IPM for Nurseries:
A Non-Chemical Control of Insects and Mites on Nursery Propagation Plants

By

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Hot water – Boiling your pest

Most nursery and greenhouse managers would love to have the chance to beat out pests before they build up to damaging levels. Greater regulation on the use of chemical pesticides has created an opportunity to look to other methods of dealing with 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. Quite often a stock plant can have an infestation of spider mites, scale, mealybug or lace bugs present. When cuttings are taken off these stock plants the pest often goes with the cutting. Some nursery managers have tried dipping cuttings in tanks with diluted pesticide concentrations with varying results. We are investigating whether plant cuttings can be suspended in water heated to temperatures to kill insect or mite but not damage the plant material. If this treatment works then nursery managers would be starting with clean plant material that is unencumbered by pest populations.

Can this work?

Can hot water really help nursery managers control pest populations on cutting plant material? Research work conducted in Hawaii indicates that plant material infested with insects and mites can be submerged in hot water for short durations and effectively control plant pests without injuring the plant material. Hot water treatments may offer nurseries involved with plant propagation a safe method of controlling pests without pesticide applications.

Pest management has become increasingly challenging for nursery managers. Concerns over owners' and workers' 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 pesticide applications. The problem is often small insects and mites present on the cuttings go undetected at the propagation stage, resulting in pest outbreaks when plants are moved to nursery benches or production greenhouses. Pests carried through the plant propagation phase must be detected rapidly, before populations build to severe damaging levels and treated with applications of insecticides to prevent damage to the plant materials.

Alternative, non-chemical control tactics have been examined and found to be successful for insects in Hawaii. For example, hot-water immersion has been used successfully in controlling root mealybug, *Rhizoecus falcifer*, (Hara, 2000 - SAF Conference), green scale, *Coccus viridis (*Hara, et al., 1994), and Pseudaulacaspis *cockerelli* (Hara, et al., 1993).

The idea is relatively simple but effective. Most pests of ornamental plants can survive at high temperatures but there is a 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 8 – 10 minutes gave effective control of several species of scale, mealybug, and mites on nursery plant cuttings.

Grant money funds alternative method of controlling pest

Grant money was provided by the Maryland Nursery and Landscape Association, USDA CREES IPM funds, and the Virginia Nursery Association funding to build and conduct trials with nurseries using a portable hot water re-circulation system that can be used to safely and quickly kill insect pests on plant material in the propagation stage. The purpose of this report is to keep each of the funding contributors informed of the progress of this program.

Our Goal

Our lofty goal was to build a device that is affordable (Under $3000), portable and practical for treating large numbers of cuttings. The system we choose was based on a modified model developed by Arnold Hara of the University of Hawaii. 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.

Phases of the Project

We completed phase one of the project, building the system, in 2003. The new portable re-circulation system was unveiled at the CMREC University of Maryland evening field day for nursery managers on July 2, 2003. Phase two conducted in 2004 involved working with several Maryland nurseries and greenhouse operations in testing out the system on several plant species to see what temperatures plants can tolerate but plant pests cannot. Phase three will involve testing the temperatures on major nursery pests.

Building of the System

Keeping the device simple and made from material readily available was a primary goal. We chose to use materials that are available from local suppliers or ordered from a supplier with very little modification. The old adage "Keep it simple" was our motto. The building of the system basically involved building a hot water whirlpool for plant material.

A 100 gallon animal stock tank was purchased and a plywood wooden box was constructed around the tank and fiberglass. Polystyrene insulation was placed in between the box and the tank to help hold the temperature even in the tank. The insulated box was coated with paint to make it weatherproof. An instant hot water heater was used to heat the water to the desired temperature. The hot water heater was the most expensive part of the system purchased. The trailer that the tank and heater were placed on was the next most expensive part. The system could be built as a stationary device but we decided that most nursery managers would want the system to be portable so they could move it to the area where they want to use it and then store it away at other times of the year.

Proper water 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 values. 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 value 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.

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 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 (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 Systems 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 ¾" opening to allow the water to flow through the cage. This ¾" 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.

Testing out the Tolerance of Plant cutting to Treatment with Hot water Immersion
Nurseries we worked with in 2004

Special thanks to the following nurseries for working closely with us in this project: Chesapeake Nursery, Woodland Nursery, Marshy Point Nursery, The Ivy Farm and Hillcrest Nursery.

Plant material tested in 2004

Each of the plant species listed in this chart were treated using the hot water immersion system. Treatment temperatures were 135 °F, 130 °F, 125 °F, 120 °F, 115 °F and 110 °F. Treatment times were 10, 15 and 20 minutes. In preliminary trials we found that herbs we tested were all damaged at the higher temperatures so we lowered the temperature treatments in the second trial. Treatment made for the herbs was 125 °F, 122 °F, 120 °F, 118 °F, 115 °F, 112 °F and 110 °F. 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 (120 °F) 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.'

