HOT WATER DRENCH TREATMENT FOR CONTROL OF RENIFORM NEMATODES IN POTTED DRACAENA

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ABSTRACT

R. Y. M. Cabos, A. H. Hara, and M. M. C. Tsang. 2012. Hot water drench treatment for control of reniform nematodes in potted dracaena. Nematropica 42:72-79.

A continuous hot water drench treatment was evaluated for disinfesting potted dracaena of reniform nematodes, *Rotylenchulus reniformis*. Modifications were made to a hot water shower container to allow the delivery of a continuous stream of hot water directly to the media and roots of infested plants. Reniform nematodes were successfully eliminated in dracaena of marketable age treated at 50°C for 10 minutes or longer. No evidence of thermal damage was observed on plants drenched with hot water even at 52°C for 14 minutes. Continuous drenching for 15 minutes at 50°C is recommended to ensure effective penetration of water through the media.

Keywords: Dracaena, Drenching, Hot water, Potting media, Reniform nematodes, *Rotylenchulus reniformis*

RESUMEN

R. Y. M. Cabos, A. H. Hara, and M. M. C. Tsang. 2012. Tratamiento con agua caliente para el control de nematodo reniforme en dracaena en macetas. Nematropica 42:72-79.

Se evaluó un tratatmiento con agua caliente para tratar dracaenas en macetas contra el nematodo reniforme, *Rotylenchulus reniformis*. Se modificó una ducha de agua caliente para permitir el flujo contínuo de agua caliente directamente sobre el medio de cultivo y las raíces de las plantas. El tratamiento de dracaenas de edad mercadeable a 50°C durante 10 minutos ó más permitió la eliminación exitosa del nematodo reniforme. No se observó evidencia de daño térmico en las plantas tratadas aún a 52°C durante 14 minutos. Se recomienda el tratamiento contínuo durante 15 minutos a 50°C para asegurar la penetración efectiva del agua a través del medio de cultivo.

Palabras clave: Agua caliente, Dracaena, Medio de cultivo, Nematodo reniforme, *Rotylenchulus reniformis*

INTRODUCTION

Reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira, 1940) is an invasive pest of regulatory importance due to its detrimental effect on host crop yields. Areas without *R. reniformis* have implemented quarantine restrictions to prevent its introduction. For example, California considers reniform nematode an A rated quarantine pest because of its potential to damage their cotton (*Gossypium* sp.), tomato (*Solanum lycopersicum*), and ornamental industries (Chitambar, 2007). Foliage and landscape nurseries within infested regions must certify their products are free of plant-parasitic nematodes before export. Propagating plant material by seed or cuttings, using sterilized potting media, growing out plants on benches, and good sanitation practices are typically sufficient for preventing nematode contamination. However, if infestation does occur, no post-plant disinfestation options exist. The use of chemical disinfectants and nematicides are prohibited by the U.S. Environmental Protection Agency due to the health hazard that exists for workers and quarantine inspectors, and its adverse effect on the environment. A safe and environmentally friendly alternative is needed and the utilization of hot water has potential.

Hot water dips and showers have been employed to eradicate insect pests of quarantine importance. Immersion of tropical flowers at 49°C successfully eliminated scales, aphids, ants, and mealybugs (Hara *et al.*, 1993; Hara *et al.*, 1994; Hara *et al.*, 1996; Hara and Jacobsen, 2005). An inexpensive hot water immersion unit was designed for disinfesting tropical cut flowers and foliage (Tsang *et al.*, 1995) and is currently in use

by packing houses in Hawaii. A commercial-scale hot water shower container is being utilized to treat potted foliage plants for quarantine pests such as coqui frogs, nettle caterpillars, snails, slugs, scales, mealybugs, and whiteflies (Hara *et al.*, 2010; Hara, unpublished data).

