Table 5. Average yields of seed and vegetatively-propagated rhubarb. 1986-1989.

| Plant Source | Years | Yield (T/acre) | Petiole Wt (oz) | U.S. Grade Distribution (%) Fancy | No 1 | No 2 |
|---|---|---|---|---|---|---|
| Victoria Seed | 4 | 9.1 | 2.0 | 34 | 37 | 29 |
| McDonald crown division | 2 | 7.1 | 1.8 | 63 | 34 | 3 |
| McDonald single-bud division | 3 | 5.5 | 1.9 | 69 | 28 | 3 |

and rhubarb vigor and yields also increased. In 1988-89, fertilizer rates were reduced somewhat which resulted in vigor similar to the 1987-88 crop, reduced yields of plants from 'Victoria' seeds and increased yields of plants from 'McDonald' crown divisions and single-bud divisions. Symptoms presumed to be caused by P deficiency did not occur in the 1987-88 or 1988-89 seasons following elevated P applications.

Plant vigor declined each season in late April to early May. By mid-May, all above-ground plant parts were dead, and crowns excavated in June were decayed. Accordingly, rhubarb must be produced as an annual in Florida and other parts of southern United States (10). Seed-propagated rhubarb, although variable in plant vigor and petiole shape and color, is suitable for direct-marketing and for home-garden use. Vegetatively-propagated rhubarb having desirable petiole characteristics would be required for production of crops for shipping.

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# EFFECTS OF CGA-163935 AND UNICONAZOLE ON FOUR ORNAMENTAL PLANTS

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*Additional index words.* growth retardant, flowering, phytotoxicity, vase life, disease resistance, crape myrtle, *Lagerstroemia indica,* variegated Chinese privet, *Ligustrum sinense* 'Variegatum', red top, *Photinia* x *fraseri,* sweet viburnum, *Viburnum odoratissimum.*

*Abstract.* **CGA-163935 and uniconazole (Sumagic), at concentrations of 0, 25, 100 and 250 ppm, were applied as foliar sprays to run-off to crape myrtle (*Lagerstroemia indica* L. 'Firebird'), variegated Chinese privet (*Ligustrum sinense* Lour. 'Variegatum'), red top (*Photinia x fraseri* Dress) and sweet viburnum (*Viburnum odoratissimum* Ker-Gawl) growing in containers. Growth (defined as a percentage increase in plant canopy volume, shoot elongation, and/or top fresh weight) and phytotoxicity were determined periodically. None of the treatments affected days to first flower color for the crape myrtles. CGA-163935 caused no phytotoxicity but was only effective in reducing the growth of sweet viburnum. Growth of the plants, except crape myrtle, was reduced by uniconazole with increasing concentrations causing increasing growth reduction. Uniconazole at the 100 and 250 ppm concentrations caused 1) red top leaves to be darker green (chroma C*), 2) viburnum leaves to be distorted, 3) privet and viburnum stems to have reduced vase life, and 4) privet to have reduced resistance to *Rhizoctonia solani* damage.**

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Growth regulators can be very useful in controlling vegetative growth of woody landscape plants and can thereby decrease maintenance costs (4). They can also darken the green color of plant foliage (3). However, sensitivity to a specific chemical can vary greatly from species to species and phytotoxicity is quite common. In addition, growth regulators have the potential to affect disease (1, 2) and insect resistance (5).

