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Evaluation of Bedding Plant Varieties for Resistance to Phytophthora[1]

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Abstract

Seedlings of several annual and perennial bedding plant species were inoculated with an isolate of *Phytophthora nicotianae* (synonym = *P. parasitica*) and planted into field beds in a simulated landscape situation. Throughout the growing season, growth measurements and disease ratings of the inoculated plants were compared with those of non-inoculated control plants of the same species in identical beds. *Phytophthora*-inoculated plants that continued to thrive through most of the growing season included *Ageratum houstonianum*, *Celosia* 'Apricot Brandy', and 'New Look'; *Dahlia* 'Harlequin'; *Eustoma grandiflorum* (prairie gentian); *Lobularia* 'Carpet of Snow'; *Nicotiana* 'Alta Dwarf White', 'Domino Salmon', and 'Nicki Red'; *Pelargonium* (geranium) 'Multibloom Scarlet Eye'; *Petunia* 'Polo Salmon', and 'Sugar Daddy'; *Portulaca* 'Sundial Peppermint'; *Rudbeckia* 'Rustic Dwarf'; *Salvia* 'Lady in Red', and 'Victoria Blue'; *Tagetes* (marigold) 'Disco Mix', 'Inca Orange', 'Inca Yellow', 'Janie Harmony Improved', and 'Gold Fireworks'; and *Zinnia angustifolia*. Plants that performed poorly following inoculation with *Phytophthora* include *Antirrhinum* (snapdragon) 'Liberty White', and 'Liberty Mix'; *Catharanthus* (vinca) 'Little Bright Eye', and 'Tropicana Rose'; *Hibiscus* 'Disco Belle Mix'; *Impatiens* 'Accent Bright Eye'; *Leucanthemum* x 'Alaska'; *Melampodium* 'Medallion'; *Salvia* 'Turkestanica'; *Torenia* 'Clown Mix'; *Verbena* 'Imagination'; and *Viola* (pansy) 'Fama See Me'. This study identifies bedding plant taxa which will provide an acceptable display in landscape beds infested with *Phytopthora nicotianae* (synonym = *P. parasitica).*

Index words: disease tolerance, disease resistance, flowering bedding plants, landscape plants, *Phytophthora nicotianae, Phytophthora parasitica.*

Species used in this study: ageratum (*Ageratum houstonianum* Mill.); snapdragon (*Antirrhinum majus* L. 'Liberty White', 'Liberty Mix'); Madagascar periwinkle (vinca) (*Catharanthus roseus* (L.) G. Don 'Tropicana Rose', 'Little Bright Eye'); celosia (*Celosia argentea* L. 'Apricot Brandy', 'Castle Pink', 'New Look'); dahlia (*Dahlia coccinea* Cav. 'Harlequin'); prairie gentian (*Eustoma grandiflorum* (Raf.) Shinn.); rose mallow (*Hibiscus moscheutos* L. 'Disco Belle Mix'); garden balsam (*Impatiens balsamina* L.); impatiens (*Impatiens walleriana* Hook. f. 'Accent Bright Eye'); shasta daisy (*Leucanthemum* x *superbum* (J. Ingram) Bergmans ex Kent.); alyssum (*Lobularia maritima* Desv. 'Carpet of Snow'); melampodium (*Melampodium cinereum* DC. 'Medallion'); flowering tobacco (*Nicotiana* x *sanderae* hort Sander ex Will. Wats. 'Alta Dwarf White', 'Daylight Mix', 'Domino Salmon', 'Nicki Red'); geranium (*Pelargonium* x *hortorum* L. H. Bail. 'Multibloom Scarlet Eye'; petunia (*Petunia* x *hybrida* hort. Vilm.-Andr. 'Polo Salmon', 'Red Picotee', 'Sugar Daddy'); moss rose (*Portulaca grandiflora* Hook. 'Sundial Peppermint'); black-eyed Susan (*Rudbeckia hirta* L. 'Rustic Dwarf'); scarlet salvia (*Salvia coccinea* Juss. ex Murray. 'Lady in Red'); mealy sage (*Salvia farinacea* Benth. 'Victoria Blue'); clary sage (*Salvia sclarea* L. 'Turkestanica'); African marigold (*Tagetes erecta* L. 'Inca Orange', 'Inca Yellow'); French marigold (*Tagetes patula* L. 'Disco Mix', 'Gold Fireworks', 'Janie Harmony', 'Janie Harmony Improved'); wishbone flower (*Torenia fournieri* Lind. ex Fourn. 'Clown Mix'); moss verbena (*Verbena tenuisecta* Briq. 'Imagination'); pansy (*Viola* x *wittrockiana* Gams. 'Fama See Me'); zinnia (*Zinnia angustifolia* Kunth.)