Plant-parasitic nematodes have historically been eradicated from bulbs and planting rootstocks through the use of hot water dips. Staniland (1953) optimized a hot water bath for treatment of strawberry runners (*Fragaria* × *ananassa*) at 45°C for 9 minutes to control *Ditylenchus dipsaci* (Kühn) Filipjev (stem nematode). Birchfield (1954) found hot water at 50°C for 10 minutes could eradicate *Radopholus similis* (Cobb, 1893) Thorne, 1949 (burrowing nematode) in citrus roots (*Citrus reshni* and *Citrus jambheri*). In Hawaii, hot water dips at 50°C for 10 minutes are recommended for disinfesting ginger rhizomes (*Zingiber officinale*), anthurium cuttings (*Anthurium andreanum*), and banana suckers (*Musa acuminata*) of plant-parasitic nematodes before replanting (Nishina *et al.*, 1992; Higaki *et al.*, 1995; Wang and Hooks, 2009).

Dipping potted plants in hot water baths is inefficient because the conduction of heat through the media is slow and the long exposure time would likely damage the plant. Alternatively, continuous drenching with hot water results in a rapid increase in temperature as the water flows quickly through the media (Tsang *et al.*, 2001). Tsang *et al.* (2001) compared treating seifrizii palms (*Chamaedorea seifrizii*) by continuous drenching with immersing plants, potted or bare rooted, in hot water baths. Although bare root treatment resulted in 100% mortality of *R. similis*, it is too labor intensive for a commercial operation. Immersing the entire pot in a hot water bath killed 93% of the nematodes, but was not sufficient for complete eradication which is a requirement for any quarantine treatment. Continuous hot water drenches for 15 minutes at 50°C completely eliminated all burrowing nematodes in the roots and media. Tsang *et al.* (2004) also found that drenching potted anthurium was as effective as hot water baths on bare-rooted plants. Similar results with continuous drenching that resulted in 100% mortality of *R. similis* were seen in bamboo palms (*C. seifrizii*), fishtail palms (*Caryota mitis*), and rhapis (*Rhapis excelsa*) (Tsang *et al.*, 2003; Arcinas *et al.*, 2004). The purpose of this study was to evaluate the effectiveness of continuous hot water drenching on potted dracaena (*Dracaena deremensis*) infested with *R. reniformis*.

MATERIALS AND METHODS

System Description

A recirculating hot water shower quarantine treatment system designed by the University of Hawaii at Hilo and University of Hawaii at Manoa College of Tropical Agriculture and Human Resources staff (Hara and Tsang, unpublished) was modified for the continuous hot water drench experiments (Fig. 1). A refrigerated freight container 7.3 m x 2.4 m x 2.6 m (L x W x H) fitted with several rows of spray nozzles served as the treatment chamber. The container was mounted on a 12.2 m trailer with a 3.4 m deck which holds three instant hot water heaters, control system, pumps, propane tanks, and a generator (Fig. 2). For its designed use as a shower treatment, water was delivered at 265 L/min (70 gpm) at 276 kPa (40 psi) through 110 full cone nozzles (2.5 L/min each) at 43° - 49°C to treat foliage plants for insects, coqui frogs, geckos, nettle caterpillars, and slugs (Hara *et al.*, 2010). For this experiment, the overhead and first 2 rows of side nozzles in the treatment chamber were turned off. The bottom row of nozzles were removed and replaced with short lengths of water hoses (41 cm) to deliver hot water to flood the potting media (Fig. 3). Each pot received approximately 8.9 L of hot water per minute. The flow rate was sufficient to ensure continuous drenching of the media and root mass in the pots.

Hot water for drenching was supplied from a 1,703 L (450 gal) holding tank which was initially filled with water at the desired temperature using the instant hot water heaters. Water temperature was then maintained at the set point ±0.2°C by a temperature controller which added 82.2°C water as needed on demand from the instant hot water heaters via a normally closed solenoid valve whenever the temperature dropped in the holding tank. A 0.75 kW (1 hp) centrifugal pump provided continuous mixing through a circulation grid and maintained uniform water temperature throughout the tank. Hot water was delivered to the drenching hoses in the chamber by a 2.25 kW (3 hp) centrifugal pump and returned by gravity flow through a manual bypass valve to the holding tank. A fine mesh (100 µm) bag filter was used to remove dirt and media from the return flow. As part of the control system to ensure rapid temperature recovery, the initial portion of the return flow was diverted by the bypass valve to avoid excessive temperature drop in the holding tank from the cooler water.

