EVALUATION OF A FERTILIZER AND FUNGICIDES FOR CONTROL OF PHYTOPHTHORA ROOT AND STEM ROT IN MADAGASCAR PERIWINKLE

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INTRODUCTION. Phytophthora blight caused by *Phytophthora nicotianae* (syn. = *P. parasitica*) is one of the most damaging diseases of Madagascar periwinkle (*Catharanthus roseus*, a.k.a. "vinca") in Florida. Symptoms of the disease may include root, crown and stem rot, discoloration of shoot tips and foliage, followed by defoliation, wilting, and plant death. One shoot or the entire plant may be initially infected. Total losses of landscape plantings at wet sites are not uncommon, and considerable losses in the production of vincas as transplants and potted plants may also occur. Our research objective was to evaluate the effectiveness of a fertilizer, Phorus (0-31-23) and commercially available and experimental fungicides for the control of Phytophthora blight in Madagascar periwinkle in two experiments. In a separate experiment we also tested the phytotoxic potential of different rates of Phorus to vinca.

MATERIALS & METHODS.
Experiment 1. Test plants consisted of 6-week-old plants of Madagascar periwinkle 'Peppermint Cooler' grown in "six packs" containing a peat-based medium (Fafard #4). The experiment used a randomized complete block design with eight replications consisting of individual sick packs per fungicide treatment and non-treated control. Treatments consisted of a fertilizer Phorus (0-31-23), and Phorus + the fungicide, Subdue Maxx, and other fungicides including Hurricane 48 WP (Mefenoxam and Fludioxonil), Medallion (Fludioxonil), Subdue Maxx (Mefenoxam), two rates of Heritage (Azoxystrobin). Treatments were applied as 5 ml soil drenches to each six pack cell. Fungicides were reapplied twice more at a 2-week interval. Control plants received an equal volume of water. A total of three applications were made.

Plants were inoculated with *P. nicotianae* 48 hours following the initial fertilizer or fungicide application by pouring 5 ml of a zoospore suspension (8.0×10^4 zoospores/ml) of the pathogen into each cell, plus an additional 5 ml/six-pack added into the plastic saucer. The saucers were kept filled with water throughout the experiment. Plants were maintained in a greenhouse for 6 weeks at average high and low temperatures of about 79 F and 59 F, respectively. Plants were fertilized with a water-soluble fertilizer (Nutricote 20-20-20) applied at concentrations that furnished about 50-75 ppm N at every watering, supplemented every 2 weeks at a rate of 200 ppm N. Plants were examined for phytotoxicity and mortality weekly for 6 weeks after inoculation. The

development of disease over time was assessed by generating the area under the mortality progress curve (AUMPC). Disease incidence (stem rot), plant survival %, root rot severity, flower number and diameter, and shoot weight were obtained at the end at the experiment. Root rot severity was estimated using a 1-8 rating scale (1=0%, 2=1-10%, 3=11-25%, 4=26-50%, 5=51-75%, 6=76-90%, 7=91-99% and 8=100% root discoloration). Flower number and diameter, and shoot weight were based on all surviving plants. Representative root and stem segments from symptomatic plants were tested for infection by *P. nicotianae* using a *Phytophthora*-selective medium, and for the presence of other pathogens using a general mycological medium (1/4 acidified PDA) following surface disinfestations in 0.5% NaOCl. Seven, three, and seven symptomatic plants were sampled 11, 34, and 43 days after inoculation.

Experiment 2. Experiment 2 used 8-week-old plants of the Madagascar periwinkle cv. Santa Fe and same methodology as in Experiment 1 with some exceptions. Plants were maintained in saucers filled with water for 4 instead of 6 weeks, the inoculum level of *P. nicotianae* was slightly higher ($1.0x10^5$ zoospores/ml), and the average greenhouse temperatures were higher (average high ≅ 82.0 F and average low ≅ 70 F). Two rates of the fertilizer, Phorus (0-31-23), were tested alone and in combination with Subdue Maxx. Other fungicides tested included Hurricane 48 WP (Mefenoxam and Fludioxonil), Medallion (Fludioxonil), Subdue Maxx (Mefenoxam), one rate of Heritage (Azoxystrobin). The same parameters were measured as in Experiment 1. Thirteen plants symptomatic for Phytophthora blight were tested for *P. nicotianae* and other pathogens 20 days after inoculation as in Experiment 1.

Experiment 3. Experiment 3 used 8-week-old plants of the Madagascar periwinkle cv. Santa Fe planted in Fafard #4 mix and tested the phytotoxic potential of Phorus (0-31-23). The experiment used a randomized complete block design with six replications consisting of individual six packs per Phorus rate and non-treated control. The three rates of Phorus tested, 2%, 4%, and 8% v/v, were applied every 2 weeks as 6, 12, and 24 ml soil drenches, respectively. Control plants received 5 ml water every 2 weeks. A total of four applications of Phorus or water were applied.

