2004 Northeast IPM Project
Progress Report

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Reducing Pesticide Inputs in Nurseries Using a Portable Hot Water Immersion System

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B. Non-technical Summary:

Nursery managers are anxious to adopt effective, cost efficient methods of non-chemical control of pests. Concerns about 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 that frequently 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 then treated quickly with applications of insecticides to prevent damage to the plant materials.

This project involves controlling nursery pests early in the production cycle to reduce the need for pesticide inputs. In many cases nursery managers take cuttings from stock plants that have insects and mites present, often at levels undetectable to the grower. Growers place cuttings in mist systems where pest populations can survive and continue to increase as the plants move through the production cycle. Pest populations often build to levels that require the manager to apply repeated pesticide applications to bring the pest situation under control. Our method of treating plant cutting material with hot water at set temperatures and treatment times before it is moved to the propagation stages will control several of the major pests of nursery plants. This non-chemical system will reduce the pest population and reduce the pesticide inputs needed to produce a quality nursery plant.

We have built a mobile, insulated tank with controlled hot water re-circulation system that works in temperate regions to treat pests on nursery plants at the propagation stage. We have been working with Maryland nurseries to establish what temperature and length of immersion that different species of nursery plants can tolerate without interfering with the propagation of the plant. The temperatures and length of treatment needs to be evaluated on plant material commonly grown in nurseries in the continental United States.

C. Introduction:

Nursery managers 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. Such a stock plant may have a small infestation of insects or mites such as scale, mealybugs, thrips, aphids or spider mites and broad mites that are difficult to detect. Growers strive to propagate from clean plant material but sometimes the pests are so small or are hidden 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 insecticides applied to substrate are not practical since the plants do not have roots to take up the soil drench applied insecticides. 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 problems with this approach are multi-fold: 1.) Most pesticides are not labeled for this usage and therefore, there are no labeled rates and directions 2.) Exposure risk to pesticides by employees dipping the plants is very high 3.) There is no good way for owners to dispose of the remaining pesticide dip when the process is completed.

Plant cuttings can hide pest populations that are not easily detectable. These pests survive through misting and rooting stages. As a consequence, the plants start out with an established pest population as they are moved into the production area of the nursery or greenhouse. Growers need an alternative method of insuring that the plant material is clean of pests before they go under a mist system. Reducing or eliminating pests on plants in the rooting stage reduces the chance that a grower will need early applications of insecticides once the plants are moved into the growing facility, assuming they keep the growing area relatively free of pests.

The idea of using hot water immersion 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 while the plant material is tolerant. Dr. Arnold 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 materials.

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 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.

D. Objectives

1. Work with Maryland nursery and greenhouse operations in investigating a non-chemical method of killing pests on woody and herbaceous plant material that is vegetatively propagated.

We worked with eight nurseries and greenhouse operations in testing out the hot water immersion recirculation system.

2. Establish guidelines for optimum temperatures for several plant species that will kill insects but allow plant material to be unharmed.

We developed chart of plant material tested which lists the temperature threshold levels for plants tested.

3. Work with nursery plant propagators in evaluating the most effective method in using the hot water immersion system on plant material used in nursery propagation that will not damage propagation plant material but effectively kills insects.

Some of the treated cuttings were returned to growers for them to evaluate further.

4. Increase nursery plant propagators adoption of alternative methods to control pests as part of an IPM approach.

This system has been demonstrated at a nursery field day.

E. Approach (1 – 2 paragraphs, describe your approach, the methods used, and the overall design of your project)

Our goal was to build a device that was affordable (Under $4000), portable and practical for treating large numbers of cuttings. The system we chose was based on a modified model

developed by Arnold Hara of Hawaii University. The system uses an instantaneous water heater and propane gas for the energy source. Hot water is circulated through a 100-gallon stock tank and plant material is immersed into the water in PVC netted cages. Temperatures are monitored as a pump circulates the water through the tank. A thermometer displays temperature so the operator can make necessary adjustments maintain a constant temperature.
We investigated various temperatures and length of time of plant cutting were immersed in the hot water treatment. Plants and a specific pest were evaluated determined on the needs of each grower. Plant material cuttings were treated at 110 °F, 115 °F, 120 °F, 125 °F, and 130 °F for 5, 10, 15 and 20-Minute immersion treatments. A data logger was used to record the water temperature to determine how well the test temperature is maintained. Once a maximum temperature and length of immersion time that do not cause plant damage has been established for each crop, we investigated whether these temperatures reduce or eliminate the insect pests.

F. Progress

We conducted tests to evaluate the hot water re-circulation system using woody and herbaceous cuttings. 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. A temperature of 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 be safe on Azalea, Ivy (Hedera spp), Buxus sempervirens ‘Rotundifolia’, Cotoneaster dammeri ‘Coral Beauty’, Pieris japonica, Miscanthus sinensis ‘Adagio’, Viburnum tomentosum ‘Shasta’, Leyland cypress, and Arborvitae (Thuja) ‘Green Giant.’ Using this plant tolerance data, we conducted additional tests to determine whether the maximum plant tolerance temperature for a particular plant species would control an insect pest. We tested out the hot water bath system on boxwood mite (Eurytetranychus buxi) on boxwood, Miscanthus mealybug (Miscanthiococcus miscanthi) on miscanthus, cottony camellia taxus scale (Pulvinaria floccifera) on holly and fern scale (Pinnaspis aspidistrae) on liriope.
During our testing, 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.

