Increased Plant Mortality Caused by Pythium Root Rot of Poinsettia Associated with High Fertilization Rates

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ABSTRACT

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Rooted poinsettia cuttings potted in peat:perlite, soil:sand:peat, peat:vermiculite, peat:vermiculite:perlite:sand, or peat:vermiculite:sand:bark ash received soluble fertilizer with each irrigation. A range of fertilizer levels from suboptimum (100 μg N/g) to excessive (600 μg N/g) was applied. Half of the plants in each treatment were inoculated with *Pythium ultimum*. Few uninoculated plants died, and few plants given the lowest level of fertilization died even when inoculated with *Pythium*. Mortality of inoculated plants increased rapidly as the concentration of soluble salts, associated with fertility level, increased. Plants that survived inoculation were significantly shorter than uninoculated plants at all except the highest fertilizer level.

Pythium spp. cannot be totally eliminated from the greenhouse environment. Under the intense cultural practices in greenhouse production, these root-rotting fungi can cause significant crop losses. *Pythium* species are usually weak parasites of poinsettia (*Euphorbia pulcherrima* Willd.) roots but can cause severe disease under specific conditions (10). When root tips are attacked, plants become stunted and flower prematurely, disrupting the production cycle (9).

Influences of temperature, soil moisture, and soil pH on root rot of poinsettia caused by *Pythium ultimum* Trow. have been examined (1,2). *P. ultimum* caused severe disease at 17 C but little damage above 26 C. Root rot severity was greatest above 70% water-holding capacity of soil and was favored by neutral or alkaline soil. Bolton (4) found that in a soilless potting mix, fresh weight losses presumably caused by *P. aphanidermatum* (Edson) Fitzp. were greater in poinsettias grown in mixes of pH 5.5–7.0 than in plants grown at pH 3.0–5.0. Soil pH higher than 7.0 was not tested (4). Fertilization regimes used in the earlier research (1,2,4) were not reported.

Preliminary experiments indicated that poinsettias are most susceptible to Pythium root rot when fertilized at high rates (13). The experiments reported herein were designed to determine at what level of fertilization mortality of poinsettias caused by Pythium root rot increases in certain potting mixes.

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MATERIALS AND METHODS

In summer 1982, rooted Hegg Dark Red poinsettia cuttings were potted in peat:perlite (1:1, v/v) amended with 500 g of ground limestone, 200 g of superphosphate, and 6 g of fritted trace elements per 50 L of potting mix. In summer 1983, rooted cuttings of the cultivar Brilliant Diamond were potted in the same mix. In summer 1984, rooted cuttings of the cultivar Lady were potted in soil:sand:peat (1:1:1, v/v/v), peat:vermiculite (Redi-Earth), peat:vermiculite:perlite:sand (Metro-Mix 200), and peat:vermiculite:sand:bark ash (Metro-Mix 350) (W. R. Grace & Co., Fogelsville, PA). In all experiments, standard, round 152-mm-diameter plastic pots were used. Planting dates were selected on the basis of those used by growers producing poinsettias in the northeastern United States for Christmas sale.

In 1982 and 1983, plants were fertilized with 15-15-15 (NPK) soluble fertilizer (Peters Fertilizer Products, division of W. R. Grace) with each irrigation beginning 10–14 days after potting. Fertilizer at rates to provide nitrogen at 100, 200, 400, and 600 μg N/g was applied using a Hyponex Siphon Mixer (1:16) proportioner (The Hyponex Co., Inc., Copley, OH). Sufficient liquid was applied each time so that 15–20% of that applied leached through the potting mix. About 8 wk after potting in 1982 and 1983, magnesium sulfate (844 μg $MgSO_4$/g) and sodium molybdate (1,494 μg Na_2MoO_4/g) were used to supplement the fertilizer to avoid magnesium and molybdenum deficiencies.

In 1984, 15-16-17 (NPK) (Peters) soluble fertilizer was applied as before with each irrigation at rates of 150, 300, 450, and 600 μg N/g beginning 2 wk after potting. Because this fertilizer contains molybdenum and magnesium, these elements were not added.

Each week, a sample of the potting mix at each fertilizer level was taken and a saturated paste extract was prepared with distilled water (14). Electrical conductivity (EC) of the extract, a measure of the total soluble-salt concentration, was measured with a Beckman SD-B15 Solu-Bridge (Beckman Instruments Inc., Cedar Grove, NJ). The extract pH was measured with a Corning M-120 meter (Corning Science Products, Corning Limited, Halstead, Essex, England).