Nematode Inoculum

Rotylenchulus reniformis were obtained from greenhouse cultures of inoculated papaya (*Carica papaya*) grown in 15.5-cm-diameter clay pots containing 1:1 steam sterilized soil:silica sand mix. The original nematode culture was collected from a sweet potato (*Ipomoea batatas*) field in Pepeekeo, Hawaii. Roots were removed from the papaya and shaken in 0.3% NaOCl solution for 15 minutes. The resulting mixture was poured through a nested 150 µm opening and 20 µm opening sieves and rinsed. Eggs were collected and placed on a stir plate to allow some hatching. Soil from the pots was placed on Baermann funnels overnight (Walker and Wilson, 1960) and live vermiform-stage *R. reniformis* were collected through a 20 µm mesh sieve 24 and 48 hours later. Each dracaena plant (*Dracaena deremensis*) was inoculated with 1,500

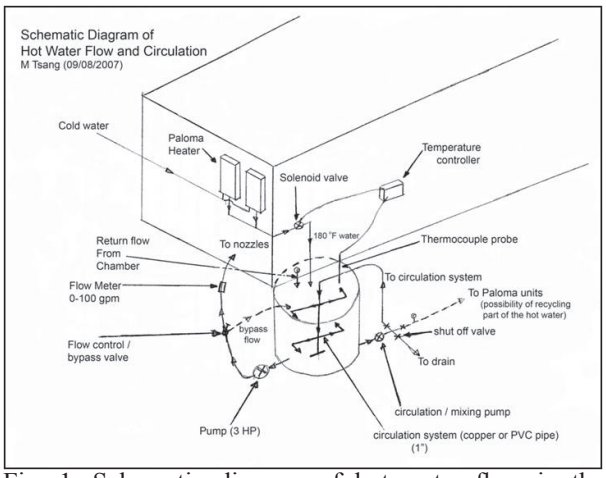

Fig. 1. Schematic diagram of hot water flow in the recirculating hot water shower quarantine treatment system.

Fig. 2. Exterior view of hot water treatment container.

Fig. 3. Interior view of hot water treatment container modified for drenching the media and roots of potted plants with shower nozzles turned off.

Fig. 4. Tee and elbow fittings used for water distribution in trial 2, thermocouple probe placement, and secondary pot to improve water circulation.

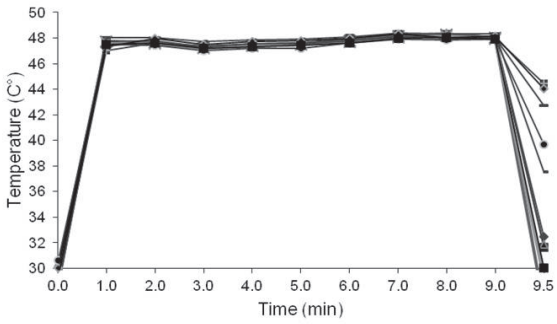

Fig. 5. Temperature rise in potting media during an 8 minute drench of dracaena at 48°C.

Fig. 6. Gentler water flow and reduced washing of the media in trial 3 with removal of elbow fittings

reniform nematodes of mixed life stages including eggs. Nematodes were allowed to reproduce on the plants for 6 months before the experiment was conducted. One week before the trial, each plant was inoculated again with 500 *R. reniformis*.