G. Results

We worked closely on this project with: Chesapeake Nursery, Woodland Nursery, Marshy Point Nursery, Ivy Farm (Virginia) and Hillcrest Nursery, the Perennial Farm, Bluemel Nursery, and Greenstreet Growers Greenhouses.
We looked 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 were 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.

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 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

Plant material tested in our trials
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.’

Chart of temperatures and time intervals at which plant material can be safely treated usin gth ehot water immersion system:

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 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 colchicaPlant 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 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 Plants treated at 115 °F can tolerate 20 minutes with no injury
Ilex crenata ‘Convexa’Treated June 6 115 °F 10 minutes Not very tolerant of treatments
Pieris japonica 120 °F 20 minutes Less than 20 % foliar injury and all cutting ssurvived.
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 plant ok
Bluemel Nursery of Harford CountyAnd The Perennial Farm of Baltimore County Miscanthus sinensis 120 F 20 minutes
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 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 New Guinea impatiens 120 °F 20 minutes
Treatment of insects and mites

Boxwood mite control using hot water treatments
Cuttings from boxwood plants infested with eggs of boxwood spider mite were treated in the hot water bath to compare two time / temperature regimes (20 minutes at 115°F and 15 minutes at 120°F) to each other and to a control (no hot water bath treatment). There were significant differences in the number of active boxwood mites on boxwood cuttings receiving the various treatments two weeks following treatment application ($F = 121.9$; $df = 2, 12$; $P = <0.0001$; Proc Mixed, SAS Institute 2001). Hot water bath treatments significantly reduced the number of active boxwood spider mites (mean ± SEM) on boxwood cuttings (20 minutes at 115°F: 3.8 ±

0.7; 15 minutes at 120°F: 0.8 ± 0.49) compared to the untreated control plants (15.5 ± 6.92). In addition, cuttings treated for 15 minutes at 120°F in the hot water bath had fewer active mites than those treated for 20 minutes at 115°F. Hot water bath treatments dramatically reduced boxwood spider mite activity. This trial shows that the hot water treatment has potential for use in controlling boxwood mite on vegetative cuttings of boxwood.

Fern Scale control
Liriope plants were obtained from Landscape Contractor's of Annapolis for this trial. Soil was removed from the root system before treatment in the hot water immersion system. We examined twenty liriope plants 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. The data is still being analyzed to see if the treatment with hot water immersion was effective.

Miscanthus mealybug
Container grown infested miscanthus plants were obtained from a Maryland nursery. 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. Whole plants were treated at 120 °F for 20 minutes and 125 °F for 20 minutes on April 14, 2005. The plants were then potted and placed under mist. Plants were examined on May 14 and the number of mealybugs were counted. Since mealybugs hide between the leaf rolls, this was destructive sampling so only one sampling could be taken. The data is still being analyzed to see if the hot water immersion treatment with was effective.

H. Impacts
Safeguarding human health and the environment
Treatment of vegetative plant material with water heated to a pre-determined temperature level is a non-toxic method of controlling nursery pests. We have shown that a hot water recirculation immersion system can be built for under $4000 and can be operated using propane fuel as an economical and practical method of dealing with insect and mite pests.

Through our trials with the hot water circulation immersion system we have established threshold temperatures for treating vegetative plant material used in the nursery and greenhouse industry. We have provided a chart of upper threshold temperatures and treatment times for 13 plants.
Our trial to evaluate the efficacy of hot water treatments for control of boxwood mite has shown that treatments of 15 minutes at 115°F significantly reduced the spider mite population without additional chemical treatments.

This project builds on the data generated by Arnold Hara in Hawaii who published on temperatures and lengths of treatment to control 8 major pests of tropical nursery plant material. The data from our treatments of fern scale and Miscanthus mealybug is still be analyzed at this time.

Economic benefits

Since the hot water circulation immersion system does not use expensive chemicals to control the pest the savings to growers should be significant. The system provides growers with a non-chemical method so they can start with relatively pest-clean plants and delay the need for pesticide applications. The easy disposal of the hot water at the completion of treatment provides a very positive impact for the environment. The growers that worked with us in the trial felt that the system was useable and practical for use in a typical nursery environment.

Implementation of IPM

The University of Maryland Cooperative Extension will publish a fact sheet on how to build and use the hot water circulation immersion system. We presented the results of the trial at the Maryland Nursery and Landscape Association field day at Environmental Concern Nursery in June of 2005. As a result three plant propagation nurseries expressed interest in trying the system at their nursery. We were also invited to present the results of the trial as a poster at the National Plant Propagator’s conference in October of 2005. We will also present a talk on the system at the 2006 Plant Propagator’s Conference to encourage adoption of this IPM technology. We will encourage growers to adopt this technology through presentations at professional meetings, publication of a fact sheet, posting of information on our IPMNET web pages, and through articles published in the popular literature.