Significance to the Nursery Industry

Knowledge of bedding plant susceptibility or resistance to *Phytophthora* will allow growers to take appropriate preventive control measures during production. In addition, knowledge of resistant bedding plant taxa permits landscapers and nursery retailers to recommend bedding plants that will provide an acceptable landscape display in *Phytophthora*-infested beds. Several *Phytophthora*-resistant annual and perennial bedding plant species were identified that performed well in the landscape following inoculation with *Phytophthora.* Several species that proved very susceptible to *Phytophthora* were also noted.

Introduction

Phytophthora nicotianae Breda de Haan (synonym = *P. parasitica* Dastur) is a non-selective fungal pathogen, attacking a wide variety of host plants. This pathogen is soil-borne, and its motile zoospores move freely in water. *Phytophthora* generally invades the roots, crowns, and stems; however, foliar blights occasionally occur. Symptoms of *Phytophthora*-incited disease include chlorosis, wilting, dieback, general decline, or rapid collapse and death (blighting). A number of bedding plants has been reported as host to *P. nicotianae*, including *Antirrhinum* (snapdragon), *Catharanthus* (Madagascar periwinkle, vinca), celosia, chrysanthemum, dianthus, *Gypsophila* (baby's breath), *Hedera* (ivy), petunia, *Vinca*, and *Viola* (pansy) (2). Since this pathogen normally inhabits soil and attacks a variety of hosts when conditions are favorable for its development [temperatures >25C (77F) and overwatering or poor drainage (5)], knowledge of a host plant's susceptibility to attack by *P. nicotianae* would make disease avoidance possible. For many popular bedding plants, relative susceptibility to *P. nicotianae* in production or landscape settings is unknown. This research evaluates the susceptibility of selected bedding plant taxa to *Phytophthora*-incited root and crown rot.

Materials and Methods

An isolate of *Phytophthora nicotianae* (synonym = *P. parasitica*) (isolate 336) was obtained from D.M. Benson, Department of Plant Pathology, North Carolina State Uni-

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versity. Rice grain inoculum was prepared by adding 19 ml (0.6 oz) of distilled water to 25 ml (0.8 oz) of dry white rice in a 250 ml (8.5 oz) Erlenmeyer flask, and autoclaving for 20 min, twice at 1.1 kg/cm^2 (15 psi). The autoclaved, sterile rice grains were then inoculated with plugs of *P. nicotianae* cultured on corn meal agar. The fungus was allowed to colonize the rice grains for 3 weeks, with daily agitation to keep the grains separated, prior to inoculation of the test plants.

Selected bedding plant seeds were germinated in early April 1993, and seedlings were transferred to 6 × 6 cm (2.4 × 2.4 in) cell packs containing ProGro 300S soilless medium. On April 30, 1993, seedlings of dahlia, melampodium, and pansy were inoculated with the rice grain inoculum. Two wells were made in the medium of each cell by inserting the tip of a pencil into the medium to a depth of approximately 2 cm (0.8 in). The wells were placed on opposite sides of each plant, midway between the plant and the wall of the cell. Four grains of rice inoculum were placed in each well and covered with the medium. This same procedure was repeated for Madagascar periwinkle, geranium, rudbeckia, impatiens, verbena, salvia, ageratum, torenia, marigolds, prairie gentian, and celosia between May 11 and May 21, 1993. Seedlings to be used as controls for each species or cultivar were left uninoculated.