Hot Water Drench Treatment

Trial 1. Forty 7.6 L (2 gal.) potted 16-month old *D. deremensis* (cultivars 'Janet Craig', 'Warneckei', and 'Lisa') were used for the first trial. Plants were grown in a 2:1 volcanic cinder (3.81 cm minus):peat moss mix in a greenhouse in Hilo, Hawaii under 70% shadecloth. The treatment temperatures were 48°C and 50°C for 8 and 12 minutes each, with 7 plants per time/temperature combination. Each plant was placed inside an empty 11.4L (3 gal.) pot that had 2 of the 4 drainage holes sealed with duct tape. This allowed the water to circulate within the inner pot and less overflow to occur. Four thermocouple probes each were placed in three selected pots at different depths and locations in the pots to monitor the temperature rise in the media. Probes were inserted half way into media and about 2.5 cm from the bottom of the pots with two probes at the center and two 2.5 cm from the outer edge of each pot. The pump was turned on and treatment time started when 75% of the probes reached target temperature. After the treatment, the pots were immediately cooled with ambient temperature water for half the heating time. Twelve plants were used as controls with half being exposed to a 26°C water drench for 12 minutes and the remaining with no treatment and an average soil temperature of 23°C. All plants were held on sterilized benches in a greenhouse with 70% shade.

After the hot water drench treatment reniform nematodes were allowed to reproduce for 46 days to increase the chances of detecting survivors. At that time four soil cores were taken from each potted plant. These 4 cores represented approximately 5% of the total volume of media per pot. Samples contained a mixture of soil and roots in a ratio of approximately 2:1. Three cores were taken 2.5 cm from the edge of the pot between each of the three dracaena canes and one sample was collected from the center of the pot. Samples were composited, weighed, and loaded on Baermann funnels. It was necessary to divide the composited sample among two funnels due to the sizeable quantity of media obtained from the cores. After 24 hours, the funnels were drained into a 20 µm opening sieve, rinsed, and the nematodes were collected in a beaker with approximately 15 mL of water. The entire contents of the sample were transferred to a counting dish and observed for the presence of live *R. reniformis*. To examine nematode distribution within the pots, each of the four soil cores from selected control plants were divided into upper and lower halves. The eight subsamples were labeled and processed separately on the Baermann funnels without compositing. To determine if *R. reniformis* was infecting dracaena canes above the soil line, canes were cut from selected control plants and processed. The bottom 30 cm was cut into 5 cm segments, labeled, and placed on Baermann funnels. Samples were extracted and examined for the presence of reniform nematodes. At the time of sampling all plants were observed for phytotoxicity from the hot water treatment and rated on a scale of 0 – 5 with 0 being no symptoms and 5 being death of the plant. Data were subjected to analysis of variance using the general linear models test and means separated using the least significant difference analysis (SAS Institute, 2007).

Trial 2. The experiment described above was repeated focusing on the 50°C temperature for 8, 10, 12, and 14 minutes. Adjustments were made to the system by adding a 1.27 cm schedule 40 PVC tee with two 90° elbow insert fittings at the end of each hose to improve water distribution in the pots (Fig. 4).

Trial 3. Trial 3 was repeated as previously described except the cultivar 'Janet Craig' was replaced with 'Janet Craig Compacta' due to plant availability. Dracaena plants were 5-months old, the normal shipping age, and younger than in previous trials. Roots were less developed resulting in reduced media compaction within the pots. Plants were inoculated with 1,000 reniform nematodes of mixed life stages including eggs one week prior to treatment. Treatment temperature of 50°C for 10, 12, and 14 minutes was compared to untreated controls. Each time/temperature combination had 18 replicates. The 90° elbow fittings were removed as the exiting water velocity was slightly too high and caused excessive washing of the surface media. The water flowed directly out of the 2 openings on the tee resulting in a gentler flow with less media loss and lower filtration load.

Trial 4. A phytotoxicity test was conducted with 5-month old 'Warnecki', 'Lisa', 'Compacta', and 'Janet Craig' cultivars to evaluate plant tolerance to harsher heat exposure during drenching of the root system. The experiment was conducted as previously described for trial 3 except the time/temperature treatments were 50°C for 20 minutes (n=15), 52°C for 8 minutes (n=16), and 52°C for 14 minutes (n=16). Treated plants were compared with untreated controls (n=9) and controls treated with ambient water for 20 minutes (n=6). Symptoms of thermal damage were observed 2 and 6 weeks after treatment. Weeds were identified in pots before commencement of the hot water trial and monitored 4 and 30 days after treatment.

