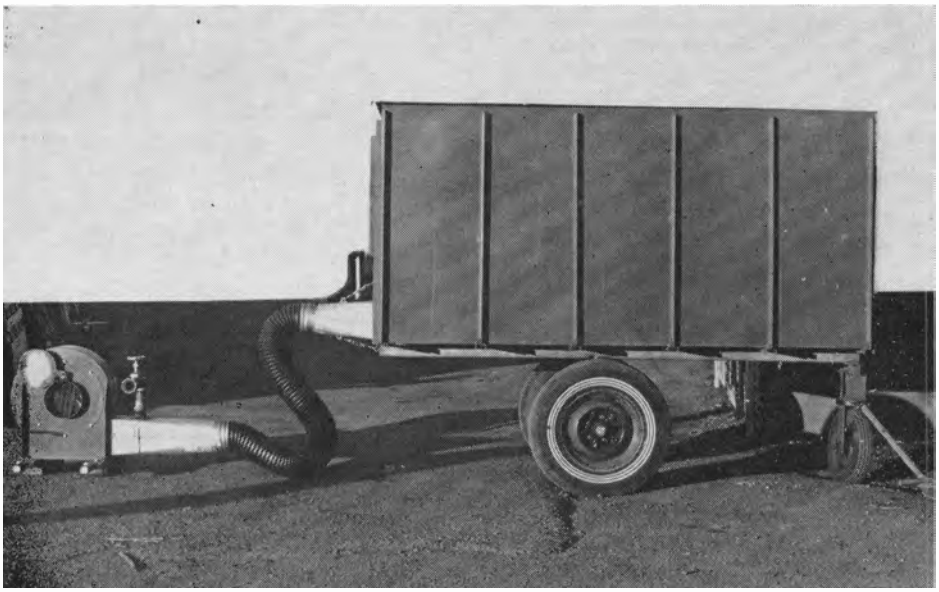
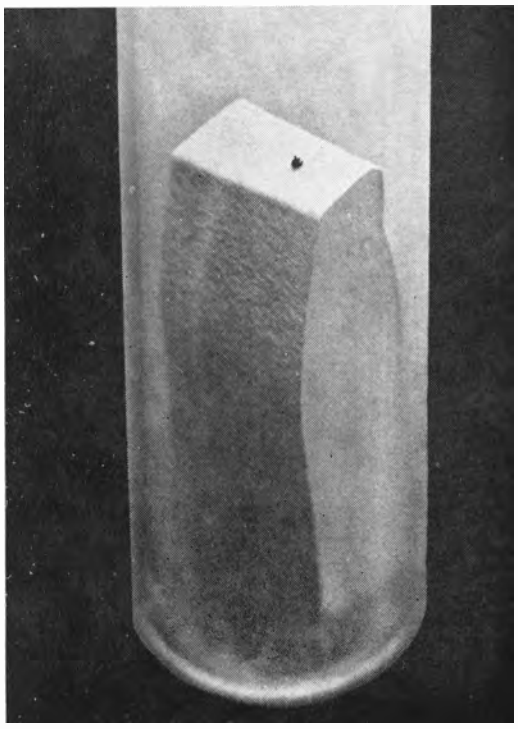


A commercial soil sterilization unit for either bin or potting bench, with centrifugal blower for diluting the steam. The mixture is injected into the plenum chamber, under the soil being treated.

Meristem-tip culture, showing the minute piece of plant on a small strip of sterile filter paper arched over a nutrient solution.



MODERN CONTROL OF PLANT DISEASE by florists and nurserymen is based on the fact that, in the last analysis, the sources of pathogens are the soil (including water and nonliving organic matter) and the host plants. Plant diseases generally may be prevented by planting clean stock in clean soil, and by practicing sanitation to prevent contamination. This basic program has resulted in a striking reduction in disease losses in florist and nursery crops in the past 20 years.

