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Keeping the Heat on Pests: Using a hot water immersion system effectively can control certain plant pests during propagation

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Based on trials conducted by the University of Hawaii Cooperative Extension and the University of Maryland Cooperative Extension, using a hot water immersion system effectively can control certain plant pests during propagation.

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Can very warm water kill pests and make a nursery plant propagator happy and rich? Yes, it can, but whether you get rich using this method is up to you. We think that multiple potential benefits can be found using a hot water immersion system to decimate insects, or should we say cook insects, at the propagation stage. This method was developed through research at the University of Hawaii Cooperative Extension, Manoa, and at the Central Maryland Research and Education Center of the University of Maryland Cooperative Extension, Ellicott City.

Many nursery plant propagators are eager to adopt effective, cost-efficient methods of nonchemically controlling pests. Concern over a worker's unnecessary exposure to chemicals has prompted many nursery owners to look for alternative methods to deal with insect and mite control that places less reliance on pesticides. Greater regulation on the use of chemical pesticides has created an opportunity to move to other methods of dealing with pests.

Funding from the Maryland Nursery and Landscape Association (MNLA) and the Northeastern IPM Center, Pennsylvania State University, University Park, enabled us to build a portable hot water immersion system that is economical and relatively easy to construct and operate by nursery plant propagators. The system involves an instantaneous water heater that rapidly heats water to the proper temperature and recirculates the water around plant cuttings. Propagation plant material is placed in treatment mesh baskets and placed in a recirculating hot water system. Growers are likely to adopt methods that are practical and easy to use — criteria that this system meets.

We tested multiple temperature and treatment times for 13 species of woody and herbaceous plant material and a couple of greenhouse species. We established threshold temperatures so cuttings of these species could be treated without suffering injury. We also evaluated the impact of hot water treatment on four different insect and mite populations on plant cuttings taken.

A portable hot water immersion system involves an instantaneous water heater that rapidly heats water to the proper temperature and recirculates the water around plant cuttings. A good water-circulation system to stir the water is desired to maintain temperature uniformity. The system is used to kill plant pests during the propagation stage.

Why hot water treatment is effective. Nursery managers will propagate many species of plant material by taking cuttings from stock plants and rooting them in mist chambers before moving them to production growing areas. A stock plant can have a small infestation of insects or mites that are difficult to detect, such as scale, mealybug, thrips, aphids, spider mites or broad mites. Growers strive to propagate from clean plant material, but sometimes the pests either are so small or found on cryptic parts of the plant that they go undetected.

In a mist chamber, it nearly is impossible to apply insecticides because the foliage constantly is being syringed off by the frequent mist cycle needed to keep plants moist during the rooting stages. Applying systemic insecticide to substrate is not practical because the plants do not have roots to pull up the soil drench. Some nursery managers have resorted to dipping cuttings in dip tanks with pesticides in the hope of killing pests before they are moved into mist greenhouses for rooting. The problem with this approach is threefold: Most pesticides are not labeled for this use, and there are no labeled rates and directions; exposure risk to pesticides by employees dipping the plants is very high; and there is no good way for owners to dispose of the remaining pesticide dip when the process is completed.

The method of using hot water treatments to control pests is relatively simple and effective. Most pests of ornamental plants can survive at high temperatures, but there is a small temperature window at which insect pests die and plant material is tolerant.

Dr. Arnold Hara, professor of entomology in the department of plant and environmental protection sciences at the University of Hawaii, Manoa, has tested the hot water bath method on a number of plant species and found that 120.3° for one to 10 minutes gave effective control of several species of insects, including aphids, scale, mealybug and mites, on nursery plant cuttings.

In our trials at the University of Maryland Cooperative Extension, we established the threshold temperatures at which temperate-zone plant material can be treated safely using hot water without damaging the plant material. We also needed to establish whether these hot water treatment temperatures and the length of treatment killed pests. We worked with several Maryland nurseries on this project — Chesapeake Nurseries Inc., Salisbury; Woodland Nurseries of Salisbury Inc., Salisbury; Marshy Point Nursery Inc., Chase; Hillcrest Nursery, Millers; The Perennial Farm, Glen Arm; Kurt Bluemel Inc., Baldwin; and Greenstreet Growers Inc., Lothian — as well as The Ivy Farm, Locustville, VA. We let the nursery managers select plant material that has been damaged by pests.