Plants were fertilized with a water-soluble fertilizer (Nutricote 20-20-20) applied at concentrations that furnished about 50-75 ppm N at every watering. With the onset of foliar chlorosis, a the supplemental application of Nutricote 20-20-20 at 200 ppm N was made to all plants at 19, 27, 33 and 48 days after transplanting. Plants were maintained in a greenhouse at average high and low temperatures of about 82.0 F and 66.0 F. Plant height was measured after two Phorus applications, number of flowers/plant after three applications, and fresh weight of shoots and % plant mortality after four applications.

Treatment means from all three experiments were separated by Fisher's Protected LSD Test ($P \leq 0.05$) following appropriate transformation of percentage data.

RESULTS

Experiment 1. Phytophthora crown and stem rot developed rapidly in controls; after 6 weeks disease incidence and plant mortality in non-treated plants reached 81% and 77%, respectively. *P. nicotianae* was consistently isolated from symptomatic root and stem tissue 11 days after inoculation. However, in addition to *P. nicotianae*, *Fusarium* sp. and/or *Thielaviopsis basicola* were isolated at high incidences 34 and 43 days after inoculation. All treatments except Medallion and the lowest rate of Heritage significantly reduced root and stem rot incidence, with Phorus + Subdue Maxx being the most effective in comparison with the non-treated control (**Table 1**). Subdue Maxx, Hurricane, Phorus, and Phorus + Subdue Maxx increased plant survival with equal efficacy, while the high rate of Heritage was of intermediate effectiveness. Subdue Maxx and Phorus + Subdue Maxx were the most effective treatments in reduction of root rot severity, and Hurricane, Phorus and the high rate of Heritage were the next most effective treatments. All treatments except Medallion reduced the AUMPC; Subdue Maxx, Hurricane, Phorus, and Phorus + Subdue Maxx were the most effective and both rates of Heritage were of intermediate effectiveness. The fresh weight of shoots/plant was significantly reduced by Medallion and the low rate of Heritage, and increased by Subdue Maxx, Hurricane, and Phorus + Subdue Maxx, with the latter treatment being the most effective. The average number of flowers/plant was significantly reduced by Medallion and the low rate of Heritage, and significantly increased by Phorus + Subdue Maxx. Flower diameter was significantly reduced by Phorus. Plant distortion and necrosis following application of the treatments was not observed. However, reduction of shoot weight, flower number per plant, and flower size represent possible phytotoxicity symptoms.

Experiment 2. Phytophthora crown and root rot developed rapidly in controls; after 6 weeks, disease incidence and plant mortality in non-treated plants reached 100% and 97%, respectively (**Table 2**). *P. nicotianae* was consistently isolated from symptomatic root and stem tissue 20 days after inoculation. Only Phorus (both rates) + Subdue Maxx significantly reduced crown and root rot incidence. All fungicides except Medallion increased plant survival; Phorus (both rates) + Subdue Maxx was the most effective, both rates of Phorus were of intermediate effectiveness, and Subdue Maxx and Hurricane were the least effective. Phorus (both rates) + Subdue Maxx was the most effective treatment in reduction of root rot severity, the high rate of Phorus was of intermediate effectiveness, the low rate of Phorus was least effective, and other treatments were ineffective. Medallion significantly increased the AUMPC compared to the non-treated control. All other treatments significantly reduced the AUMPC; Phorus (both rates) + Subdue Maxx was the most effective, the low rate of Phorus was of intermediate effectiveness, and the other treatments were less effective. The fresh weight of shoots/plant was significantly increased by all

treatments except Medallion; Phorus (both rates) + Subdue Maxx was the most effective and the other treatments less effective. The average number of flowers/plant was significantly increased by all treatments except Medallion and Heritage; Phorus (both rates) + Subdue Maxx produced. Plant distortion and necrosis following application of the treatments was not observed. As in Experiment 1, flower diameter was significantly reduced by Phorus at 2% v/v compared to the other treatments.

Experiment 3. Plant height, flower number/plant, and average shoot fresh weight/plant were significantly reduced by the two highest rates of Phorus, with Phorus at 8% v/v producing the greatest reductions. The highest rate of Phorus also resulted almost total plant mortality. The lowest rate of Phorus tested, 2% v/v, did not affect plant height, flower number/plant, or average shoot fresh weight/plant.