On May 3 and 4, 1993, raised beds were prepared with a rototiller in a field previously covered with rye and fescue grasses. The soil texture was silt loam. Pansies, dahlias, and melampodium were transplanted to the field beds on May 13. All remaining bedding plant taxa were transplanted on May 21, 1993, except for prairie gentian and celosia which were transplanted on June 3. Plants were spaced at 30 cm (12 in) intervals within beds 7.9 × 2.4 m (26 × 8 ft), with 4 plants of each species or cultivar in each of eight replications (beds) for both the inoculated and uninoculated plants, in a completely randomized design. Uninoculated plants were separated from the inoculated plant beds with a 0.9 m (3 ft) wide buffer strip depressed 15 cm (6 in) below the planting surface in order to inhibit the movement of *P. nicotianae* spores into the beds containing uninoculated plants. On June 3, after transplanting was completed, plant heights, widths, and disease ratings were recorded. The disease rating scale used was: 1 = healthy; 2 = some leaf chlorosis; 3 = chlorosis and some necrosis or wilting; 4 = dead. Plant heights and widths were measured again on July 15 and August 26, and disease was visually assessed weekly until September 23. Plots were irrigated twice each week using overhead impact sprinklers.

In the spring of 1994, 25 bedding plant taxa were selected for evaluation. Most were additional cultivars of species identified in the 1993 evaluation as tolerant or resistant to *P. nicotianae*. Two taxa known to be susceptible to this pathogen (*Antirrhinum* and *Catharanthus*) were included as indicator plants. In 1994, plants were inoculated as described previously during the last week of May, and were transplanted to the field plots on June 6. Six 5-plant replications were inoculated, and three 5-plant replications were included as the uninoculated controls. Disease development was monitored by measuring the plants and by visually rating disease symptoms. Disease ratings were recorded weekly for 10 consecutive weeks, while plant heights and widths were measured at monthly intervals (3 times). In both 1993 and 1994, as disease symptoms developed, representative symptomatic plants were removed with roots attached to determine the presence of *P. nicotianae*. Roots and stems were washed in running tap water. Shoot and root tissues were separated, cut into pieces approximately 1 cm (0.4 in) in length, and plated on PARP (pimaricin, 10 mg; ampicillin, 250 mg; rifampicin, 10 mg; pentachloronitrobenzene, 125 mg; Difco corn meal agar, 17 g, deionized water, 1 liter), a *Phytophthora*-selective medium (4). After five to seven days incubation, the plates were examined for the presence of *P. nicotianae*.

The growth and disease rating data for the inoculated plants and the uninoculated control plants were compared over time with a 2-way analysis of variance (treatment × day), with day (measurement dates) as a repeated measure (1). Each species or cultivar was evaluated separately. In 1993, measurement dates were June 11, July 15, and August 26. In 1994, measurement dates were June 14, July 18, and September 24. Inoculated vs. uninoculated control means for individual plant taxa on each evaluation date were compared with a t-test.

Results and Discussion

Analysis of variance (ANOVA) results are provided in Table 1 for plant taxa evaluated in 1993 and 1994 that did not have significant treatment by day interactions or significant inoculation treatment main effects for disease rating. Significant disease symptoms were not noted on any of the taxa in Table 1 during the evaluation period with the exception of some reduction in growth for a few taxa. For example, *Tagetes* 'Inca Orange' in 1993 and *Salvia* 'Lady in Red' and 'Victoria Blue' in 1994 had significant treatment by day interactions for growth index but not for disease rating. This indicates that there were differences in the growth rates, over time, between the inoculated plants and the uninoculated control plants for these taxa, but that disease symptom comparisons did not differ significantly. Growth index mean comparisons provided in Tables 2 and 3 show that the inoculated plants of these taxa grew less than the controls as the growing season progressed. In 1993, *Tagetes* 'Gold Fireworks', *Ageratum houstonianum*, *Celosia* 'New Look', *Dahlia* 'Harlequin', *Eustoma grandiflorum* (prairie gentian), *Pelargonium* 'Multibloom Scarlet Eye', *Petunia* 'Polo Salmon', and *Rudbeckia* 'Rustic Dwarf' were not visibly affected by *Phytophthora* inoculation (Table 1).

