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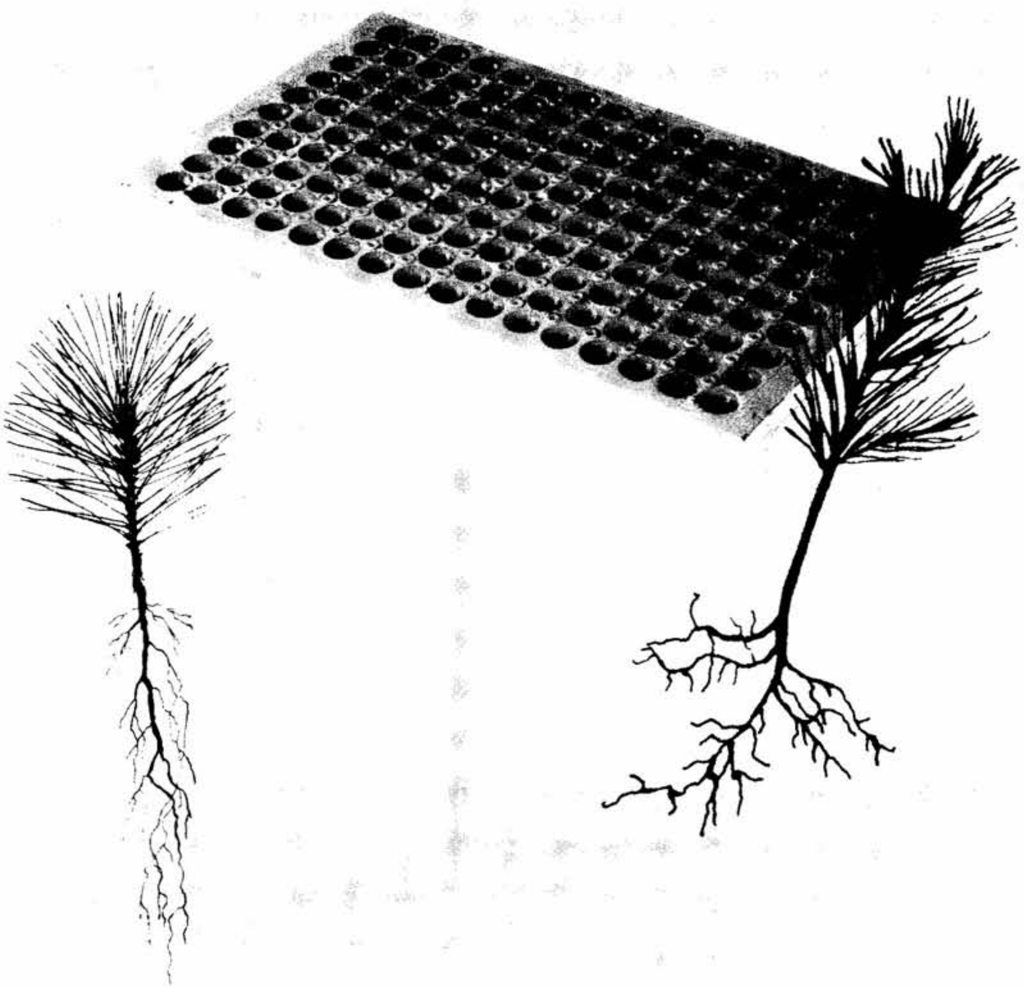
Using a Steamroom To Sterilize Pallets of Styrofoam Seedling Container Blocks



Using a Steamroom To Sterilize Pallets of Styrofoam Seedling Container Blocks

Andy Trent
Project Leader

Robert James
Forest Health Protection, Northern Region

Clark Fleege and Gary Hileman
Lucky Peak Nursery

USDA Forest Service
Technology and Development Program
Missoula, MT

3E32E55—Styrofoam Block Sterilizer

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Introduction

Styrofoam container blocks (styroblocks, figure 1) are a popular media for growing seedlings in greenhouse nurseries. They come in a variety of sizes and can be reused several times. They must be sterilized before reuse because they may harbor pathogens that can cause diseases to seedlings. Potential pathogens, such as *Fusarium* fungi, live on residual organic matter and within the inner cell walls of styroblocks. They also may colonize fragments of roots left on containers after the seedlings have been removed.