Hot water as a soil drench to control pests. Bob McMahon, associate professor in the horticultural technologies division of The Ohio State University Agricultural Technical Institute, Wooster, has been working on controlling greenhouse pests using hot water drenches. In his studies, he found that treating soils using hot water drenches and taking the soil up to 110° kills larvae of fungus gnat very effectively. He also tested the tolerance of poinsettia and 'New Guinea' impatiens to hot water drenches. McMahon found that poinsettia can tolerate soil temperatures up to 135° without damage. 'New Guinea' impatiens tolerated even higher temperatures, up to 150° without damage. McMahon applied 24 ounces of water to 6-inch pots, waited three minutes and applied a cooling drench of water at 20 ounces per pot.

Our approach at the University of Maryland Cooperative Extension has been a little different. We are looking at treating plant cuttings taken from infested stock plants and cleaning them so they are relatively pest-free. In our system, whole plant cuttings are submersed in water held at a constant temperature for a set amount of time with the water being recirculated around the plant cuttings. The treated cuttings are cooled using water at 110° to 135° for 60 to 120 seconds. The cuttings then are stuck using normal propagation methods.

A temperature gauge was used to measure the temperature in various parts of the hot water immersion system's stock tank to determine if the water temperature was uniform.

Developing an effective IPM tool for nursery managers. Our goal was to build a device that is affordable (under $4,000), portable and practical for treating large numbers of cuttings. The system we chose was based on a model developed by Hara. The system uses an instantaneous water heater and propane for the energy source. Hot water is circulated through a 100-gallon stock tank, and plant material is lowered into the water in PVC-netted cages. Temperatures are monitored as the water moves to the tank, and a thermostat records the temperature of the recirculating water to make sure the temperature is constant and even.

Circulation and temperature uniformity in the treatment tank is achieved through a circulation grid consisting of a centrifugal pump and plumbing system. The pump outlet is split to both sides of the tank, causing the water to follow the oval-shaped perimeter of the tank. Our extension agricultural engineers designed the piping, placement of thermocouplers and control valves. We used temperature gauges to measure the temperature in various parts of the stock tank to determine if the water temperature was uniform.

The first pump placed on the system did not give adequate circulation, and we had temperature variation in the stock tank. We requested that our agricultural engineers increase the horsepower to move the water around the plant cuttings. This large pump greatly helped in making the temperatures in the treatment tank more uniform. A circulation-control valve was placed on the system so we could increase or decrease the recirculation rate as desired. It would be increased when the tank was filled completely with treatment cages, as we needed maximum flow around the cuttings.

Design of the system. The hot water immersion method has two main systems. The first is the water-heating system. The instantaneous water heater, with its water and gas supplies, provides the hot water for the immersion tank. Thermometers, control valves and pressure gauges also are part of the system to monitor and to help achieve the hot water necessary.

The second system centers on a pump that circulates the water in the immersion tank through pipes and risers. Nozzles mix the water and push it into the plant material. Using control valves, the discharge from the pump can be directed into the tank to mix the water, or the water can be directed away from the tank to dispose of it. Cooled water may be recycled to the heater.

Certain design considerations are important in order to make a good, functioning system. The water heater has a given capacity for heating water, and that defines the water-flow rate and water pressure required for the system. It sets the limitation on the amount of hot water that will be available to fill the immersion tank initially and the amount of hot water available to maintain a given temperature.

Because the water temperature is critical to the success of the immersion process, insulation was placed around the immersion tank to reduce heat loss, thus temperature change is reduced. The ability to monitor the temperature of the water going into the immersion tank and the temperature of the water being circulated is essential. A good water-circulation system to stir the water is desired to maintain temperature uniformity.

Cotoneaster dammeri ‘Coral Beauty’ was tested for its tolerance to high temperatures, as well as the time interval that did not cause burning, dieback or lack of rooting of the cuttings.

Water-heating system. An instantaneous water heater was selected for the portable hot water immersion system. For a stationary system, a regular commercial- or residential-type water heater with a fairly fast recovery rate would work. For the purpose of clarity, the brand name and model numbers of the actual equipment used to build the system are given. This does not mean that other equipment could not be used, nor is it an endorsement for any specific equipment.

For the University of Maryland Cooperative Extension unit, a Paloma Automatic Gas Water Heater Model PH-24M-DP for propane was used. The unit has a maximum rated input of 178,500 BTUs per hour on high and 37,700 BTUs per hour on halfway. This translates into a 90° rise in water temperature at a water-flow rate of 3.17 gallons per minute (gpm) on high burner and a 100° rise in water temperature at a water-flow rate of 2.85 gpm on high burner. Other data to note is for the flow-control valve of the heater to work properly, a water pressure of 12.9 pounds per square inch is required to push the water through for heating.