Fifty plants in each potting mix were fertilized at each rate noted previously.

Twenty-five plants in each treatment were inoculated with *P. ultimum* ATCC 32231 (American Type Culture Collection). In 1984, 11 additional plants in peat:vermiculite were inoculated with *P. ultimum* ATCC 36443, and another 11 plants were inoculated with *P. ultimum* isolated by A. F. Schmitthenner (Ohio State University, Wooster). *Pythium* cultures, which had been grown on cornmeal agar in 100-mm petri dishes for 7–10 days, were homogenized in tap water (100 ml/dish), and 10 ml of this suspension was applied to the surface of the potting mix. Dead and permanently wilted plants were counted weekly after inoculation.

At the end of the experiment in 1984, surviving plants potted in peat:vermiculite:sand:bark ash were measured from the soil line to tops of the flowers. The mean heights of inoculated and uninoculated plants were compared at each fertilizer level (15).

RESULTS

Average conductivity and pH readings recorded during the experiments are given in Table 1. Because results of the 1982 (cultivar Hegg Dark Red) and 1983 (cultivar Brilliant Diamond) experiments done in peat:perlite were similar, only the survival of Hegg Dark Red is shown (Fig. 1A,B). Likewise, only the results using *P. ultimum* isolate ATCC 32231 are shown,

Table 1. Average pH and electrical conductivity (EC) of saturated paste extracts of potting mixes

Potting mix	Nitrogen level (μg/g)	pH	EC (× 10^{-5} mhos/cm)
	1982		
Peat:perlite	100	5.8	119
	200	5.6	158
	400	5.5	274
	600	5.4	468
	1983		
Peat:perlite	100	5.4	102
	200	5.5	188
	400	5.6	319
	600	5.7	459
	1984		
Soil:sand:peat	150	6.6	124
	300	5.7	333
	450	5.5	389
	600	6.0	572
Peat:vermiculite	150	6.1	189
	300	5.7	349
	450	5.6	394
	600	5.5	449
Peat:vermiculite: sand:bark ash	150	6.8	178
	300	6.0	293
	450	5.8	425
	600	5.7	496
Peat:vermiculite: perlite:sand	150	6.6	182
	300	6.3	272
	450	6.1	428
	600	6.3	431