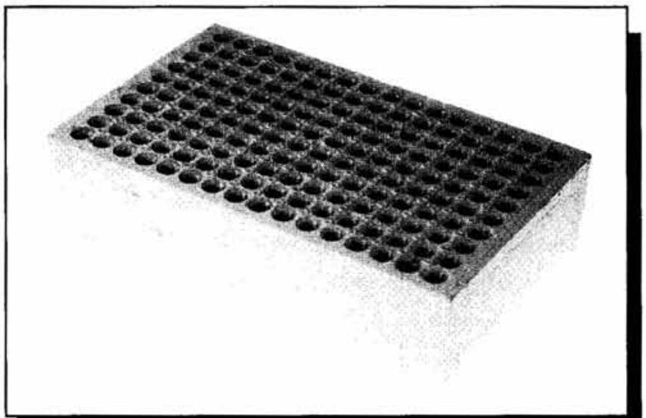

Figure 1—Styrofoam container blocks (styroblocks) are used to grow seedlings in greenhouse nurseries. The styroblocks must be sterilized after each use to kill pathogens that damage future seedlings.

Figure 2—Container blocks are loaded in a cage and submerged in hot water for 2 minutes during the conventional method of sterilization. A forklift forces the blocks down into the water.

Several approaches to sterilizing styroblocks have been investigated. Chemicals such as sodium hypochlorite (bleach) and sodium metabisulfite have been used. But these chemicals present problems with workers' exposure to toxic chemicals and disposal of the chemicals. Many nurseries use hot-water dipping (figure 2), immersing the styroblocks in hot water (from 140 to 160 °F) for about 2 minutes. This method kills most pathogens.

Hot-water dipping can be time consuming and labor intensive. Styroblocks must be loaded individually into a cage or basket that holds 20 to 50 styroblocks. The cage is submerged in the hot water for 2 minutes. The styroblocks are removed and the process is repeated. At larger nurseries where thousands of styroblocks need to be sterilized, this process can take many days. Additionally, the energy required to keep the water hot can be expensive.

The Missoula Technology and Development Center (MTDC) was asked to look at alternatives to hot-water dipping that would reduce the cost and labor required to sterilize styroblocks.

Highlights...

- Styrofoam container blocks used to grow seedlings need to be sterilized before reuse.
- The conventional method of dipping the blocks in hot water took workers several days at large nurseries.
- Sterilizing pallet loads of blocks in a steam room is effective and more efficient than dipping the blocks in hot water.

Testing Different Methods of Sterilization

MTDC conducted several evaluations to determine the effectiveness of different treatments for reducing fungal contamination on styroblocks. Styroblocks that were tested had been used to grow several seedling crops at a large forest seedling nursery. The goal was to determine whether such treatments could kill fungi that were potential pathogens, leaving the styroblocks relatively safe to reuse.

MTDC tested several different ways of sterilizing styroblocks. One method used radiofrequency (RF) waves to treat the blocks. Other methods used dry heat (with low humidity) and wet heat (with high humidity).

Before treatment, each styroblock was sampled for fungal colonization near the bottom of cells at the drainage hole where the highest populations of contaminating fungi, including potential pathogens, tend to congregate. Two pieces of Styrofoam (about 2 by 5 millimeters) were cut from each sampled cell using sterile procedures and placed on an agar medium selective for *Fusarium* and closely related fungi. Plates were incubated for 7 to 10 days at about 24 °C under diurnal (day and night) cycles of cool, fluorescent light. Emerging fungi were identified by genus. Selected isolates were transferred to potato dextrose agar (growth medium) and carnation leaf agar for identification of the species of *Fusarium* and *Cylindrocarpon*. Styroblock colonization was calculated as the percentage of sampled Styrofoam pieces that were colonized by a particular fungus. Specific cells were sampled in each styroblock. Two small pieces of Styrofoam were taken from each sampled cell.

After treatment, another two pieces of Styrofoam were taken from each sampled cell. The fungal colonization (the number of sampled Styrofoam pieces colonized by particular fungi) before and after treatment were analyzed statistically.

Sterilization Using Radiofrequency Ovens

Radiofrequency (RF) wave ovens can raise the temperature of styroblocks to levels that will kill pathogens. Industrial RF ovens are used for baking, curing, and drying many types of foods and materials. These ovens operate at an electrical frequency of 10 to 100 megahertz.

The material being heated is subjected to an alternating electrical field that makes the molecules inside the material rotate and move from side to side millions of times per second as they try to align themselves with the changing electrical field. This movement generates heat within the material similar to heat generated by friction. The ovens can be incorporated in a conveyor system to mechanize operations. Common microwave ovens operate on the same principle but use radio waves of about 2,450 megahertz to heat food and beverages.

