

Growing Insect Free Plants with New Technology

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Dealing a blow to pest at the propagation stage

Can very warm water kills pests and make a nursery plant propagator happy and rich? Yes to the warm water killing pest and yes to the part about making nursery professionals happy . Whether you can 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 University based research in Hawaii and at the University of Maryland.

Many nursery plant propagators are anxious to adopt effective, cost efficient methods of non-chemically controlling pests. Concerns over worker's unnecessary exposure to chemicals has prompted many 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 look to other methods of dealing with pests. The idea of using hot water treatments to control pests on nursery cuttings is relatively simple but effective. Most pests of ornamental plants can survive at high temperatures but there is a temperature window at which insect pest die and at which plant material is tolerant.

Funding from Maryland Nursery and Landscape Association (MNLA) and the Northeast IPM (NEIPM) Group enabled us to build a portable hot water immersion system that is economical, relatively easy to construct and operate by nursery plant propagators. The system involves an instant hot water heater that rapidly heats water to the proper temperature and re-circulates the water around plant cuttings. Propagation plant material is placed in treatment mesh baskets and placed in a re-circulating hot water system. Growers are likely to adopt methods that are practical and easy to use – criteria which this system meets.

We tested multiple temperature and treatment times for 13 species of woody plant and herbaceous plant material and a couple of greenhouse species. We established threshold temperatures that cuttings of these species can be treated without suffering injury. We also

evaluated the impact of hot water treatment on 4 different insect and mites populations on plant cuttings taken.

Introduction

Nursery managers will propagate many species of nursery 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 or spider mites and broad mites. Growers strive to propagate from clean plant material but sometimes the pests are so small or the pest is found in cryptic parts on the plant that they go undetected.

In a mist chamber it is nearly impossible to apply insecticides since the foliage is being constantly syringed off by the frequent mist cycle needed to keep plant moist during the rooting stages. Systemic insecticide applied to substrate are not practical since the plants do not have roots to pull up the soil drench applied insecticides. Some nursery managers have resorted to dipping cuttings in dip tanks with pesticides in the hope of killing pest before they are moved into mist greenhouses for rooting. The problems with this approach is multi-fold: 1.) most pesticides are not labeled for this usage and therefore, they are no labeled rates and directions 2.) exposure risk to pesticides by employees dipping the plants is very high 3.) there is not a good way for owners to dispose of the remaining pesticide dip when the process is completed.

The idea of using hot water treatments to control pests is relatively simple but effective. Most pests of ornamental plants can survive at high temperatures but there is small temperature window at which insect pests die and at which plant material is tolerant. Dr. Hara at Hawaii University has tested the hot water bath method on a number of plant species and found that 49 °C (120.3 °F) for 1 –10 minutes gave effective control of several species insects including aphids, scale, mealybug, and mites on nursery plant cuttings. Hara tested hot water treatments on tropical plant material.

In our trials we established the threshold temperatures that temperate zone plant material can be safely treated with hot water and not damage the plant material. We need to also establish whether these hot water treatment temperature and length of treatment that are safe on plants also kills the pests.

For this project we worked with several Maryland nurseries in evaluating temperature ranges and length of treatment that are safe. We let the nursery managers select plant material that have known pest damaging them and commonly found on stock plants. Special thanks to the following nurseries for working closely with us in this project: Chesapeake Nursery, Woodland Nursery, Marshy Point Nursery, Ivy Farm and Hillcrest Nursery, the Perennial Farm, Bluemel Nursery, and Greenstreet Growers Greenhouses.

Hot Water as a Soil Drench to Control Soil Pests

In Ohio, Bob McMahon of Ohio State University 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 °F 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 °F without damage. New Guinea Impatiens tolerated even higher temperatures up to 150 °F without damage. McMahon

has applied 24 ounces of water to 6” pots, waited 3 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 up 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 re- circulated around the plant cuttings. The treated cuttings are then cooled using water at 50 -60 F, for 60 -120 seconds. The cuttings are then stuck as in normal propagating methods.

