In-Furrow Applications of Metalaxyl and Phosphite for Control of Pink Rot (*Phytophthora erythroseptica*) of Potato in New Brunswick, Canada

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ABSTRACT

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The efficacy of metalaxyl-m (Ridomil Gold 480EC) and phosphite (Phostrol) applied at planting in-furrow against pink rot (*Phytophthora erythroseptica*) of potato (*Solanum tuberosum*) 'Shepody' and 'Russet Burbank' was evaluated in field trials conducted in 2005 and 2006 in Florenceville, New Brunswick, Canada. Inoculum made from a metalaxyl-m-sensitive isolate of *P. erythroseptica* from New Brunswick was applied either in-furrow as a vermiculite slurry at planting or as a zoospore drench in soils adjacent to potato plants in late August. After harvest, the number and weight of tubers showing pink rot symptoms were assessed and expressed as percentages of the total tuber number and total weight of tubers. Metalaxyl-m applied in-furrow was significantly more effective against pink rot than phosphite. The mean percentage of diseased tubers as a percentage of total tuber weight was 1.5% (2005) and 1.2% (2006) for metalaxyl-m-treated plots and 9.6% (2005) and 2.8% (2006) for phosphite-treated plots, a percentage similar to that obtained in inoculated control plots with no fungicide treatment. The mean percentage of diseased tubers expressed as a percentage of the total number of tubers was 1.7% (2005) and 1.3% (2006) for metalaxyl-m-treated plots and 10.1% (2005) and 3.1% (2006) for phosphite-treated plots. Disease incidence was significantly higher using the late-season inoculation technique (respective means in 2005 and 2006 were 9.9 and 3.8% diseased tubers, by weight, and 10.6 and 3.9%, by number) than with the in-furrow inoculation method (respective means in 2005 and 2006 were 3.3 and 0.7% by weight, and 3.7 and 1.3%, by number). The potato cv. Shepody was significantly more susceptible to pink rot (9.9 and 3.3% diseased tubers, by weight, in 2005 and 2006, respectively, and 10.6 and 3.9%, by number) than Russet Burbank (respective means in 2005 and 2006 were 3.4% and 1.2%, by weight, and 3.7% and 1.2%, by number). Our findings indicate that metalaxyl applied in-furrow at planting is a viable option for control of pink rot caused by metalaxyl-sensitive strains of *P. erythroseptica*, whereas phosphite was ineffective.

Additional keywords: phosphorous acid, resistance

In New Brunswick, 23,000 ha were planted with potato (*Solanum tuberosum* L.) and the produce accounted for approximately 30% of the province's farm cash receipts in the year 2005 (1). Pink rot (*Phytophthora erythroseptica* Pethybr.) is a disease of economic importance to the Canadian potato industry, and is responsible for severe yield losses in the field and storage facilities (27,31). Pink rot has been detected in most potato-growing areas worldwide (36). None of the potato cultivars commonly grown in Canada are completely resistant to pink rot (25,30). The

incidence and severity of pink rot in New Brunswick were extremely high in 2004, which resulted in a loss in excess of \$20 million.

The interest in *P. erythroseptica* has increased since the recovery of metalaxyl-resistant strains in 1994, and also due to an increase in disease incidence in certain potato-growing regions of North America (14,18,29,34). Tubers infected with the pink rot pathogen usually are found in wet, low-lying areas of the field during harvest. Symptom development also can occur soon after tubers are placed in storage (31). Warm (20 to 30°C) and wet weather conditions at harvest increase disease incidence and severity, although potato plants can be infected soon after emergence (28). Potato plants with infected roots and stems may wilt, resulting in the death of the plant. Infected tubers are relatively firm and rubbery and cut surfaces turn pink when exposed to air for 20 to 30 min. The patho-

gen has the capability to survive as oospores in soil for many years (37) and the pathogen propagules are prevalent in soils where potato is cultivated (19). The pathogen can be introduced into unfested soils by infected seed tubers (9).

Over the years, *P. erythroseptica* has developed resistance to various fungicides that are used to control pink rot. Metalaxyl-m (mefenoxam), or its isomer metalaxyl, is the only fungicide currently used to control pink rot (21,24,27,31,38). Since its introduction, this phenylamide fungicide has been used effectively against a wide range of pathogens belonging to the order Peronosporales. Although resistance to metalaxyl-m has been found in populations of *P. erythroseptica* (14,18,34), it still provides reliable control of pink rot in production areas where metalaxyl-m-sensitive strains predominate (21,24,33,38). The effectiveness of metalaxyl-m has precluded efforts to develop resistant cultivars. Some cultivars are less severely affected by *P. erythroseptica*, but most commonly grown cultivars are susceptible to the pathogen (30). Therefore, cultivar resistance is not commonly used as a means of controlling water rots. The application of metalaxyl-m as a single application in-furrow at planting or at planting with a follow-up sidedress was reported to have significantly reduced the incidence of pink rot when compared with the foliar application method (33).