PCS, Inc., in Cleveland, OH, treated styroblock containers with RF heating in a laboratory test oven. The oven operated at 40 kilowatts at a frequency of 18 megahertz using a parallel plate electrode system with variable electrode heights. The plate voltage was 12 kilovolts. Ten styroblocks were divided into two groups of five containers each. One group of styroblocks was soaked in water before treatment; the dry group was not. The styroblocks in the wet group were immersed in water for a short while, shaken to remove excess water, and placed in the RF oven. The RF field was on for 2 minutes. Blocks were removed from the oven and the surface temperatures of cells were measured with an infrared (IR) sensor. Temperatures varied somewhat, ranging from 80 to 120 °F and averaging 92 °F.

The RF treatment (table 1) reduced pathogens when the styroblocks were wet. It was ineffective when the styroblocks were dry. Apparently, the thin film of water on the surface of the styroblocks is heated by the RF waves, killing

Table 1—Test results for the radiofrequency wave oven. Styroblocks were treated either dry or wet.

	PERCENT COLONIZATION			
	Wet containers		Dry containers	
Fungus	**Before**	**After**	**Before**	**After**
Fusarium	54	3	73	71
Cylindrocarpon	2	0	1	1
Trichoderma	35	5	34	30
Penicillium	4	3	15	13
Other fungi	37	29	14	39
No fungi	0	60	0	0

fungal pathogens. The RF waves themselves are not toxic to pathogens because dry treatments are ineffective.

While the results indicated that RF treatment is effective when styroblocks are wet, the high cost of the RF oven and conveyor system (more than $65,000) probably would allow only the largest nurseries to use this method.

Low-Humidity Heat Treatment

Another method subjected the styroblocks to hot, low-humidity (dry) air in an oven. If the oven was actually a large room, pallet loads of styroblocks could be left in the room long enough to sterilize them. The styroblocks would not need to be handled individually or loaded as they are with hot-water dipping, freeing workers for other tasks while the blocks were being treated.

Individual dry styroblocks were treated in an industrial oven (figure 3) for 10, 20, or 60 minutes at 170 °F. Additionally, one set of styroblocks was wetted before the same treatments.

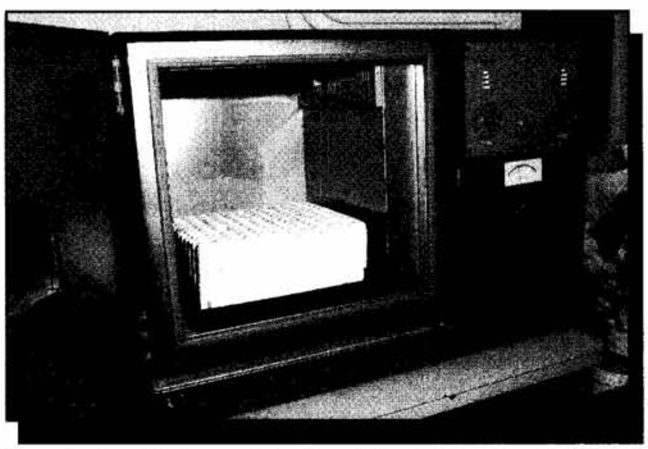

Figure 3—Styroblocks were baked in an industrial oven set to 170 °F to determine whether dry heat would sterilize them.

Subjecting the styroblocks to hot, low-humidity air for up to 60 minutes was ineffective (tables 2 and 3). Wetting the blocks improved the effectiveness, even when the blocks were heated for just 10 minutes.

Table 2—Test results for the industrial oven. Dry styroblocks were heated for 10, 20, and 60 minutes at 180 °F.

	PERCENT COLONIZATION					
	10 min. dry		20 min. dry		60 min. dry	
Fungus	Before	After	Before	After	Before	After
Fusarium	11	19	7	8	7	7
Cylindrocarpon	2	0	0	0	0	0
Trichoderma	28	36	42	46	37	33
Penicillium	23	19	28	13	27	18
Other fungi	66	65	55	53	63	51
No fungi	0	0	0	0	0	13

Table 3—Test results for the industrial oven. Wetted styroblocks were heated for 10, 20, and 60 minutes at 180 °F.