Taxa that showed significant inoculation treatment by evaluation day interactions, or significant inoculation treatment main effects for disease rating have not been included in Table 1; however, means for the significant effects and interactions have been presented in Table 2 (1993) and Table 3 (1994). In 1993, *Antirrhinum* 'Liberty White', *Catharanthus* 'Little Bright Eye', *Hibiscus* 'Disco Belle Mix', *Impatiens* 'Accent Bright Eye', *Melampodium* 'Medallion', *Torenia* 'Clown Mix', *Verbena* 'Imagination', and *Viola* 'Fama See Me' had highly significant treatment by day interactions ($P \leq 0.01$) for both growth indices and disease ratings. These interaction effects show increasing differences over time between the inoculated plants and the control plants in both size and appearance (Table 2). This implies that disease symptoms progressively intensified from one evaluation period to the next and shows that the above taxa are highly susceptible to *P. nicotianae*. The inoculated plants of these species declined in quality over the three evaluation dates, and grew less than the controls. *P. nicotianae* was also isolated from symptomatic plants of the above taxa on the PARP selective medium (Table 4). *Antirrhinum*, *Catharanthus*, and *Viola*

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Table 1. Bedding plant taxa for which the inoculation treatment by evaluation day interaction or the inoculation treatment main effect for disease was not significant, indicating resistance or tolerance of *Phytophthora* through the evaluation periods. 1993 and 1994 studies.

Taxon	Inoculation treatment	Evaluation day	Treatment × day interaction
	1993		
Ageratum houstonianum			
Growth index[z]	NS[x]	***	NS
Disease rating[y]	NS	***	NS
Celosia 'New Look'			
Growth index	NS	***	NS
Disease rating	NS	**	NS
Dahlia 'Harlequin'			
Growth index	*	***	NS
Disease rating	NS	***	NS
Eustoma grandiflorum			
Growth index	NS	*	NS
Disease rating	NS	***	NS
Pelargonium 'Multi. Scarlet Eye'			
Growth index	NS	*	NS
Disease rating	NS	***	NS
Petunia 'Polo Salmon'			
Growth index	NS	***	NS
Disease rating	NS	NS	NS
Rudbeckia 'Rustic Dwarf'			
Growth index	NS	***	NS
Disease rating	NS	***	NS
Tagetes 'Inca Orange'			
Growth index	*	***	*
Disease rating	NS	NS	NS
Tagetes 'Gold Fireworks'			
Growth index	NS	***	NS
Disease rating	NS	***	NS
Ageratum houstonianum			
Growth index[z]	NS[x]	***	NS
Disease rating[y]	NS	NS	NS
Celosia 'Apricot Brandy'			
Growth index	NS	**	NS
Disease rating	NS	**	NS
Celosia 'Castle Pink'			
Growth index	**	NS	NS
Disease rating	NS	***	NS
Celosia 'New Look'			
Growth index	NS	***	NS
Disease rating	NS	*	NS
Lobularia 'Carpet of Snow'			
Growth index	NS	***	NS
Disease rating	NS	**	NS
Nicotiana 'Alta Dwarf White'			
Growth index	NS	***	NS
Disease rating	NS	NS	NS
Nicotiana 'Domino Salmon'			
Growth index	NS	***	NS
Disease rating	NS	*	NS
Nicotiana 'Nicki Red'			
Growth index	NS	***	NS
Disease rating	NS	NS	NS
Petunia 'Sugar Daddy'			
Growth index	NS	***	NS
Disease rating	NS	***	NS
Portulaca 'Sundial Peppermint'			
Growth index	NS	***	NS
Disease rating	NS	***	NS
Rudbeckia hirta			
Growth index	NS	***	NS
Disease rating	NS	***	NS
Salvia coccinea 'Lady in Red'			
Growth index	*	***	**
Disease rating	NS	NS	NS
Salvia farinacea 'Victoria Blue'			
Growth index	***	***	***
Disease rating	NS	NS	NS
Tagetes 'Disco Mix'			
Growth index	NS	***	NS
Disease rating	NS	NS	NS
Tagetes 'Inca Orange'			
Growth index	NS	***	NS
Disease rating	NS	NS	NS
Tagetes 'Inca Yellow'			
Growth index	*	***	NS
Disease rating	NS	NS	NS
Tagetes 'Janie Harmony Improved'			
Growth index	NS	***	NS
Disease rating	NS	NS	NS
Zinnia angustifolia			
Growth index	NS	***	NS
Disease rating	NS	***	NS