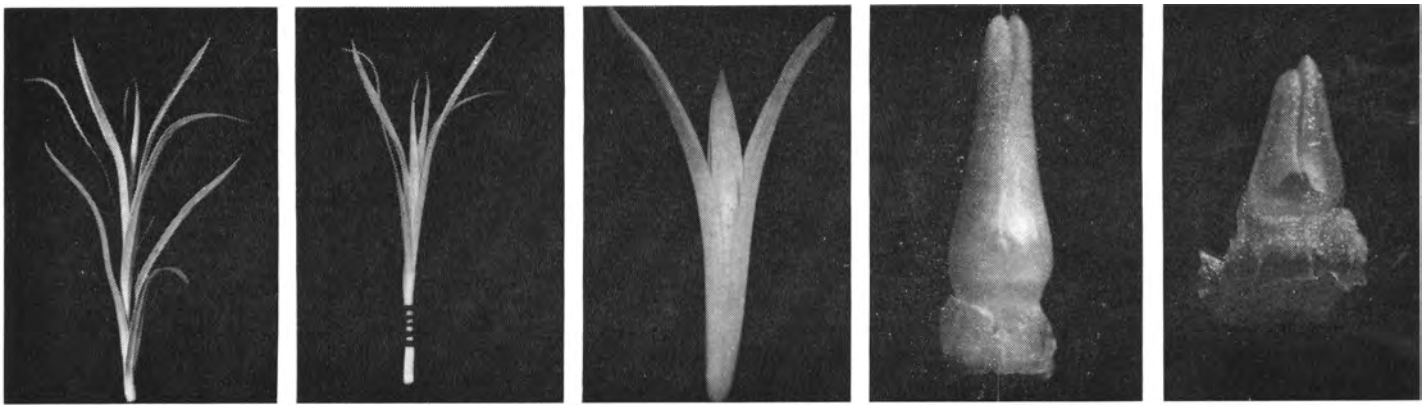
Pathogen-free propagating material

Propagating material provides an effective means for transmitting a plant pathogen to new areas and maintaining it in established areas, since the parasite and host are constantly associated and infection may have already occurred. The future commercial propagator of clean stock, therefore, faces the prospect of a zero tolerance on important plant pathogens.

The mother plant in every type of propagation should be grown under conditions as free as possible from pathogens, and in an environment known to help keep them free. There are many modifications of cultural practices (such as avoidance of overhead watering) which reduce the probability of infecting the seeds or vegetative material by pathogens. It is always desirable to visually select healthy plants as sources for propagating material.

Smaller and smaller vegetative propagating units have been used in recent years—shifting from divisions, to cuttings, to stem tips, to growing points, to meristem-tip cultures (see photos). One of the principal reasons for this trend is

TYPES AND USES OF PLANT PROPAGATIVE MATERIAL



	CUTTING	CULTURED CUTTING	TIP CUTTING	GROWING POINT	MERISTEM TIP
Name:					
Size:	Down to 1 in.	Down to 1 in.	1–0.25 in.	0.25–0.02 in.	0.02–0.004 in.
Rooting:	Direct	Direct	Direct	In culture	In culture
Uses:	Commercial propagation.	Commercial propagation to select clones free from fungi, bacteria, and nematodes to establish mother blocks.	Often mistaken for meristem-tip culture.	Often mistaken for meristem-tip culture.	Select clones free from viruses, fungi, bacteria, and nematodes; to establish mother blocks.
Advantages:	Ease of successful use in propagation.	Commercially used to select cuttings free of microorganisms.	Ease of successful use in propagation.	More successful propagation than with meristem-tip culture.	A percentage of plants obtained are free of many viruses and of all microorganisms.
Disadvantages:	Practically no selection for freedom from viruses or micro-organisms.	Does not select for freedom from viruses. Requires culture laboratory.	Does not select for freedom from most viruses, nor even most microorganisms.	Does not select for freedom from viruses, or from all microorganisms. Requires culture laboratory.	Precise technique requiring skill and adoptotion to each species or variety. Requires culture laboratory. Low percent of surviving virus-free plants.
Combined treatments:	Heat therapy of mother plants frees some cuttings of certain viruses.	Virus indexing of cuttings will select plants free from certain viruses.	Heat therapy of mother plants will help free cuttings from certain viruses.	Heat therapy of mother plants will help free clones from certain viruses.	Heat therapy of mother plants will help free clones from certain viruses.

that the smaller the tissue piece used, the more likely it is to be free of pathogens. However, as the propagule size becomes smaller, the difficulties of propagation increase, the chances of successful growth decrease, and the difficulties of indexing increase. Moreover, it becomes necessary to use increasingly complex techniques that require laboratory facilities and trained personnel, as has been the case in the highly successful commercial production of cultured and virus-indexed cuttings of chrysanthemum, carnation, and geranium.