	PERCENT COLONIZATION					
	10 min. wet		20 min. wet		60 min. wet	
Fungus	Before	After	Before	After	Before	After
Fusarium	17	0	4	4	13	0
Cylindrocarpon	0	0	0	0	0	0
Trichoderma	8	4	4	0	4	0
Penicillium	33	4	38	0	29	0
Other fungi	75	0	83	13	79	8
No fungi	0	88	0	88	0	92

Bulk Testing Using Low- and High-Humidity Heat

Initial tests did not show whether the heat would penetrate to the innermost styroblocks if a pallet load of styroblocks (figure 4) was being sterilized. MTDC designed a test box (figure 5) for a pallet load of about 50 styroblocks. A metal storage container (7-feet wide by 13-feet long by 7-feet high) was insulated with rigid Styrofoam insulation. A residential sauna heater was mounted inside the box to heat it to 160 to 170 °F. Designers fabricated a device to spill water on the sauna rocks to generate steam and raise humidity.

A series of tests were conducted using different exposure times with low and high relative humidities. During three tests conducted at low relative humidities (less than 30

Figure 4—Styroblocks loaded on a pallet were heated to 170 °F. Tests were conducted at low and high (higher than 75 percent) humidities.

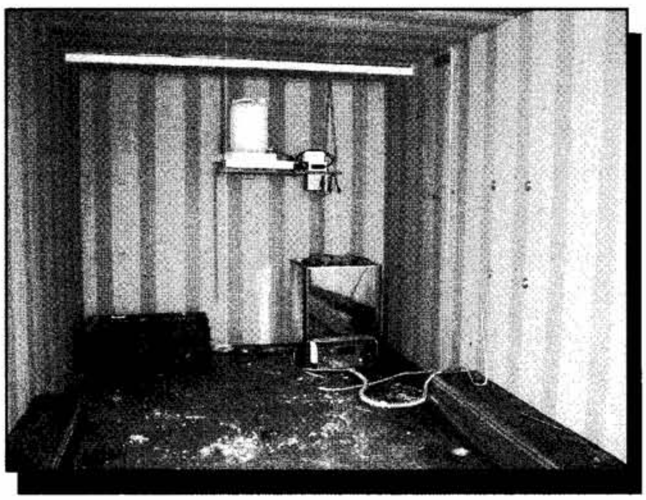

Figure 5—A storage container outfitted with a commercial sauna heater was used to sterilize styroblocks during testing.

percent), the blocks were wetted before they were heated for 15, 30, and 60 minutes. During three additional tests at high relative humidities (higher than 75 percent), the blocks were not wetted before being heated for 15, 30, or 60 minutes.

These tests monitored styroblocks in the center of a pallet load. The blocks were thoroughly soaked with water for the tests that required wetting. Styroblocks were exposed to 160 to 170 °F for the appropriate time periods.

Styroblocks tested were from the Forest Service nursery in Coeur d'Alene, ID. Samples were taken from the styroblocks before and after testing. High-humidity heat was more effective than low-humidity heat (tables 4 and 5). *Fusarium* and *Cylindrocarpon* colonization was eliminated even when the blocks were heated for just 15 minutes at high humidity.

Table 4—Results for bulk testing styroblocks in the MTDC sterilization container. Wetted styroblocks were treated for 15, 30, and 60 minutes with low relative humidities at 170 °F.

	PERCENT COLONIZATION					
	15 min.		30 min.		60 min.	
	Low humidity		Low humidity		Low humidity	
Fungus	Before	After	Before	After	Before	After
Fusarium	0	0	79	88	46	13
Cylindrocarpon	0	0	42	0	0	0
Trichoderma	0	0	42	42	8	17
Penicillium	8	83	67	96	21	17
Other fungi	42	8	13	0	92	42
No fungi	0	0	0	0	0	17

Table 5—Results for bulk testing styroblocks in the MTDC sterilization container. Styroblocks were treated for 15, 30, and 60 minutes with high relative humidities (higher than 75 percent) at 170 °F.