Objective – Develop an effective IPM tool for Nursery Managers

Our lofty goal was to build a device that is affordable (Under \$4000), portable and practical for treating large numbers of cuttings. The system we choose was based on a modified model developed by Dr. Arnold Hara of Hawaii University. The system uses an instant hot water heater and propane gas 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 re-circulating water to make sure the temperature is constant and even.

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

Design of the System

The hot water immersion system has two main systems. The first is the water heating system with the instantaneous water heater and its water and gas supplies that provides the hot water for the immersion tank. Thermometers, control valves and pressure gauges are part of the system to monitor and to help achieve the hot water necessary. The second system centers around a pump that circulates the water in the immersion tank through pipes and risers with nozzles to 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 might be recycled to the heater.

Certain considerations for the design 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 initially fill the immersion tank and the amount of hot water available to maintain a given temperature. Since 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 water temperature 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.

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 should work. For the purpose of clarity, the brand name and model numbers of the actual equipment used to build the system will be 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 unit, a Paloma Automatic Gas Water Heater Model PH-24M-DP for propane gas was used. The unit has a rated input of 178,500 BTU/hr on high and a 37,700 BTU/hr rate at half way on. This translates into a 90° F rise in water temperature at a water flow rate of 3.17 gpm on high burner rate and a 100° F rise in water temperature at a water flow rate of 2.85 gpm on high burner rate. This is important design information because this is the maximum water heating rate for the system. Other data to note is that a water pressure of 12.9 psi is required to push the water through at the high rate of heating. This pressure differential is required for the flow control valve of the heater to work properly. The section on operating the system will illustrate this.

The instantaneous 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 is used.

System Operation

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

It is much more efficient to start at the high 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, and be above the blue suction line for the circulation pump.

Temperature stabilization is important.

Use of 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 pump motor.

Establishing Killing Temperatures for Insects and mites

Hara, in his research work on hot water immersion, placed plant cuttings into a netted cage and the plant material. He preconditioned the plant material by holding the cuttings at 40 °C (104 F) for up to 15 minutes. The plant cuttings and net holding chamber is removed and the temperature is then raised to 49 °C (120 °F) for 8 –12 minutes. After the disinfecting treatments at 49 °C the plants are then cooled to ambient air temperatures which was approx. 24 °C (74 °F) for 5 – 6 minutes. The cuttings are then stuck into a mist chamber.

Hara noted that hot water treatment at 49 C (120 F) kills the following pests:

Insect (treated with hot water)	Temperature in Centigrade and Fahrenheit	Time to obtained >99% mortality
Ants	49	0.5 minutes
Aphids (banana and cotton)	49	1.0 minutes
Taro root aphid (on roots)	49	5.5 minutes
Cockerell scale	49	8.0 minutes
Green Scale	49	10.0 minutes
Mealybug (Obscure and Citrus)	49	12.0 minutes
Spiraling whitefly	49	12.0 minutes
Root mealybugs (potted)	46	Variable due to density of root ball

Testing out the System Performance

We set up tests to evaluate the hot water re-circulation system when under a working load of cuttings. We quickly found out that if we brought the temperatures up to the desired temperature and then inserted cages holding the cuttings the water temperature dropped. We experimented with heating up the water in the stock tank to higher temperatures then slowly lowering the temperatures. Through repeated trials we found that it is best to run the temperatures up to 145 – 150 °F for at least 30 minutes to heat up the stock tank and the surrounding insulation. In the colder weather of the winter it may require up to 45 - 60 minutes to adequately heat up the tank. We also raised the temperature one degree warmer than the target temperature to compensate for the lowering of the temperature when the cutting baskets were lowered into the treatment tank.

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

Temperature Adjustment and Treatment Cages

To improve the ease of placing and removing the cuttings easily into the tank we constructed large cages of 18" X 18". We found 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 were 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" X 12". Since the cages were made of PVC plastic pipe they tend to float up in the tank. We drilled holes into the PVC pipe so the cages sank into the water in the tank. These smaller cages appeared to fit the cuttings better with fewer floating out in the main body of treatment tank.