This method, devised by A. W. Dimock in 1943, was based on the concept that, if the base of the cutting was free from vascular fungi or bacteria, the entire cutting was also practically certain to be free. This method has been the basis for development of a large propagation business.

Meristem-tip cultures require considerable manual dexterity on the part of the technician to remove the clasping leaves, expose the meristem, aseptically remove the terminal $\frac{1}{50}$ inch or less (see photo series) under the microscope, and aseptically transfer this minute piece to a small strip of sterile filter paper arched over a nutrient solution (see photo). If microorganisms are present, their development may be evident in the nutrient medium. A skilled technician may remove 100 of these in a half day, using a favorable plant. Of these, perhaps 50% will successfully grow, and 50% of the survivors may be free of microorganisms and virus.

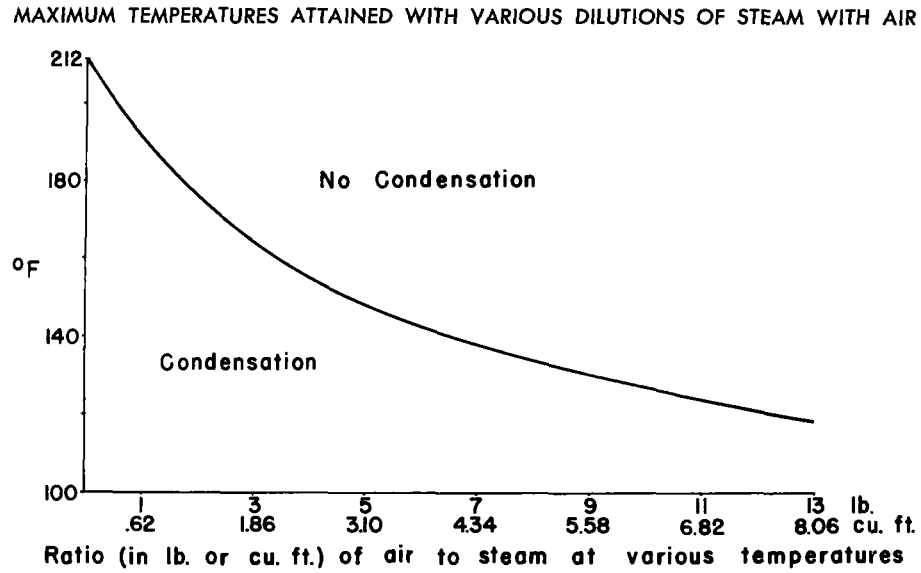
Indexing

Any system for providing clean planting material is only as good as the available methods of indexing for the pathogen. It cannot be assumed that a given meristem culture is virus-free, and testing over a year or two may be necessary to be certain of freedom from small amounts of virus.

The meristem-tip method is sufficiently expensive and complicated that it should be attempted only by propagation specialists under the supervision of trained pathologists. However, the method has already proven commercially feasible in obtaining material free from most pathogens. In this, as in all methods of propagation, there must be continuous and vigorous selection for horticultural type.

As indicated in the photo series, the first three propagule types may be rooted directly, whereas the other two are so small that it is necessary to provide optimal nutritional and environmental conditions. Several laboratories are now studying the possibility of vegetative propagation from a single cell or from tiny clumps of cells. It is not improbable that, for some plants, this method eventually may provide the ultimate means of obtaining pathogen-free stock.

The factor limiting more widespread use of pathogen-free stock at this time, however, is the need for an efficient organized means of maintaining and distributing it, once obtained. Many floricultural varieties have been "cleaned up" in various laboratories, kept for a time, and eventually lost or discarded because of tedious maintenance requirements. Once research pathologists obtain pathogen-free stock through use of one of the more complicated techniques, the personnel and laboratory facilities should not be tied up in maintaining such stock.



Trained pathologists are needed, however, to supervise such maintenance as is necessary to preserve the pathogen-free status of the plants.