## Materials and Methods

Crape myrtle (*Lagerstroemia indica* 'Firebird'), variegated Chinese privet (*Ligustrum sinense* 'Variegatum'), red top (*Photinia* x *fraseri*) and sweet viburnum (*Viburnum odoratissimum*) plants growing in 3.8-liter containers were repotted into 11.3-liter plastic containers in 30 Mar. 1990. The growing medium consisted of Florida sedge peat:milled pine bark:builders' sand (6:3:1 by volume) amended with 4.2 kg·m$^3$ of dolomite for a pH of 5.9. Crape myrtles were pruned to a single, 1-meter tall stem and all branches and suckers were removed. The other plants were lightly trimmed by species to a uniform size. Pots were watered daily using overhead irrigation and fertilized every two months with 18 grams of 17-2.6-10 (N-P-K) controlled-release fertilizer (Sierra 17-6-12 with minors, Grace/Sierra, Milpitas, CA 95035-2003). Heights and widths (narrowest and widest) of plants were measured prior to treatment on 4 May 1990. Plants were sprayed to the point of run-off with deionized water or uniconazole (10 WP) or CGA-163935 (2.0 EC) solutions with 25, 100 or 250 ppm concentrations. The experimental design was a randomized complete block with five replications. Crape myrtles were monitored daily and the date of first flowering was recorded. Leaf color readings:

L★ (value), 100 = lightest, 0 = darkest

a★ (hue), more negative = greener, more positive = redder

b★ (hue), more negative = bluer, more positive = yellower

were made using a colormeter (CR-100, Minolta, Ramsey, NJ 07446) 40 days after treatment (DAT). Chroma C★ was calculated as the square root of ($a\star^2 + b\star^2$). All plants were remeasured and rated for phytotoxicity at 20, 40 and 60 DAT (0 = none; 1 = slight, salable; 2 = moderate, not salable; 3 = severe; 4 = dead). Increases in plant size were expressed as a percentage change in volume of the above ground portion of the plant where the volume (V) was calculated using the equation for a right circular cylinder ($V = ((\text{narrow width} + \text{wide width})/4)^2 \times \pi \times \text{height}$). Due to the irregular growth habit of the photinia which made volumetric estimation of plant size difficult, top fresh weights of those plants were determined. In addition, stem elongation of crape myrtles, photinia and viburnums were measured 60 DAT. Visual disease ratings were also made at that time using a scale of 0 = no damage; 1 = slight damage, salable; 2 = moderate damage, unsalable; 3 = severe damage; 4 = dead. Twenty-five-cm stem cuttings of red top, sweet viburnum and variegated Chinese privet were harvested on 2 Aug. 1990 for vase life determinations. Additional privet and viburnum stems were harvested on 27 Aug. 1990. Stems were stored for 1 week at 4°C in polyethylene-lined, waxed, corrugated fiberboard boxes. After storage, stems were recut and placed in glass jars filled with deionized water. Stems were held in rooms with light levels of 17 μmol·m$^{-2}$·s$^{-1}$ for 12 hours per day. Temperatures and relative humidities were maintained at 23.5 ± 1.5°C and 67 ± 24%, respectively, in these simulated home/office environments.

Table 1. Phytotoxicity[z] response of *Viburnum odoratissimum* to growth regulator treatments.

| | 40 days after treatment | | 60 days after treatment | |
|---|---|---|---|---|
| Rate (ppm) | CGA-163935 | uniconazole | CGA-163935 | uniconazole |
| 0 | 0 | | 0 | |
| 25 | 0 | 0.6 | 0 | 0.4 |
| 100 | 0 | 2.6 | 0 | 3.0 |
| 250 | 0 | 2.6 | 0.2 | 3.0 |
| Significance[y] | | | | |
| Linear | ns | *** | ns | *** |
| Quadratic | ns | *** | ns | *** |
| Cubic | ns | ns | ns | * |

[z]0 = none; 1 = slight, salable; 2 = moderate, not salable; 3 = severe; 4 = dead.
[y]ns = not significant, * and *** indicate significance at $P$ = 0.05 and 0.001, respectively.

## Results and Discussion

*Crape myrtle flowering.* The average number of days to flowering ranged from 33.4 for uniconazole at 100 ppm to 43.2 for uniconazole at 25 ppm. None of the treatments affected days to flowering compared to the control (data not shown).