The instantaneous water heater turns on as the hot water tap is opened, and cold water flows through the heat exchanger. A pressure differential switch controls flow. A water temperature knob can be adjusted to set the water temperature at a given flow rate. For this application, the "Hot" setting was used.

System operation. Here are some lessons we learned during our trials on system operation:

• Determine the high temperature intended for the process. We found that most plants can tolerate between 120° and 125° for varying amounts of time. Some more sensitive plant material will need lower temperatures.

• It is much more efficient to start at a higher temperature and work down to a lower temperature than to try to increase the temperature after starting at a low temperature.

• Allow the water to flow into the tank to a point that will cover the baskets used to hold plant material. It should be above the blue suction line for the circulation pump.

• Temperature stabilization is important.

• The lid will help hold water temperature and should be used whenever possible.

• Allow at least 15 minutes for tank temperature to stabilize before starting the process of putting plants in the tank.

• Tank temperature can be monitored using the circulation pump system and temperature gauge located to the right of the pump motor. Pump motor control is located below the pump motor.

Temperatures that kill. In his research work on hot water immersion, Hara placed plant cuttings and plant material into a netted cage. He preconditioned the plant material by holding the cuttings at 104° for up to 15 minutes. The plant cuttings and net holding chamber were removed, and the temperature was raised to 120° for eight to 12 minutes. The plants then were cooled to ambient air temperatures (approximately 74°) for five to six minutes. The cuttings then were stuck into a mist chamber.

Hara noted that hot water treatment at 120° kills the following pests: ants, aphids, taro root aphid, Cockerell scale, green scale, mealybug, root mealybug and spiraling whitefly (see chart 1).

Testing the system's performance. We set up tests to evaluate the hot water recirculation system while under a working load of cuttings. We quickly found that if we increased the desired water temperature, then inserted the cages holding the cuttings, the water temperature dropped. We experimented with heating the water in the stock tank, then slowly lowering the temperatures. Through repeated trials, we found that it is best to run the temperatures to 145° to 150° for at least 30 minutes to heat up the stock tank and the surrounding insulation. In the winter, it may require 45 to 60 minutes to heat the tank adequately. We also raised the temperature 1° warmer than the target temperature to compensate for lowering the cutting baskets into the treatment tank.

Another modification was the addition of an insulated lid with a 1-inch polystyrene layer that covered the treatment stock tank. The insulated lid, combined with preheating the tank to 145° to 150° for 30 minutes, worked well. Slowly introducing water from a hose to bring the temperature down to the desired temperature worked well. The preconditioning of the stock tank allowed us to maintain a constant temperature of the water for 20 to 30 minutes.

Temperature adjustment and treatment cages. To improve the ease of placing and removing the cuttings into the tank, we constructed large, 18- by 18-inch cages. However, these cages were too large and cumbersome for treating a small number of cuttings at a time. These larger cages might work if a grower was treating large numbers of cuttings of the same plant species. For our trials, smaller was better. We modified our experimental cages by making them a compact 12 by 12 inches. Because the cages were made of PVC pipe, they tended to float up in the tank. We drilled holes into the PVC pipe so the cages sank into the water. These smaller cages appeared to fit the cuttings better with fewer floating out in the main body of the treatment tank.

We were able to fit up to six cages into the stock tank during a treatment. The plastic mesh used to cover the cages had a three-fourths-inch opening to allow the water to flow through the cage. This net opening worked well for most of the woody cuttings with very few cuttings escaping. When testing herbs, we had to place the cuttings into finer silk mesh bags. They then were placed in the cages to keep them from escaping into the stock tank.

Plant material tested. Each treatment temperature and time interval had five replications. Immediately after being taken out of the hot water treatments, the cuttings were moved into water at 65° to 70° for a cooldown period of five minutes. Cuttings immediately were stuck into substrate and placed under a timed interval mist system. Cuttings were observed over a six- to eight-week period. We noted if the treatments caused scorching of foliage, dieback of the cutting or lack of rooting. If any damage was recorded at temperature or time interval, it was determined to be unacceptable.

Hara noted in his work in Hawaii that 120° was the temperature that effectively killed mealybug, armored scale, aphids, whitefly and ants. He noted that 117° also killed pests, but it required longer treatment times of 30 minutes, which often caused injury on plants he tested.