[z]Growth index: (height + width) / 2.

[y]Disease rating: 1 = healthy; 2 = some chlorosis; 3 = chlorosis and some necrosis or wilting; 4 = dead.

[x]NS, *, **, ***: Nonsignificant, or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

(pansy) were particularly susceptible to attack by *P. nicotianae*. Symptom onset and isolation of the pathogen occurred very early in the study, and all inoculated plants died. For pansy, the control plants also died prior to study termination, but this was expected due to the intolerance of pansy to high summer temperatures. In 1993, *Salvia* 'Lady in Red' had significant treatment by day interactions for both growth index and disease rating; however, the decline in the health of the inoculated plants did not begin until August. *Salvia* 'Lady in Red' proved more tolerant of *P. nicotianae* than other susceptible taxa throughout most of the season.

In 1994, *Antirrhinum* and *Catharanthus* were again very susceptible to *P. nicotianae*, with highly significant treatment by day interactions for both growth indices and disease ratings ($P \leq 0.001$). For both species, most of the inoculated plants had died prior to July 14 (Table 3). *Leucanthemum* 'Alaska' (shasta daisy) also had highly significant treatment by day interactions for growth indices and disease ratings ($P \leq 0.01$). Significant differences in size and appearance were apparent by July 14, but none of the plants died during the evaluation period. No treatment by day interactions were noted for *Celosia* 'Castle Pink' but inoculated plants were significantly smaller than the uninoculated controls and *P. nicotianae* was isolated from the roots (Table 4). However, the appearance of this cultivar was otherwise unaffected. The other two cultivars of *Celosia* did not appear to have suffered notable damage. *Impatiens balsamina* had significant treatment by day interactions for growth indices and disease but inoculation effects were insignificant on individual evaluation dates until August 24. *Salvia sclarea* 'Turkestanica' had a significant treatment by day interaction for growth ($P \leq 0.01$), and there was a significant treatment effect for disease ratings ($P \leq 0.01$). Inoculated plants of this species had higher disease ratings and were smaller during most of the season than the controls (Table 3). *Nicotiana* 'Daylight Mix' had a significant treatment by day interaction for disease ($P \leq 0.05$);

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Table 2. Growth index and/or disease rating means of taxa evaluated in 1993 for which there was a significant interaction of inoculation treatment and evaluation day, or a significant inoculation treatment main effect from the ANOVA.