We were able to fit up to 6 of these cages into the stock tank during a treatment. The plastic mesh used to cover the cages had a 3/4" opening to allow the water to flow through the cage. This 3/4" opening net opening worked well for most of the woody cuttings with very few cuttings escaping. When testing the herbs we had to place the cuttings into finer silk mesh bags and place them in the cages to keep them from escaping from the cage into the stock tank.

Plant material tested in 2004 - 2006

Each treatment temperature and time interval had 5 replications. Immediately after being taken out of the hot water treatments the cuttings were moved into water at 65-70 F for a cool down period of 5 minutes. Cuttings were then immediately stuck into substrate and placed under a timed interval mist system. Cuttings were observed over a 6 – 8 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.

In the chart we report the lowest temperature and time interval that did not cause burning , dieback or lack of rooting of the cuttings. Hara noted in his work in Hawaii that 49 C (120F) was the temperature that gave effective kill of mealybug, armored scale, aphids, whitefly and ants. He noted that 46 F (117 F) also killed pest but required longer treatment times of 30 minutes which often caused injury on plants he tested in Hawaii.

120 F appears to be the threshold above which injury is incurred on several species of plants in our trial. We found that 120 F at 10 -20 minute treatment times appears to safe on Azalea, Ivy (*Hedera* spp), Boxwood (*Buxus* spp), Leyland cypress, and Arborvitae (*Thuja*) ‘Green Giant.’

Nursery supplying plant material	Plants used in trail and month tested	Highest temperature plants will tolerant	Greatest length of treatment time without damaging plant material	Additional comments
Marshy Point Nursery	Azalea ‘Rosebud’, Plants treated August 13 th	120 °F	10 minutes	At 120 F for 15 minutes caused 50% treated plants foliage to scorch
Ivy Farm, Eastern Shore of Virginia	<i>Hedera helix</i> ‘Wingertsburg’	120 °F	15 minutes	At 20 minutes 75 % of plants were scorched
	<i>Hedera helix</i> ‘ Marginata of	120 °F	20 minutes	125 F at 10 minutes or more

	Hibbard'			caused scorching of foliage
	<i>Hedera colchica</i> Plant treated in April	120 °F	15 minutes	At 20 minutes 25% of foliage was scorched. Treatment at 125 F for 10 minute caused 20% foliar injury. At 125 F for 15 minutes or more caused over 50% foliar scorching.
Chesapeake Nursery	<i>Cotoneaster dammeri</i> 'Coral beauty' Treated: June 6 2004	120 °F	10 minutes	At 115 F the plants can stand up to 20 minutes with no damage to foliage
	Viburnum 'Shasta' Treated June 6	120 °F	10 minutes with 30% of plant showing leaf scorch	Plants treated at 155 F can tolerate 20 minutes with no injury
	<i>Ilex crenata</i> 'Convexa' Treated June 6	115 °F	10 minutes with 40% of plants damaged	Not very tolerant of treatments
	<i>Pieris japonica</i>	120 °F	20 minutes	Less than 20 % foliar injury and all cutting survived.
Woodland Nursery	<i>Buxus sempervirens</i> 'Rotundifolia' Treated in August	120 °F	15 minutes	At 125 F for 10 minutes 70% of plants dead
Hillcrest Nursery	Sage	112 °F	20 minutes	At 115 F for 15 minutes 10% of plants dead, at 20 minutes 50% dead
	Tarragon	110 °F	0 minutes	At 110 F al plants died regardless of length of treatment. Tarragon appears to very heat sensitive
	Rosemary	115 °F	10 minutes	At 115 F for 20 minutes plant ok