*Phytotoxicity.* No phytotoxicity was visible at 20 DAT but by 40 DAT the terminal foliage on viburnum stems treated with uniconazole were visibly distorted. The severity of twisted, abnormal growth increased with increasing uniconazole concentration and phytotoxicity ratings at 60 DAT were similar (Table 1). None of the other crops exhibited symptoms of phytotoxicity.

*Leaf color.* Photinia was the only plant that had leaf color affected by growth regulator treatments. CGA-163935 did not influence leaf color but uniconazole lowered L★,a★,b★ and C★ readings (Table 2).

*Growth.* Crape myrtle was not affected by growth regulator treatments; however, the growth of the three other crops was reduced by uniconazole treatments and *Vibur-*

Table 2. Effects of growth regulators on leaf color[z] of *Photinia* x *glabra* 40 days after treatment.

| | L★ | | a★ | | b★ | | C★[y] | |
|---|---|---|---|---|---|---|---|---|
| Rate (ppm) | CGA-163935 | unicon-azole | CGA-163935 | unicon-azole | CGA-163935 | unicon-azole | CGA-163935 | unicon-azole |
| 0 | 35.8 | | −10.3 | | 13.3 | | 16.8 | |
| 25 | 35.2 | 34.9 | −10.1 | −9.6 | 12.7 | 12.1 | 16.2 | 15.4 |
| 100 | 34.9 | 33.9 | −9.2 | −8.3 | 11.2 | 10.4 | 14.5 | 13.3 |
| 250 | 35.1 | 35.2 | −9.9 | −9.1 | 12.5 | 11.5 | 15.9 | 14.7 |
| Significance[x] | | | | | | | | |
| Linear | ns | ns | ns | * | ns | ns | ns | * |
| Quadratic | ns | * | ns | ** | ns | ** | ns | ** |
| Cubic | ns | ns | ns | ns | ns | ns | ns | ns |

[z]L★ (value), 100 = lightest, 0 = darkest; a★ (hue), more negative = greener, more positive = redder; b★ (hue), more negative = bluer, more positive = yellower
[y]Chroma C★ = square root of ($a\star^2 + b\star^2$).
[x]ns = not significant, * and ** indicate significance at $P$ = 0.05 and 0.01, respectively.

Table 3. Influence of growth regulator treatments on volume change (percentage of initial volume) for crape myrtle, privet and viburnum, and top fresh weight (in grams) for red top 60 days after treatment.

| Crop | Above ground volume change (%) | | | | | | Top fresh wt (g) | |
|---|---|---|---|---|---|---|---|---|
| | *Lagerstroemia indica* | | *Ligustrum sinense* | | *Viburnum odoratissimum* | | *Photinia* x *fraseri* | |
| Rate (ppm) | CGA-163935 | uniconazole | CGA-163935 | uniconazole | CGA-163935 | uniconazole | CGA-163935 | uniconazole |
| 0 | 279 | | 679 | | 269 | | 295 | |
| 25 | 203 | 219 | 690 | 661 | 304 | 98 | 207 | 167 |
| 100 | 236 | 300 | 823 | 145 | 261 | 31 | 257 | 150 |
| 250 | 120 | 259 | 839 | 186 | 167 | 26 | 277 | 173 |
| Significance[z] | | | | | | | | |
| Linear | ns | ns | ns | *** | * | *** | ns | ns |
| Quadratic | ns | ns | ns | *** | ns | *** | ns | * |
| Cubic | ns | ns | ns | ns | ns | ** | ns | ns |

[z]ns = not significant; *, ** and *** indicate significance at the $P = 0.05$, 0.01 and 0.001 levels, respectively.