The threshold that injury is incurred on several species of plants in our trial appears to be 120° (see chart 2). We found that 120° at 10- to 20-minute treatment times appears to be safe on azalea, ivy (Hedera sp.), boxwood (Buxus sp.), Leyland cypress (x Cupressocyparis leylandii) and ‘Green Giant’ arborvitae (Thuja ‘Green Giant’).

Treatment of insects and mites. Here are some findings based on hot water immersion trials conducted on pests at the University of Maryland Cooperative Extension (see chart 3):

Boxwood mite control. Boxwoods were obtained that had heavy populations of boxwood mite (Eurytetranychus buxi) eggs present and damage to 90 percent to 100 percent of the foliage from last season. Cuttings were taken from the plants, and 20 6-inch branch tips, taken randomly, were examined and the number of eggs recorded to establish a precount average number of eggs. Only eggs were present at this time of year because the boxwood mite overwinters as eggs. Because growers take cuttings for rooting during winter months, we felt this test was appropriate to evaluate whether the hot water treatment would kill the eggs.

On April 7, 2005, 6-inch cuttings were treated at 120° for 15 minutes. This temperature and length of treatment were chosen because this was the highest temperature and greatest length of time we could treat without causing damage to the plant cuttings. Plants treated at 120° for 15 minutes gave 100 percent control of boxwood mite. Plants treated at 115° for 15 minutes only had a little more than 60 percent control.

Fern scale control. Species of Liriope infested with fern scale (Pinnaspis aspidistrae) were used in the trial. Soil was removed from the root system before treatment in the hot water immersion system. Twenty Liriope plants were examined, and the amount of third-instar females present was recorded. This established an average number of scale per plant for the pretreatment count.

Plants were treated at 120° for 15 minutes and 115° for 15 minutes. Plants then were potted and placed under a mist system. Untreated control plants also were placed under mist. We found that 115° was not sufficient to kill the scale, but 120° for 15 minutes gave 99 percent control.

Miscanthus mealybug control. Container-grown Miscanthus infested with Miscanthus mealybug (Miscanthicoccus miscanthi) was obtained from a local grower. A precount was taken on 20 plants to establish an average number of overwintering mealybugs per plant. Plants then were taken out of the pots and the soil removed. Whole plants were treated at 120° for 15 minutes and 125° for 15 minutes on April 14, 2005. The plants were potted and placed under mist. Plants were examined on May 14 and the number of mealybugs counted. The mealybug hides between the leaf roles, and because this was destructive sampling, only one sampling could be taken. We found that treatment at 120° for 15 minutes gave a more than 99 percent level of control of Miscanthus mealybug. Treatment at 125° also worked with no damage to the plants; however, a grower only needs to reach 120° to control this pest.

Cottony taxus scale/cottony camellia scale control. Ten branch samples treated at 120° for 15 minutes and 10 branch samples with untreated control were compared. Post counts of hot water-treated plants gave a 99 percent or above level of control of this scale (Pulvinaria floccifera).

Where do we go from here? We believe the potential for using hot water treatments for reducing certain ornamental pests is strong. It may not control all pests, and some plants may be sensitive to the temperatures needed to kill pests, but these conditions can be established by continued research on temperature tolerance of additional species of plants.

We conducted trials on a couple of herb species and found that plants, such as tarragon (Artemisia dracunulus), could not withstand temperatures above 110° — the cuttings were cooked at this temperature. Sage (Salvia) only tolerated temperatures up to 112°, and rosemary (Rosmarinus officinalis) could take 120°, but for just 10 minutes. Growers are not likely to kill many pests at this lower temperature and shorter treatment interval. These findings are unfortunate because there only are a limited number of labeled chemical options for growers to use on herb crops.

On the bright side, we found that ‘New Guinea’ impatiens cuttings are very tolerant of 120° treatments for up to 20 minutes. One pest that damages ‘New Guinea’ impatiens is the cyclamen mite (Phytonemus pallidus). Other researchers have reported that treatment with hot water at 112° for 10 to 12 minutes kills cyclamen mites.

We plan to continue our work at the University of Maryland Cooperative Extension by expanding the list of species of plants tested to establish whether they can tolerate 120° temperature treatments and for how long.

We will be publishing a two-part fact sheet in early 2007 that explains how to build and operate the hot water immersion system. Until then, we will try to keep the heat on the pests, at least at the propagation stage.

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