Supplier	**Plants used in trail and month treated**	**Highest temperature plants will tolerate**	**Greatest length of treatment time without damaging plant material**	**Additional comments**
Marshy Point Nursery	Azalea 'Rosebud', Plants treated August 13th	120 °F	10 minutes	At 120 F for 15 minutes caused 50% treated plants foliage to scorch
Ivy Farm, Eastern Shore of Virginia	Hedera helix 'Wingertsburg'	120 °F	15 minutes	At 20 minutes 75 % of plants were scorched
	Hedera helix ' Marginata of Hibbard'	120 °F	20 minutes	125 F at 10 minutes or more caused scorching of foliage
	Hedera colchica 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	Cotoneaster dammeri 'Coral beauty' Treated: June 6 2004	115 °F	20 minutes	At 120 F for 10 minutes, 30% of plants showed leaf scorch.
	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
	Ilex crenata 'Convexa' Treated June 6	115 °F	10 minutes with 40% of plants damaged	Not very tolerant of treatments
Woodland Nursery	Buxus sempervirens '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 - plants ok

CMREC Nursery plants	Leyland cypress	120 °F	15 minutes	120 °F for 20 minutes suffered >40% damage. Higher temperature caused 100% death
	Thuja 'Green Giant'	120 °F	10 minutes	Plants looked good for 2 weeks then browning and dieback occurred on anything above 120 °F or treatment times of 15 minutes or longer

Preliminary test in 2004 using 20 azalea cuttings infested with nymphs, adults and eggs.

We conducted a preliminary test to see the impact on an insect pest. We obtained azalea cuttings infested with nymphs, adults and eggs of azalea lace bugs. The plant material was placed in the hot water immersion system for 10 minutes at 120 F. This was the maximum temperature and time interval recorded that did not cause injury to azalea foliage.

Pre-counts and post counts were taken on the cuttings. The hot water treatment washed off and killed all nymphs and adult lace bug. This impact was immediate and very encouraging. This was not so with the impact on the eggs. The eggs remained inserted in the foliage. When cutting were placed in the University of Maryland greenhouses the number of eggs hatching on foliage was observed. There was no real differnece noted in egg survival in treated and untreated cuttings.

Nursery supplying plant material:	**Plant material used in trial and month tested**	**Temperature**	**Treatment time**	**Comments:**	**Comments**	**Comments**
Plants obtained from source in Clarksville, MD	Azalea 'Rosebud' July	120 °F	10 minutes	All nymphs and adults washed off cutting and dead by end of treatments		No foliar injury to foliage

July 18, 2004

Obtained 20, 6" cuttings of azaleas infested with naturally occurring population of nymphs, adults and unhatched eggs of lace bugs. 10 cuttings were tagged and were treated at 120 °F for 10 minutes. Pre counts were taken and post counts of nymphs and adults after treatment. Plant cutting were placed in mist house at University of MD greenhouses and number of eggs hatching were observed and recorded 4 weeks after sticking. If eggs were unhatched after 4 weeks they were assumed to be dead.

T=Treated at 120 °F for 10 minutes
C= Control – no treatment

Treatment	Pre-treatment # of adult	Pre-treatment # of nymphs	Pre-treatment # of unhatched eggs	Post-treatment # of adults	Post-treatment # of nymphs	Post treatment # of eggs H=hatched U=unhatched
T1	3	4	11	0	0	H = 9 U = 2
T2	5	3	0	0	0	0
T3	1	4	15	0	0	H = 14 U = 1
T4	7	2	22	0	0	H = 14 U = 6
T5	12	5	0	0	0	0
T6	5	2	0	0	0	0
T7	8	3	17	0	0	H = 15 U = 2
T8	4	3	14	0	0	H = 14
T9	3	3	8	0	0	H = 4 U = 4
T10	2	4	8	0	0	H= 2 U= 6
C 11	11	5	24	11	5	H= 19 U =5
C 12	9	2	16	9	2	H= 16
C 13	5	3	0	4	3	0
C 14	3	2	0	2	2	0
C 15	9	3	17	9	3	H=13 U=4
C 16	7	2	15	5	2	H = 13 U= 2
C 17	10	5	25	10	5	H= 24 U = 1
C 18	6	3	14	6	3	H = 8 U = 6
C 19	3	2	11	3	2	H = 11
C 20	7	3	30	7	3	H= 25 U= 5

What we will test in March of 2005:
Miscanthus – supplied by Perennial Farm Nursery and Homestead Nursery - to be treated in late March of 2004. Perennial Farm Nursery will supply *Miscanthus purpurescens* infested with miscanthus mealybug. Treat at 125 °F, 120 °F, 115 °F, and 110 °F for 10, 15, and 20 minute treatments.

Greenstreet Growers will supply New Guinea Impatiens cuttings and Lantana cuttings. We will test this plant material out 125 °F, 120 °F, 115 °F and 110 °F for 10, 15 and 20 minute treatments.