RESULTS

Trial 1. Continuous hot water drenching of 16-month old potted dracaena reduced or eliminated *R. reniformis* populations in the media at 50°C compared to the controls (Table 1). Seventy-one percent of potted plants treated at 50°C for 12 minutes demonstrated complete control of reniform nematodes whereas only 14% were free of nematodes after an 8 minute drench at 50°C.

Table 1. Presence of *Rotylenchus reniformis* in 16-month old potted *Dracaena deremensis* after continuous hot water drench treatment in Trial 1.

Temp °C	Time (min)	% of Pots w/Survivors	Mean # of *R. reniformis*[y]	No. of Exp Reps
50	12	29%	17 a[z]	7
50	8	86%	9 a	7
48	12	71%	81 a	7
48	8	100%	2219 b	7
26	12	100%	1274 b	6
23	0	100%	1270 b	6

[y]Mean number of *R. reniformis* recovered from four soil cores representing 5% of the total volume of media per pot.
[z]Means followed by a different letter are significantly different ($P < 0.05$) according to the least significant difference procedure (LSD).

Table 2. Presence of *Rotylenchus reniformis* in 16-month old potted *Dracaena deremensis* after continuous hot water drench treatment in Trial 2.

Temp °C	Time (min)	% of Pots w/Survivors	Mean # of *R. reniformis*[y]	No. of Exp Reps
50	14	17%	16 a[z]	6
50	12	43%	41 a	7
50	10	57%	39 a	7
50	8	71%	23 a	7
26	12	100%	2278 b	6
23	0	100%	1752 b	6

[y]Mean number of *R. reniformis* recovered from four soil cores representing 5% of the total volume of media per pot.
[z]Means followed by a different letter are significantly different ($P < 0.05$) according to the least significant difference procedure (LSD).

Table 3. Presence of *Rotylenchus reniformis* in 5-month old potted *Dracaena deremensis* after continuous hot water drench treatments in Trial 3

Temp °C	Time (min)	% of Pots w/Survivors	Mean # of *R. reniformis*[y]	No. of Exp Reps
50	14	0%	0 a[z]	18
50	12	0%	0 a	18
50	10	0%	0 a	18
23	0	100%	40 b	18

[y]Mean number of *R. reniformis* recovered from four soil cores representing 5% of the total volume of media per pot.
[z]Means followed by a different letter are significantly different ($P < 0.05$) according to the least significant difference procedure (LSD).

Although complete control did not occur in all treated samples, 93% of pots drenched at 50°C for 8 and 12 minutes demonstrated a nematode-reduction of > 98%.

Some control was observed at 48°C for 12 minutes with no live nematodes extracted from 29% of treated plants. The average number of *R. reniformis* recovered was higher although not statistically different from the 50°C treatment. A reduction in nematode numbers of >98% was observed in 57% of dracaena treated at 48°C for 12 minutes. There was no significant difference between plants treated at 48°C for 8 minutes and the untreated controls ($P < 0.05$). Exposing the pots to a 12 minute drench at ambient temperature (26°C) had no negative effect on the nematode numbers as compared to pots with no drenching.

Distribution of nematodes within the soil media was consistent but non-uniform in cores taken between the canes, with the majority of the nematodes located in the center of the pot and in the bottom 10 cm of media. No eggs from embedded females or vermiform *R. reniformis* were recovered from canes above the soil line. No phytotoxic effects due to heat injury were observed on the foliage of treated plants or on roots from soil cores.