Table 4. Vase life (in days) of 25-cm terminal stem cuttings harvested 2 Aug. 1990. Stems were stored for one week at 4°C and then held in deionized water under simulated home/office conditions.

| Crop | *Ligustrum sinense* | | *Viburnum odoratissimum* | | *Photinia* x *fraseri* | |
|---|---|---|---|---|---|---|
| Rate (ppm) | CGA-163935 | uniconazole | CGA-163935 | uniconazole | CGA-163935 | uniconazole |
| 0 | 41.1 | | 30.3 | | 12.7 | |
| 25 | 38.9 | 47.3 | 20.5 | 25.8 | 14.3 | 12.4 |
| 100 | 42.7 | 17.3 | 24.9 | 10.9 | 15.8 | 12.0 |
| 250 | 30.5 | 13.5 | 24.9 | 11.2 | 16.7 | 12.6 |
| Significance[z] | | | | | | |
| Linear | ns | ** | ns | *** | ns | ns |
| Quadratic | ns | ns | ns | ** | ns | ns |
| Cubic | ns | ns | ns | ns | ns | ns |

[z]ns = not significant; ** and *** indicate significance at the $P = 0.01$ and 0.001 levels, respectively.

Table 5. Vase life (in days) of 25-cm terminal stem cuttings harvested 27 Aug. 1990. Stems were stored for one week at 4°C and then held in deionized water under simulated home/office conditions.

| Crop | *Ligustrum sinense* | | *Viburnum odoratissimum* | |
|---|---|---|---|---|
| Rate (ppm) | CGA-163935 | uniconazole | CGA-163935 | uniconazole |
| 0 | 34.6 | | 12.[illegible] | |
| 25 | 43.5 | 46.5 | 13.5 | 7.7 |
| 100 | 42.0 | 54.1 | 14.1 | 7.2 |
| 250 | 39.2 | 13.8 | 14.9 | 7.1 |
| Significance[z] | | | | |
| Linear | ns | * | ns | ns |
| Quadratic | ns | * | ns | ns |
| Cubic | ns | ns | ns | ns |

[z]ns = not significant; *indicates significance at the $P = 0.05$ level.

Table 6. Disease ratings[z] for *Ligustrum sinense* 'Variegatum' infested with *Rhizoctonia solani*.

| Crop | *Ligustrum sinense* | |
|---|---|---|
| Rate (ppm) | CGA-163935 | uniconazole |
| 0 | 0.4 | |
| 25 | 0.2 | 0.6 |
| 100 | 0.2 | 1.8 |
| 250 | 0 | 2.2 |
| Significance[y] | | |
| Linear | ns | *** |
| Quadratic | ns | ns |
| Cubic | ns | ns |

[z]0 = none; 1 = slight, salable; 2 = moderate, not salable; 3 = severe; 4 = dead.
[y]ns = not significant; *** indicates significance at $P = 0.001$.

*num odorattisimum* growth was reduced by increasing CGA-163935 concentrations (Table 3). All growth measurements yielded similar treatment effect results whether based on stem elongation, percent volume change or top fresh weights (data not shown).

*Vase life.* Vase life of plant and viburnum stems treated with uniconazole and harvested on 2 Aug. 1990 was reduced (Table 4). By 27 Aug. 1990 viburnum stems had outgrown the deleterious effects of uniconazole (Table 5). CGA-163935 did not affect vase life of the crops tested.

*Disease.* Symptoms of damage to Chinese privet due to the fungal pathogen *Rhizoctonia solani* at 90 DAT increased with increasing uniconazole treatment rate but was not affected by treatment with CGA-163935 (Table 6).

Uniconazole was more effective at reducing vegetative growth than CGA-163935; however, uniconazole increased disease susceptibility and reduced vase life of Chinese privet. In addition, uniconazole was phytotoxic to and reduced the vase life of sweet viburnum stems.

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# POTENTIAL FOR BIOLOGICAL CONTROL OF PHYTOPARASITIC NEMATODES IN BERMUDAGRASS TURF WITH ISOLATES OF THE *PASTEURIA PENETRANS* GROUP[1]


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*Additional index words.* bacterial parasite, *Belonolaimus longicaudatus*, bermudagrass, biological control, *Pasteuria penetrans* group, sting nematode.