	PERCENT COLONIZATION					
	15 min.		30 min.		60 min.	
	High humidity		High humidity		High humidity	
Fungus	Before	After	Before	After	Before	After
Fusarium	58	0	50	0	25	0
Cylindrocarpon	0	0	0	0	0	0
Trichoderma	8	0	8	0	21	0
Penicillium	75	13	25	0	33	29
Other fungi	96	17	88	0	88	17
No fungi	0	71	0	100	0	54

Lucky Peak Nursery Steamroom

Lucky Peak Nursery near Boise, ID, constructed a new greenhouse facility to grow containerized seedlings (figures 6 and 7). The nursery needed an inexpensive way to sterilize large numbers of styroblocks. The nursery converted a cold storage room into a styroblock sterilization room by piping in low-pressure steam to supply high-humidity heat. A propane boiler supplies steam to heat the room to a constant temperature of 160 °F. Operators loaded styroblocks into the room, using a forklift and storage racks (figure 8), treating the styroblocks for several hours to ensure that they were sterilized completely.

Figure 6—The new greenhouse facility at the Forest Service's Lucky Peak Nursery near Boise, ID.

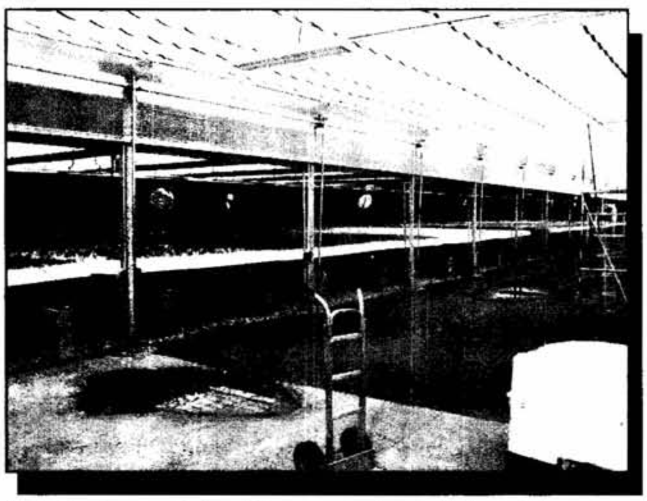

Figure 7—Containerized seedlings growing in styroblocks in the new greenhouse facility at the Forest Service's Lucky Peak Nursery near Boise, ID.

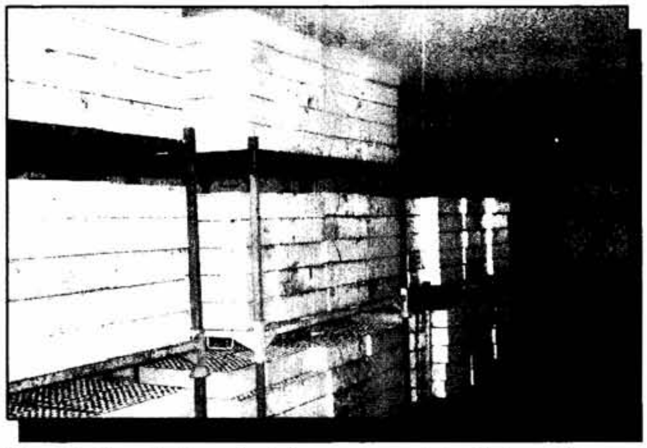

Figure 8—Styroblocks are loaded on storage racks inside the sterilization room.

Sterilization Room

The sterilization room (figure 9) measures more than 11,000 cubic feet (24-feet wide by 47-feet long by 10-feet high, lined with 2-inch-thick rigid foam insulation. The rigid foam not only insulates the steam room to reduce energy costs, but protects the existing plywood from the high-temperature and high-humidity environment, which would cause the plywood to delaminate. Workers painted the foam

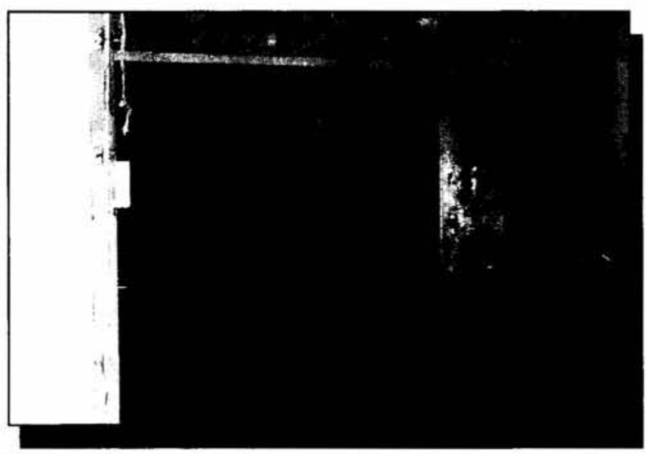

Figure 9 A storage cooler was converted into a sterilization room. Steam pumped into the room provides high-humidity heat.

with a special latex paint designed for the high-humidity and high-temperature conditions. The paint helps to seal the foam and prevents mold from growing.