There is real need for industrial or government facilities, or both, to preserve valuable vegetative clones, much as has already been provided for other needs through blood banks, gene banks for agricultural crops, and collections of cultures of industrially useful microorganisms. Whatever agencies finally supply this service, the floricultural industry must provide the impetus for its establishment. Such an arrangement has already been set up in Great Britain under the supervision of plant pathologists at the Glasshouse Crops Research Institute in Littlehampton, England.

Pathogen-free growing media

The traditional idea in treating soil or other growing media with heat or chemicals has been to destroy all living microorganisms present. This essentially creates a "biological vacuum," and the first microorganisms to return will luxuriate in it. Thus established, a pathogen can cause severe disease losses.

Reducing the severity of treatment is the most generally useful method for avoiding this effect. Although it is difficult to achieve uniform treatment of soil with reduced dosages of chemical fumigants, this is easily obtained with steam. It has been recognized for 30 years that it is only necessary to steam soil at a temperature of 140°F for 30 minutes to kill plant-pathogenic fungi, bacteria, and nematodes. Most viruses in plant residues are also destroyed. Since uniform heating was only possible (in the past) by keeping the soil in motion during steaming, little use was made of this method. However, following the California development of the aerated-steam method of treatment about eight years ago—with its easy temperature control and ready adaptation to existing treating equipment—low-temperature steaming has come into use in this country, Australia, and England.

Aerated steam is easily produced by injecting steam into an air flow. The steam is diluted by air, the ratio produced determining the temperature attained, as shown in the graph. The ratio of air to steam at 212°F is 0:1; at 160°F it is 3.4:1 by weight and 2.1:1 by volume; at 140°F it is 6.5:1 by weight and 4.1:1 by volume. The steam flow is manually controlled and usually injected into the output from a vane-axial or centrifugal blower (see photo) capable of operating against a back-pressure of 2 to 4 inches of water. The volume of air may be readily and accurately controlled by a damper over the air intake. The mixture is injected into a plenum (6 to 8 inches high) under the soil, which is suspended on a perforated steel plate or an expanded metal screen. The aerated steam moves up through the soil, heating it only to the temperature determined by the air-to-steam ratio. A commercial unit of this type is now available on the market.

The steam and air are balanced in relation to the quantity of soil treated and the temperature desired. The flow rate must also be adjusted to the depth and porosity of the soil being treated. The soil should reach the desired temperature within 30 minutes, and be kept at that level for 30 minutes.

Aerated steam diffuses through the soil in the same way and at the same relative speed as does regular steam. It may be used with any of the standard methods and equipment for steaming soil described in U. C. Experiment Station Manual 23.

Since, in vault treatment, much of the space is occupied by air which mingles with the steam introduced, it is not necessary to introduce air at the beginning of the treatment. Steam is usually injected until soil at the surface of a container reaches a level 15° to 20° F below the treatment temperature, and then the blower is turned on to establish the "ceiling" temperature.

One of several advantages in using aerated steam, as compared with regular steam is that toxicity to plants (of the sort resulting from soil treated at 212°F, or with chemicals) is essentially eliminated. A change from 212° to 140° F treatment usually results in increased vigor and size of plants. Another advantage is that plant-pathogenic microorganisms in the soil are destroyed, but many saprophytes are left to compete with, be antibiotic to, or to parasitize contaminant pathogens. (This is not necessarily true, however, for media such as perlite and vermiculite that are nearly sterile or lacking in antagonists). Another advantage is that the treatment cost is substantially decreased since the temperature is raised only about half as high.

Aerated steam is neither complicated to produce nor difficult to use. Operation is similar to and no more complex than with regular steam. If the soil is held moist for 3–4 days prior to treatment, there will be essentially no more weeds surviving 140° than 212°F.

Sanitation and cultural practices

If the two preceding methods are successfully carried out, there will be little hazard of contamination from plants or soil. However, the possibility still remains for introducing a pathogen on dirty tools or containers, on the hands or feet of workmen, or from soil caught in the end of a hose thrown on the ground. Appropriate preventive measures of these sources of contamination have also been presented in Manual 23. Irrigation water from reservoirs may carry zoospores of root-rotting water-mold fungi which will reinfest treated soil—in which case the water should be chlorinated as though it were to be used for human consumption.

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