The target temperature of 48°C was reached inside the pot within 1 minute after commencing the hot water drench and was maintained throughout the run (Fig. 5). Thermocouple probes at multiple depths in the media behaved similarly. For treatments at 50°C, the desired temperature was reached within 2 minutes. Twelve thermocouple probes were available so only three plants with four probes at different depths could be monitored during each run. Complete control of *R. reniformis* occurred in all pots containing thermocouple probes as it could be confirmed that the media

Table 4. Presence of *Rotylenchus reniformis* in 5-month old potted *Dracaena deremensis* after continuous hot water drench treatments in Trial 4.

Temp °C	Time (min)	% of Pots w/Survivors	Mean # of *R. reniformis*[y]	No. of Exp Reps
52	14	0%	0 a[z]	16
52	8	0%	0 a	16
50	20	0%	0 a	15
26	20	100%	15 b	6
23	0	100%	19 b	9

[y]Mean number of *R. reniformis* recovered from four soil cores representing 5% of the total volume of media per pot.
[z]Means followed by a different letter are significantly different ($P < 0.05$) according to the least significant difference procedure (LSD).

reached the target temperature.

The flow rate of the nozzles was typically between 8.6 – 9.2 L/min each although some variation occurred. The last nozzle in the container had the lowest flow rate of 6.0 L/min and the highest flow rate observed was 11.4 L/min. After the first run the last nozzle was tied off and not utilized for future experiments.

Trial 2. The results of trial 2 followed the same trend as trial 1 (Table 2). Continuous hot water drenching at 50°C reduced *R. reniformis* in potted dracaena but not completely. Increasing the treatment time to 14 minutes decreased the number of plants with live reniform nematodes to 17%. Although the number of pots with survivors increased as the treatment time decreased, no significant difference was found in the mean number of surviving nematodes among treatment times ($P < 0.05$). Eighty-nine percent of plants drenched at 50°C at 8, 10, 12, and 14 minutes demonstrated a >98% reduction in nematode numbers compared to control plants.

The addition of the PVC tee allowed the water to flow into two sections of the pot for improved distribution however the elbow fittings caused an increase in the velocity of the exiting water which resulted in excessive washing of the surface media. Subsequently the PVC tees remained on the hose but the elbow fittings were removed for trials 3 and 4.

Trial 3. Reniform nematodes were completely eliminated from all replicates treated with a continuous drench of 50°C for 10 minutes or longer (Table 3). Live nematodes were only recovered from untreated controls. The hot water was more uniformly distributed through the media in these experiments in comparison with the older, pot bound plants treated in trials 1 and 2. In addition the two openings from the tee helped create a more circular flow of water on the surface and more effective penetration of the media. Removing the elbow fittings produced a gentler flow of water into the pots and less cinder media was lost (Fig. 6).

Trial 4. Treatments at 52°C for 8 and 12 minutes and 50°C for 20 minutes controlled reniform nematodes in all pots. Live *R. reniformis* were only observed in untreated dracaena and dracaena drenched with ambient temperature water for 20 minutes. No evidence of phytotoxicity was observed on dracaena foliage and new growth. Only young shoots emerging from the base of the stem in the 'Compacta' cultivar were damaged due to submersion during the hot water drench. Bare rooting of selected dracaena treated at 52°C for 14 minutes revealed minimal thermal damage to the root system and an increase in new root growth compared to untreated plants.

Pilea microphylla (artillery plant), *Cadamine hirsuta* (bittercress), *Ageratum conyzoides* (chick weed), *Pityrogramma calomelanos* (silverback fern), *Nephrolepis* spp. (common fern), and *Spermacoce assurgens* (buttonweed) were growing in the pots prior to the hot water treatment. Within 3 days, all weeds on the top of the media that were submerged during the drench were killed. Weeds growing out of the bottom of the pots perished except for *Nephrolepis* spp. which sustained some foliar damage. Observations at 30 days revealed the hot water may not have destroyed weed seeds as germination of S. assurgens occurred.

DISCUSSION

Continuous hot water drenching of potted dracaena is an effective method of post-plant eradication of reniform nematodes. Nematodes were completely eliminated in 100% of marketable age dracaena treated with 50°C for 10 minutes or longer.