	Evaluation date					
	June 3, 1993		July 15, 1993		August 26, 1993	
Taxon	Control	Inoculated	Control	Inoculated	Control	Inoculated
Antirrhinum 'Liberty White'						
Growth index[z]	15.4	8.3*	20.3	0*	26.3	0*
Disease rating[y]	1.0	3.0*	1.0	4.0*	1.0	4.0*
Catharanthus 'Little Bright Eye'						
Growth index	11.3	9.0*	34.0	4.2*	51.4	1.7*
Disease rating	1.0	2.3*	1.0	3.6*	1.0	4.0*
Dahlia 'Harlequin'						
Growth index	16.2	13.6*	24.4	19.2	34.6	23.6*
Hibiscus 'Disco Belle Mix'						
Growth index	10.1	8.4	33.1	12.5*	44.4	8.9*
Disease rating	1.0	1.8	1.0	2.9*	1.5	3.4*
Impatiens 'Accent Bright Eye'						
Growth index	7.1	7.4	10.6	4.0*	14.5	0.9*
Disease rating	1.3	1.2	2.5	3.5*	2.5	3.9*
Melampodium 'Medallion'						
Growth index	20.4	18.3*	52.9	26.6*	49.1	38.2
Disease rating	1.0	1.0	1.0	2.1*	1.4	2.2
Salvia 'Lady in Red'						
Growth index	11.0	10.8	32.4	33.2	61.1	53.8
Disease rating	1.0	1.0	1.0	1.0	1.1	1.5*
Tagetes 'Inca Orange'						
Growth index	11.0	11.4	39.8	32.6*	65.4	53.2
Tagetes 'Janie Harmony'						
Growth index	8.8	8.9	32.5	27.3*	45.0	38.8*
Disease rating	1.0	1.1	1.0	1.3	1.0	1.1
Torenia 'Clown Mix'						
Growth index	10.8	9.5	16.1	16.6	32.4	10.1*
Disease rating	1.0	1.1	1.0	1.3	1.0	3.3*
Verbena 'Imagination'						
Growth index	15.4	12.7	41.1	5.3*	47.6	3.8*
Disease rating	1.0	1.6*	1.0	3.6*	1.4	3.9*
Viola 'Fama See Me'						
Growth index	11.9	8.9	10.8	0*	—	—
Disease rating	1.0	2.9*	3.0	4.0*	—	—

[z]Growth index: (height + width) / 2. (in centimeters)

[y]Disease rating: 1 = healthy; 2 = some chlorosis; 3 = chlorosis and some necrosis or wilting; 4 = dead.

*Indicates significant difference from the uninoculated controls, for a given date, by t-test ($P \leq 0.05$).

however, significant differences in disease severity between the inoculated and the control plants were seen only on August 24 (Table 3). No symptoms of *Phytophthora* root and crown rot were seen on the other three *Nicotiana* cultivars. *Petunia* 'Red Picotee' had a significant treatment by day interaction for disease ($P \leq 0.01$), with significant differences in appearance between inoculated and control plants apparent on July 14. However, the growth and appearance of inoculated *Petunia* 'Sugar Daddy' was similar to that of the uninoculated controls (Table 1). In 1994, none of the *Tagetes* (marigolds) showed a significant treatment by day interaction; however, inoculated 'Inca Yellow' plants were moderately smaller than the uninoculated controls throughout the evaluation period. The growth and appearance of the other three inoculated *Tagetes* cultivars were unaffected. *Lobularia* and *Zinnia angustifolia* also performed well during the evaluation period.

In 1995 and 1996, Hagan et al. (3) evaluated several bedding plant taxa in beds infested with *P. nicotianae*. In general, the corresponding bedding plant genera that performed well in that study also performed well here. In both studies *Ageratum, Celosia, Pelargonium* (geranium), *Petunia, Salvia, Tagetes* (marigold), and *Zinnia* had excellent survival rates. Additional genera that performed well in our study that were not included by Hagan et al. were *Dahlia, Eustoma, Lobularia, Nicotiana, Portulaca,* and *Rudbeckia.* Genera that performed poorly in both studies included *Catharanthus* (annual vinca), and *Impatiens*. Those genera that performed poorly in our study that were not evaluated by Hagan et al. were *Antirrhinum, Leucanthemum, Melampodium, Torenia,* and *Viola.* The only genus included in both studies that did not show similar results was *Verbena*. *Verbena* 'Formula Mix' performed well in the study of Hagan et al., while *Verbena* 'Imagination' did poorly in this study. Species difference probably accounts for the different results obtained in the two studies.