The room is large enough for a forklift to load and unload the styroblocks easily. A drain in the middle of the room allows water that condenses from steam to drain.

Boiler and Equipment

Steam generated by a 9.5-horsepower (about 400,000 British thermal units per hour) propane boiler (figure 10) flows through a 1-inch black pipe installed along the bottom of two sides of the room (figure 11). The steam pressure was

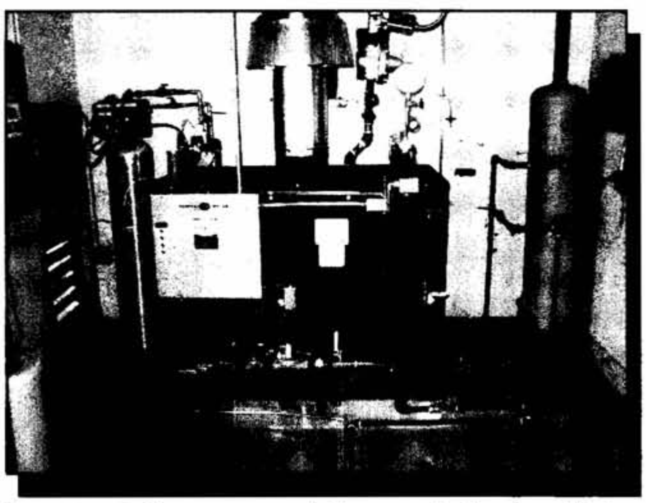

Figure 10—A 9.5-horsepower steam boiler was used to heat the sterilization room.

reduced from the standard 40 pounds per square inch at the boiler to 10 pounds before the steam entered the room. Holes $^{1}/_{16}$-inch in diameter were drilled in the pipe every 6 inches to release the steam. Galvanized steel sheets installed behind the pipes protected the foam insulation from the steam.

Remote electronic controls set the temperature inside the room. Although the temperature probe to the electronic controller could be placed anywhere in the room, we put it in the middle styroblock of a group of styroblocks on a pallet

Figure 11—Black pipe distributes steam in the sterilization room. The pipe runs along the bottom of the side walls. Steam leaves the pipe through holes ($^{1}/_{16}$ inch in diameter) drilled into the pipe.

to ensure that the interior styroblocks were heated thoroughly. An electric water feed valve, chemical feeder, blowdown tank, and a water softener were added, as were relief valves and miscellaneous plumbing, including plumbing for the propane supply. Converting the room from cold storage to a styroblock sterilization room cost about $24,000.

The time required to heat the room to sterilization temperature (160 °F) depends on the boiler size, room volume, and starting temperature. With an initial temperature of about 40 °F, it takes about 15 hours to bring the sterilization room at Lucky Peak Nursery up to 160 °F. Reheating the room for additional loads will not take as long. The walls, ceiling, and concrete floor will retain heat, which should reduce reheating time considerably. It is advantageous to fill the room with as many styroblocks as possible per load. The room holds about 4,000 styroblocks. The blocks should remain in the room for several hours at 160 °F to ensure sterilization.

Tests at Lucky Peak Nursery

Filling the room to capacity and heating it to 160 °F for 6 hours tested the sterilization room's ability to kill harmful fungi on reused styroblocks. Ten test styroblocks were placed randomly throughout the room in the center of styroblocks stacked on pallets. Results (table 6) indicate that the treatment is very effective.

Fusarium levels were reduced from almost 90 percent to 5 percent. After treatment, 80 percent of the styroblocks had no fungal growth.

Further work could determine the minimum amount of exposure time required for sufficient sterilization. The less time required, the lower the energy costs of heating the room. However, it costs just $3 per hour to heat the room, so it's best to make sure that the styroblocks are heated long enough to sterilize them.

Table 6—Test results for treating styroblocks at the Lucky Peak Nursery sterilization room. Styroblocks were treated at 160 °F for several hours.

	PERCENT COLONIZATION	
Fungus	**Before**	**After**
Fusarium	90	5
Trichoderma	15	2
Penicillium	42	3
Other fungi	0	10
No fungi	0	80

Standard Operating Procedures

Lucky Peak Nursery plans to use the following procedure to sterilize styroblocks in the steamroom.