Bluemel Nursery of Harford County And The Perennial Farm of Baltimore County	<i>Miscanthus sinensis</i>			
CMREC Nursery plants	Leyland cypress	120 °F	15 minutes	120 F for 20 minutes suffered >40% damage. Higher temperature caused 100% death
	<i>Thuja</i> 'Green Giant'	120 °F	10 minutes	Plant looks good for 2 weeks then browning and dieback occurred on anything above 120 F or times treatment times of 15 minutes or longer
Greenstreet Growers of Lothian, Annapolis	New Guinea impatiens	120 °F	20 minutes	Plant cuttings appears to very tolerant of 120 F treatment

Treatment of insects and mites

Boxwood mite, *Eurytetranychus buxi*, control

Boxwoods were obtained that had heavy population of boxwood mite eggs present and damage 90 -100% of the foliage from last season. Cuttings were taken from the plants and 20 six 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 since the boxwood mite overwinters as eggs. Growers take cuttings during the winter months for rooting cuttings. We felt this was appropriate to evaluate whether the hot water treatment would kill the eggs. On April 7, 2005 6" cuttings were treated at 120 F for 15 minutes. This temperature and length of treatment was chosen since this was the highest temperature and greatest length of time we could treat without causing damage to the plant cuttings in previous temperature phytotoxicity trials. The level of control

of boxwood mite at 120 F for 15 minutes gave 100% control on the treated plants. Plants treated at 115F for 15 minutes only had a little over 60% control.

Fern Scale control

Liriope plants 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 recorded the number of 3rd instar females present. This established an average number of scale per plant for the pre-treatment count.

Plants were then treated at 120 F for 15 minutes and 115 F for 15 minutes. Plants were then potted and placed under a mist system. Untreated Control plants were also placed under mist. 115 F was not sufficient to kill the scale but 120 F for 15 minutes gave 99% control.

Miscanthus mealybug

Container grown miscanthus plants infested with miscanthus mealybug, *Miscanthicoccus miscanthi*, were obtained from a local grower. A pre-count was taken on 20 plants to establish an average number of overwintering mealybugs per plant. Plants were then taken out of the pots and the soil removed and whole plants were treated at 120 F for 15 minutes and 125 F for 15 minutes on April 14, 2005. The plants were then potted and placed under mist. Plants were examined one time on May 14 and number of mealybugs counts. The mealybug hide between the leaf roles and since this was destructive sampling only one sampling could be taken. The treatments of 120 F for 15 gave above 99% level of control of miscanthus mealybug. The 125 F also worked with no damage to the plants but a grower really only needs to reach the 120 F temperature to control this pest.

Chinese Holly – Cottony Taxus/camellia scale, *Pulvinaria floccifera*, control

Ten branch samples were treated at 120 F for 15 minutes and 10 untreated control were compared. Post counts of hot water treated plants gave 99 % or above level of control of this scale.

Summary of trials results conducted by University of Maryland

Insect (treated with hot water)	Temperature in Centigrade and Fahrenheit	Time to obtained >99% mortality
Boxwood mites	49 C (120 F)	15 minutes
Miscanthus mealybug	49 C (120 F) * can tolerant 51 C (125 F)	15 minutes
Cottony Taxus/camellia scale	49 C (120 F)	15 minutes
Fern scale	49 C (120 F)	15 minutes

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 pest but this 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 could not withstand temperatures above 110 F and basically cooked the cuttings at this temperature. Sage only tolerated temperatures up to 112 F and Rosemary could take 120 F but for just 10 minutes. Growers are not likely to kill many pest at this lower temperature and shorter treatment intervals. This is too bad since there are only a very 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 F treatments for up to 20 minutes. One of the major pest group that damage New Guinea impatiens is broad and cyclamen mites. Other researchers have reported that treatment with hot water at 112 F for 10 -12 minutes kill cyclamen mites.

We plan to continue our work at the University of Maryland and expand the list of species of plants tested to establish whether they can tolerate 120 F temperature treatments and for what length of time. We believe we have a machine that is fairly economical to build and fairly user friendly with a little practice.

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 up on the pest, at least at the propagation stage.

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