This study shows that several annual or perennial bedding plant taxa are resistant or tolerant of *Phytophthora nicotianae* although their performance may vary with differences in species or cultivars.

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Table 3. Growth index and/or disease rating means of taxa evaluated in 1994 for which there was an interaction of inoculation treatment and evaluation day, or, a significant inoculation treatment main effect from the ANOVA.

	Evaluation date					
	June 3, 1994		July 14, 1994		August 24, 1994	
Taxon	Control	Inoculated	Control	Inoculated	Control	Inoculated
Antirrhinum 'Liberty Mix'						
Growth index[z]	11.7	8.6*	25.5	0*	36.4	0*
Disease rating[y]	1.0	2.5*	1.2	4.0*	1.9	4.0*
Catharanthus 'Tropicana Rose'						
Growth index	13.9	12.4	30.7	2.3*	39.7	1.4*
Disease rating	1.0	2.2*	1.0	3.8*	1.7	3.8*
Celosia 'Castle Pink'						
Growth index	21.0	18.3	22.9	18.9*	27.4	15.4*
Impatiens balsamina						
Growth index	19.1	17.8	62.1	56.4	80.9	54.0*
Disease rating	1.1	1.1	1.0	1.2	1.1	2.1*
Leucanthemum 'Alaska'						
Growth index	14.3	14.3	28.7	15.4*	29.0	17.9*
Disease rating	1.0	1.0	1.0	2.4*	1.2	2.1*
Nicotiana 'Daylight Mix'						
Disease rating	1.2	1.3	1.2	1.8	1.0	2.2*
Petunia 'Red Picotee'						
Disease rating	1.0	1.0	1.4	2.6*	2.9	3.5*
Salvia coccinea 'Lady in Red'						
Growth index	17.2	17.3	62.2	50.6	89.6	74.1*
Salvia farinacea 'Victoria Blue'						
Growth index	13.1	12.8	34.8	22.4*	60.9	32.5*
Salvia sclarea 'Turkestanica'						
Growth index	8.1	7.9	13.1	9.0*	25.7	10.5*
Disease rating	1.0	1.1	1.3	2.6*	1.6	2.8*
Tagetes 'Inca Yellow'						
Growth index	21.7	18.4*	47.5	43.6*	77.3	71.2

[z]Growth index: (height + width) / 2. (in centimeters)

[y]Disease rating: 1 = healthy; 2 = some chlorosis; 3 = chlorosis and some necrosis or wilting; 4 = dead.

*Indicates significant difference from the uninoculated controls, for a given date, by t-test ($P \leq 0.05$).

Table 4. Successful isolations of *Phytophthora nicotianae* (synonym = *P. parasitica*) from symptomatic bedding plant taxa in 1993 and 1994.

Plant taxon	Tissues cultured	Sampling date
	1993	
Antirrhinum 'Liberty White'	stem	6/11/93
Catharanthus 'Little Bright Eye'	root, stem	6/11/93
Dahlia 'Harlequin'	root, stem	6/18/93
Hibiscus 'Disco Belle'	root, stem	7/6/93
Impatiens 'Accent Bright Eye'	root, stem	7/9/93
Melampodium 'Medallion'	root, stem	6/17/93
Salvia 'Lady in Red'	root, stem	8/10/93
Torenia 'Clown Mix'	root	8/10/93
Verbena 'Imagination'	stem	6/17/93
	root	7/6/93
Viola 'Fama See Me'	root, stem	6/18/93
	1994	
Antirrhinum 'Liberty Mix'	root, stem	6/17/94
Catharanthus 'Tropicana Rose'	root, stem	6/17/94
Celosia 'Castle Pink'	root	8/4/94
Leucanthemum 'Alaska'	stem	8/4/94
Nicotiana 'Daylight Mix'	root, stem	6/30/94
Petunia 'Red Picotee'	root, stem	6/28/94
Salvia sclarea 'Turkestanica'	root	8/4/94

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