Although the number of reniform nematodes recovered from untreated controls in trials 3 and 4 was low, nematodes were extracted from every replicate not subjected to the hot water drench. The differences in nematode density could be attributed to the existence of nematode predators in the media or the duration that nematodes were allowed to establish and reproduce. In trials 1 and 2, dracaena plants were inoculated 6 months before drenching. To prevent overgrowth of the root system in trials 3 and 4, the hot water treatment was conducted 1 week after inoculation. Inserra *et al.* (1999) found five dracaena species to be poor hosts of *R. reniformis*. The differences in numbers between the trials suggest that the cultivars used in this experiment are good hosts of *R. reniformis* since reproduction occurred during the first two runs.

During the experimental runs, adaptations were made to the type of spigots and position of spigots within the pots to enhance the way water penetrated the media. The most effective design kept the surface of

the media continuously flooded and allowed the water to circulate around the pot until it penetrated downward. Water distribution was improved with the addition of a PVC tee at the end of the hose to split the flow in two directions. The water circulated freely when the tee was placed without nozzles in the middle of the pot just above the surface of the media.

Survivors in trial 1 and 2 were likely due to inconsistent water flow through the media and varying degrees of media compaction within pots which also impeded uniform water distribution. Plants were 16-months of age, pot-bound, and past marketability. The compaction from expanding roots made it more difficult for the hot water to completely penetrate the media and created some cold spots that did not reach the lethal time/temperature regime needed to kill nematodes. Large potted dracaenas for interior foliage are high-value export products and the plants used in these experiments were donated by growers. Plants in trials 1 and 2 could not be exported due to nematode contamination of the media and remained on the bench 5 months longer than standard practice. In addition, the plants were held another 6 months after inoculation with *R. reniformis* before the hot water drench treatment was conducted resulting in the roots becoming overgrown and pot-bound.

Hot water drenching is an effective method for eliminating nematode populations in the roots and potting media of potted plants without harming the plant. Tsang *et al.* (2003) observed no significant difference in plant height or dry weight of roots, stems, and leaves in potted palms even after a 20 minute drench at 50°C as long as the media was cooled with ambient water immediately following the treatment. During trials of the hot water shower for eradication of insect pests and coqui frogs, dracaena foliage was found to be sensitive to temperatures above 46°C (Hara, unpublished). Hot water dips of dracaena cut-back cuttings at 49°C caused increased incidence of *Erwinia* sp. in young terminal leaves during grow-out unless hardening or conditioning was performed prior to treatment (Aoki *et al.*, unpublished). In this experiment, the roots of dracaena demonstrated a high tolerance to hot water drenching with minimal thermal damage and an increase in new root initials. Differences in the quality of foliage were not observed between treated and untreated plants. Blackening of the leaves occurred only if the shoots became submerged with hot water.

The elimination of moss and weeds was a secondary benefit of the hot water treatment. Tsang *et al.* (2001) also reported that drenching purged all weeds from treated pots. Only common fern, *Nephrolepsis* spp., growing at the bottom of the pots survived the treatment. Considering the high costs associated with hiring labor for manual removal of unwanted weeds before export, hot water drenches offer the added benefit of weed control.

A limitation to the current drench system was the availability of only 12 thermocouples to monitor the temperature of the media at different levels. Pots with thermocouples in trials 1 and 2 were completely free of *R. reniformis* after the treatment due to our ability to observe when the target temperature was reached in each pot and accurately begin timing of the treatment. We would predict that if the water temperature in all treated plants were monitored at various depths simultaneously during the drench, the desired temperatures would be achieved and the treatment would likely be 100% effective at eradicating plant-parasitic nematodes even with the most compacted overgrown pots.

Continuous hot water drenching is an effective way to disinfest market-age potted dracaena of reniform nematodes with no evidence of thermal damage. A treatment time of 15 minutes at 50°C is recommended to ensure effective penetration of hot water through the media and root mass. This technique offers growers an alternative to chemical nematicides or destroying plants should post-plant infestation of *R. reniformis* occur.

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