DAY 1—

- 8 a.m. to noon—One person using a forklift will fill the sterilization room with pallets loaded with styroblocks. This will take about 4 hours.
- Noon—The boiler is turned on and set to 160 °F.
- 5 p.m.—The steamroom has reached 130 °F.

DAY 2—

- 7 a.m.—The steamroom has reached 160 °F. Styroblocks have been sterilized for several hours. The boiler is turned off. One person with a forklift removes styroblocks when they are needed for sowing.

About 4,000 stryroblocks can be sterilized in one operation.

Lucky Peak Nursery plans to use the steamroom for other tasks, such as heating lodgepole pine cones so the seeds can be extracted. The cones of lodgepole pine and some other conifers open only after they have been heated. The nursery also intends to use the steamroom to sterilize items used in bareroot and containerized seedling propagation (seed trays, mulch fabric, and so forth).

Conclusions

High-humidity heat is an effective alternative to hot-water dipping for sterilizing styroblocks. When the styroblocks and their environment was dry, heat treatments were less effective.

A steamroom developed at Lucky Peak Nursery effectively sterilized styroblocks. This room was large enough to handle styroblocks loaded on pallets, minimizing handling and reducing labor costs. The steamroom had to be insulated and equipped with a boiler that had enough capacity to provide steam for several hours. Inside temperatures had to be maintained above 160 °F with the humidity above 75 percent. The size of the sterilization room required for a nursery will depend on the number of styroblocks the nursery needs to sterilize, as well as the cost of boilers and other equipment needed for rooms of different sizes.

For smaller nurseries, a small shed may be used to sterilize one or two pallet loads of styroblocks at a time. If a boiler is too expensive, a commercial sauna heater can be used. A device could be fabricated that would periodically spray water on the sauna blocks, creating steam. This approach worked well during MTDC's high-humidity tests.

Notes

About the Authors

Andy Trent is a project engineer at MTDC. He received his bachelor's degree in mechanical engineering from Montana State University in 1989. Before coming to MTDC in 1996, he worked as a civilian engineer for the U.S. Navy. Andy works on projects in the nurseries and reforestation, forest health protection, GPS, engineering, and watershed, soil, and air programs.

Clark Fleege is the nursery manager at the USDA Forest Service Lucky Peak Nursery. He has worked in nursery and reforestation programs with the Forest Service and State forestry agencies for 27 years. He received his bachelor's degree in forest management in 1977 from the University of Wisconsin-Stevens Point.

Gary Hileman is the gardener/foreman at the USDA Forest Service Lucky Peak Nursery. He has worked at the nursery for 28 years in various capacities. He is responsible for the design and fabrication of numerous pieces of seedling nursery equipment used throughout the Federal nursery system.

Robert James is a plant pathologist with the Northern Region of the Forest Service. He has a Ph.D. and a master's degree from the University of California, Berkeley and a bachelor's degree in forestry from Utah State University. He has specialized in diseases of forest nurseries in the Western States for 28 years.

Library Card

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Describes the use of a steamroom to sterilize pallets of Styrofoam seedling container blocks (known as styroblocks). Tree nurseries grow seedlings in these stryroblocks, which can be reused several times if they are sterilized after each use. Sterilization prevents the styroblocks from harboring diseases, such as those caused by the fungus *Fusarium*. In the past, styroblocks have been loaded into a cage with 20 to 50 other stryoblocks and immersed in hot water for 2 minutes. This process can take a long time when thousands of styroblocks need to be sterilized. The U.S. Department of Agriculture Forest Service's Missoula Technology and Development Center tested several methods of sterilization, including heating styroblocks in radiofrequency ovens, to see which methods would be the most practical for tree nurseries. The study was conducted at the Lucky Peak Nursery near Boise, ID. The most practical approach involved converting a cold storage unit to a steam sterilization room. The steamroom is loaded with pallets of styroblocks during the morning. The boiler is turned on at noon and the temperature is set to 160 °F. The boiler is turned off at 7 a.m. the following day. About 4,000 styroblocks can be sterilized at one time.

Keywords: disease control, plant diseases, disinfection, fungal diseases, fungi, *Fusarium*, humidity, Lucky Peak Nursery, nurseries, ovens, steam sterilization, sterilizing, styroblocks

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For additional information, contact Andy Trent at MTDC:
Phone: 406–329–3912
Fax: 406–329–3719
E-mail: *atrent@fs.fed.us*

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