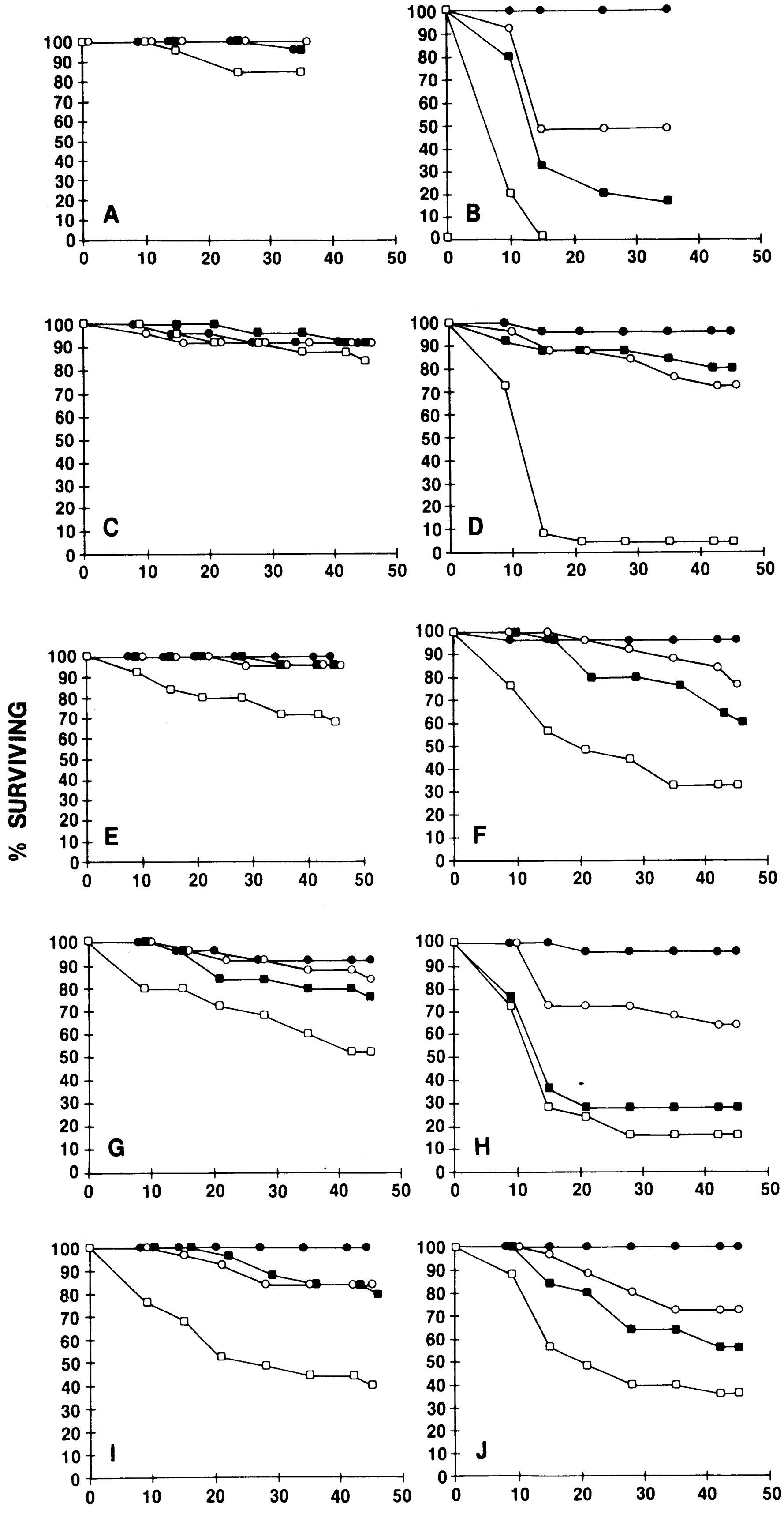

Fig. 1. Survival of poinsettias in various potting mixes **(A, C, E, G, and I)** not inoculated or **(B, D, F, H, and J)** inoculated with *Pythium ultimum* ATCC 32231. Potting mixes were **(A and B)** peat:perlite, **(C and D)** soil:sand:peat, **(E and F)** peat:vermiculite:sand:bark ash, **(G and H)** peat:vermiculite:perlite:sand, and **(I and J)** peat:vermiculite. **(A and B)** Hegg Dark Red poinsettias were fertilized at each irrigation with 15-15-15 (NPK) soluble fertilizer at 100 (●), 200 (o), 400 (■), and 600 (□) μg N/g. **(C–J)** Lady poinsettias were fertilized at each irrigation with 15-16-17 (NPK) soluble fertilizer at 150 (●), 300 (o), 450 (■), and 600 (□) μg N/g.

because plant mortality with each of the three *P. ultimum* isolates in peat:vermiculite was similar (Fig. 1I,J).

Exposure to high soluble-salt concentrations alone resulted in the death of some plants. However, 80% or more uninoculated plants potted in peat:perlite (Fig. 1A) or soil:sand:peat (Fig. 1C) survived even the highest soluble-salt concentrations. Sixty-eight percent of the plants potted in peat:vermiculite:sand:bark ash (Fig. 1E) and 52% of those in peat:vermiculite:perlite:sand (Fig. 1G) and fertilized at 600 μg N/g survived. Most of the plants fertilized at 100 or 150 μg N/g survived regardless of inoculation in all the potting mixes. As the fertilization rate increased, survival of plants inoculated with *P. ultimum* declined greatly compared with that of uninoculated plants. Survival of inoculated plants potted in peat:vermiculite (Fig. 1J) tended to decline as fertilization rates increased, regardless of the *P. ultimum* isolate to which plants were exposed. Because only 40% of the uninoculated plants potted in peat:vermiculite and fertilized with 600 μg N/g survived (Fig. 1I), it is possible that the excessive fertilization alone caused increased plant mortality. Death of inoculated plants usually began 2 wk after inoculation and continued for an additional 3–4 wk. Few plants in any treatment died after that time.