Table 1. Effect of a fertilizer and fungicides on Phytophthora Root and Stem Rot in *Catharanthus roseus* 'Peppermint Cooler' (Experiment 1)

Rate/100 gal	Disease incidence (%)	Plant survival (%)	Root rot severity (%)[1]	AUMPC[2]	Shoot fresh weight (g)/plant	Flower number/plant	Flower diameter (mm)
Non-treated control	81.2 a[3]	22.9 a	74.3 a	1397 a	5.3 d	2.2 bc	33.4 ab
Medallion, 1.0 oz	83.3 a	27.1 a	76.9 a	1373 a	1.8 e	1.1 e	29.9 b
Heritage, 0.9 oz	81.2 a	40.4 ab	68.5 a	936 b	2.9 e	1.2 de	30.5 ab
Heritage, 1.8 oz	54.2 b	48.3 b	47.0 b	822 b	6.4 cd	2.5 bc	33.5 ab
SubdueMaxx, 0.5 fl oz	20.8 c	87.5 c	14.8 de	44 c	8.1 bc	3.0 ab	34.4 ab
Hurricane 48 WP, 1.5 oz	6.7 cd	95.4 c	14.0 d	12 c	8.6 b	3.0 ab	34.8 a
Phorus 0-31-23, 2% v/v	27.1 c	93.7 c	28.7 c	75 c	6.6 bcd	2.1 cd	24.7 c
Phorus 0-31-23, 2% v/v + SubdueMaxx, 0.5 fl oz	0.0 d	100 c	3.8 e	0.0 c	11.1 a	3.9 a	30.1 b

[1] Root rot severity was estimated using a 1-8 rating scale where 1=0% and 8=100% root discoloration.
[2]AUMPC = area under the mortality progress curve.
[3]Means within columns followed by different letters are significantly different by Fisher's LSD, $P \leq 0.05$. Arc sine square root transformation was used on percentage data; non-transformed means are presented.

Table 2. Effect of a fertilizer and fungicides on Phytophthora Root and Stem Rot in *Catharanthus roseus* 'Santa Fe' (Experiment 2)

Rate/100 gal	Disease incidence (%)	Plant survival (%)	Root rot severity (%)[1]	AUMPC[2]	Shoot fresh weight (g)/plant	Flower number/plant	Flower diameter (mm)
Non-treated control	100 a[3]	2.8 a	100 a	1257 b	0.3 f	0.2 d	N. D.[4]
Medallion, 1.0 oz	100 a	0.0 a	100 a	2030 a	0.0 f	0.0 d	N.D.
Heritage, 1.8 oz	100 a	27.8 b	96.3 a	781 c	5.7 e	2.3 cd	35.1 a
SubdueMaxx, 0.5 fl oz	100 a	22.2 b	97.6 ab	617 cd	6.6 e	5.2 c	37.0 a
Hurricane 48 WP, 1.5 oz	100 a	33.4 b	96.0 ab	417 d	11.6 d	5.2 c	38.3 a
Phorus 0-31-23, 1% v/v	100 a	41.6 c	85.5 bc	329 de	17.5 c	12.8 b	32.9 ab
Phorus 0-31-23, 2% v/v	100 a	63.9 c	78.2 c	475 cd	23.5 b	15.1 ab	28.7 b
Phorus 0-31-23, 1% v/v + SubdueMaxx, 0.5 fl oz	63.8 b	94.4 d	8.5 d	43 e	30.9 a	17.2 a	37.1 a
Phorus 0-31-23, 2% v/v + SubdueMaxx, 0.5 fl oz	63.8 b	97.2 d	8.2 d	97 e	29.6 a	17.2 a	32.4 ab

[1] Root rot severity was estimated using a 1-8 rating scale where 1=0% and 8=100% root discoloration.
[2]AUMPC = area under the mortality progress curve.
[3]Means within columns followed by different letters are significantly different by Fisher's LSD, $P \leq 0.05$. Arc sine square root transformation was used on percentage data; non-transformed means are presented.
[4]Could not be determined.

Table 3. Effect of Phorus (0-31-23) on growth and survival in *Catharanthus roseus* 'Santa Fe'

Treatment	Average plant height (cm)[1]	Flower number/plant[2]	Shoot fresh weight (g)/plant[3]	Plant mortality (%)[3]
Non-treated control	9.8 a[4]	1.8 a	29.8 a	0.0 a
Phorus 2% v/v	9.5 a	1.8 a	29.2 a	0.0 a
Phorus 4% v/v	8.4 b	1.1 b	23.6 b	0.0 a
Phorus 8% v/v	6.3 c	0.2 c	10.9 c	94.9 b

[1]Plant height was measured after two Phorus applications.
[2]Number of flowers/plant was determined after three applications.
[3]Fresh weight of shoots and % plant mortality after four applications.
[4]Means within columns followed by different letters are significantly different by Fisher's LSD, $P \leq 0.05$.