*Abstract.* **Survey work done from 1985-1989 suggests that members of the *Pasteuria penetrans* group of endoparasitic bacteria are widely distributed in bermudagrass turf in southern Florida. Five morphometrically distinct isolates of the bacteria were observed on five species of plant-parasitic nematodes. These endospore-forming actinomycetes are obligate parasites of nematodes and appear to be host-specific. A one year greenhouse study was done to determine if soil infested with a large-spored isolate of *Pasteuria* (6.10 μm endospore diameter) was suppressive to populations of the sting nematode, *Belonolaimus longicaudatus*, on 'Tifgreen II' bermudagrass. Soil containing this isolate was not suppressive to *B. longicaudatus* in the first six months but caused a significant decrease in sting nematodes after one year. The positive and negative attributes for this and other isolates of the *Pasteuria penetrans* group for management of nematodes in turfgrass and ornamentals are discussed.**

Nematodes are considered one of the most important challenges to warm-season turfgrass managers in the state of Florida. Unfortunately, there are ten or more genera of phytoparasitic nematodes in Florida which parasitize turfgrass roots in two basic ways. The sting nematode, *Belonolaimus longicaudatus*, the stunt nematode, *Tylenchorhynchus* spp., the awl nematode, *Dolichodorus heterocephalus*, the ring nematodes, *Criconemella* spp., the sheathoid nematodes, *Hemicriconemoides* spp., and the sheath nematodes, *Hemicycliophora* spp. are ectoparasites that feed externally on a large number of plant hosts, including most turfgrass species. The lance nematode, *Hoplolaimus galeatus*, the lesion nematodes, *Pratylenchus* spp., the root-knot nematodes, *Meloidogyne* spp., and the cyst nematodes, *Heterodera* spp. are migratory or sedentary endoparasites which complete part of their life cycle inside the roots of grasses or other plant species. Some of these nematodes can be managed with frequent applications of postplant nematicides (organophosphates) which are currently labelled for turfgrass. Because most nematicides are highly toxic and must remain for a time in the root zone for effective management of nematodes there is always the potential for ground water contamination by the parent compound or a more toxic and soluble degradation product. Also, frequent use of some nematicides may artificially select for rhizosphere microflora which can quickly degrade such materials. Recently, biological control and cultural management tactics have received attention because they can be used alone or in combination with pesticides or other agents for nematode management with less threat to the environment.

Different species or pathotypes of obligate endoparasitic bacteria in the *Pasteuria penetrans* group are promising biological control agents for many of the above mentioned nematodes. These bacteria attach to and infect via the cuticle of the nematode host. The parasitized nematode is incapable of reproduction and eventually becomes filled with endospores which are released into the environment upon disintegration of the host (1). Some forms of the bacteria attack juveniles and do not sporulate until the nematode becomes an adult, i.e., *P. penetrans* sensu strictu (13). Other species, such as *P. thornei* can attack and complete their life cycle before the host reaches the adult stage (13). The assets of members of the *P. penetrans* group as biological control agents of turfgrass nematodes are: 1) their ability to persist for long periods of time, 2) host specificity, 3) compatability with pesticides, and 4) lack of environmental risk (9). Spores of *Pasteuria* have been reported from or adhering to over 205 species of nematodes throughout the world (13,14). *Pasteuria* is common in some areas of Florida (3). Careful characterization of the different isolates of *Pasteuria* from Florida for host specificity and virulence are just now being undertaken (3,7). This paper reviews the results of a survey of Florida golf courses for the presence and diversity of morphotypes of the *Pasteuria penetrans* group in Florida (3). Also, this paper updates a greenhouse study using soil infested with a *Pasteuria* isolate from *B. longicaudatus* against the sting nematode on bermudagrass (3).

## Materials and Methods

The methods for this study were described previously (3) and are reported here for reader convenience.

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