Surviving inoculated plants were generally shorter than uninoculated plants in the same potting mix. Mean height of surviving inoculated plants in peat:vermiculite:sand:bark ash was significantly less ($P = 0.01$) than that of surviving uninoculated plants at all fertilizer levels except 600 μg N/g (Fig. 2). Heights of plants in other potting media were not measured, but similar trends were observed.

Plants potted in peat:perlite and fertilized with 15-15-15 (NPK) soluble fertilizer at a rate lower than 200 μg N/g were chlorotic compared with plants fertilized

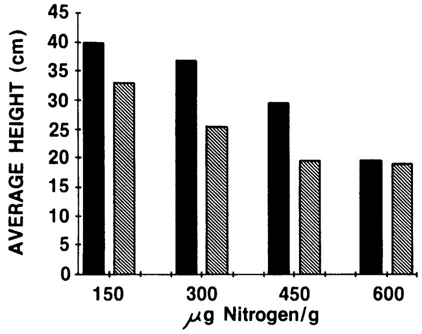

Fig. 2. Average heights (cm) of surviving Lady poinsettias potted in peat:vermiculite:sand:bark ash and fertilized with 15-16-17 (NPK) soluble fertilizer with each irrigation at 150, 300, 450, and 600 μg N/g. Uninoculated plants (solid bars) were significantly taller than plants surviving inoculation with *Pythium ultimum* ATCC 32231 (shaded bars) at all fertilizer levels except 600 μg N/g ($P = 0.01$).

at higher rates and were not of marketable quality. Plants in all potting mixes fertilized with 15-16-17 (NPK) were of marketable quality at all fertilizer levels.

DISCUSSION

These experiments demonstrated that when high levels of fertilizer are applied early in the production of poinsettias, there is a greater risk of serious loss caused by Pythium root rot than at low fertilizer levels if *P. ultimum* is present. Because *P. ultimum* also causes stunting, potential marketability can be affected adversely, even at low fertilizer levels at which plants usually survive Pythium root rot.

Plant mortality was positively correlated with soluble-salt concentration in three of the soilless mixes (peat:perlite, peat:vermiculite:sand:bark ash, and peat:vermiculite:perlite:sand and a soil-containing potting mix (soil:sand:peat) to which *P. ultimum* was added. The threshold level of soluble-salt concentration above which inoculated plant mortality increased greatly was between 100 and 200 μg N/g for peat:perlite and between 150 and 300 μg N/g for peat:vermiculite:perlite:sand, peat:vermiculite:sand:bark ash, and soil:sand:peat. In peat:vermiculite, losses of plants exposed to high levels of soluble salts alone were similar to those in the population that was fertilized and inoculated. This may indicate that plants potted in peat:vermiculite are more sensitive to high soluble-salt concentrations but that this sensitivity does not influence subsequent attack by *Pythium*. The similarity of the threshold in the soil mix and the soilless mixes was not expected. It is generally accepted that the soluble-salt concentrations that result in plants of poor quality are greater in soilless potting mixes than in soil mixes (8,12). It had been suspected that salt levels that resulted in increased plant mortality would be correspondingly greater in a soilless mix than in a soil mix.

The results reported here are similar to those reported for Phytophthora root rot of chrysanthemum (11) but are unlike those for Pythium damping-off of vegetable seedlings (3) and Pythium root rot of peperomia (6). MacDonald (11) found that as the concentration of NaCl to which young rooted chrysanthemums were exposed increased, Phytophthora root rot symptoms increased in severity. On the other hand, Beach (3) found that high salts did not significantly increase damping-off of tomato or cucumber seedlings caused by *P. ultimum*. Chase and Poole (6) found that peperomia root-quality ratings decreased most in plants inoculated with *P. splendens* and fertilized at low levels. Inoculated plants grown at the highest fertilizer level showed no decrease in root-quality rating. Their plants were older than 2 mo when inoculated. Pythium root rot of poinsettia seems to be important only on young plants. Moorman (*unpublished*) found that high fertilization rates did not predispose 1-yr-old plants to Pythium root rot.

It is not unusual to find several species of *Pythium* in a greenhouse (7,16), and a single species may attack more than one greenhouse-grown plant species (5). More work must be done before the manipulation of fertilization rates can be recommended for the control of root rots of greenhouse crops. The interactions among soluble-salt concentrations and additional plant species of varying ages as well as different species of *Pythium* and other root rot organisms in a variety of potting mixes must be examined.

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