Populations of the pink rot pathogen have developed insensitivity to products containing metalaxyl-m; therefore, alternative methods to control pink rot are required. For a fungicide to be effective against pink rot under field conditions, it should have the capability to protect roots and tubers in soil for the entire growing season. Metalaxyl is known to be highly systemic and has the capacity to translocate throughout the plant (32). Other fungicides labeled for controlling *Phytophthora* pathogens are not as systemic as metalaxyl, which makes it difficult to maintain these fungicides in the root zone throughout the potato-growing season (20). One class of fungicides that show promise in managing water mold pathogens that are resistant to metalaxyl is phosphite-based fungicides (17). Phosphite-based fungicides include commercially

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available products such as Phostrol (mono- and di-basic sodium, potassium, and ammonium salts of phosphorous acid; Nufarm Americas, Inc., AGT-Division, Burr Ridge, IL), Fosphite (JH Biotech, Inc.; mono- and di-basic potassium salts of phosphorous acid) and Topaz (Agrilience; mono- and di-potassium salts of phosphorous acid). Phosphorous acid (phosphonate or phosphite) is the anionic metabolite of the systemic fungicide aluminum tris-O-ethyl phosphonate (fosetyl-Al) (22). Both phosphorous acid and fosetyl-Al are effective in controlling diseases caused by oomycetes (3,6,12,22) and are systemic in both a basipetal and acropetal direction (7,10). Phosphorous acid and phosphonate-based fungicides disrupt the growth of *Phytophthora* spp. and have been shown to induce natural defenses in plants (10,15). In Canada, only metalaxyl-m (Ridomil Gold 480EC) is registered for use against pink rot of potato. The objectives of the present study were to (i) evaluate the efficacy of phosphite (Phostrol) applied in-furrow as an alternative fungicide to Ridomil Gold, (ii) evaluate the susceptibility of the two main potato processing cultivars to pink rot, and (iii) determine the effect of early versus late-season inoculation on pink rot disease development. This is the first study where products of this type have been challenged in the field with a late-season field inoculation method which mimics real-world scenarios.

MATERIALS AND METHODS

Experimental set up. Field trials were conducted at McCain's Research Farm, Florenceville, New Brunswick, Canada in 2005 and 2006. The experiment was designed as a randomized complete block with seven treatments consisting of four replicates for each treatment. The potato cvs. Shepody and Russet Burbank, which are industry standards, were used in this study. Seven treatments were included: (i) uninoculated untreated control; (ii) untreated control with in-furrow inoculum; (iii) untreated control inoculated late in the season; (iv) inoculated, with metalaxyl-m added in-furrow at planting; (v) inoculated, with phosphite added in-furrow at planting; (vi) metalaxyl-m applied in-furrow with inoculation late in the season; and (vii) phosphite applied in-furrow with inoculation late in the season.

Each trial consisted of four replicates and each replicate consisted of four rows, 9.14 m in length. Fertilizers were applied in bands at 453.6 kg acre⁻¹ for Shepody (N-P-K; 16.5-15-15) and Russet Burbank (N-P-K; 18.5-15-15). Seed tubers (E1) weighing 60 to 70 g for Shepody and 50 to 60 g for Russet Burbank were planted manually at an in-row spacing of 25 cm for Shepody and 38 cm for Russet Burbank.

Application of pesticides. Pesticide solutions were prepared following the recommended label rates. Metalaxyl-m (Ri-

domil Gold 480EC, metalaxyl-M and S-isomer, 48%; Syngenta Crop Protection Canada, Inc., Guelph, ON, Canada) solution was prepared by mixing at 12.2 ml liter⁻¹ of water. Phosphite (Phostrol, mono- and di-basic sodium, potassium and ammonium phosphates, 53.6%; Nufarm Americas, Inc.) solution was prepared by mixing at 271 ml liter⁻¹ of water. Both fungicides were applied in-furrow as a band at the rate of 1 ml per seed piece prior to row closure. The insecticide Imidacloprid (Admire PRO, 1-[(6-chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine, 42.8%; Bayer Crop Science, Calgary, Alberta, Canada) also was applied in-furrow on the seed pieces with a backpack sprayer at the rate of 29.4 ml liter⁻¹ of water per 9.14-m row prior to row closure. Agricultural practices commonly performed by potato growers in New Brunswick were followed throughout the growing season (4).

Inoculum preparation for in-furrow inoculation. A metalaxyl-m-sensitive isolate of *P. erythroseptica* (no. 364-2) from New Brunswick (2) was subcultured on V8 agar and incubated at 22°C for 14 days under reduced light. Twenty-five plates (100 by 15 mm) containing *P. erythroseptica* mycelium and oospores were added to 250 ml of distilled water and blended for 2 min into a thin gel. The blended material (500 ml) was mixed thoroughly with 1 kg of autoclaved horticultural vermiculite (Holiday VIL Vermiculite, Inc., Division of Normiska Corporation, Montréal, QC, Canada) until the final texture of the inoculum became crumbly. The inoculum was applied in-furrow at the rate of 1,200 g per 9.14-m row and covered lightly with soil before planting.

Inoculum preparation for late-season inoculation. Zoospore inoculum of *P. erythroseptica* was prepared according to Peters et al. (26). Briefly, three agar plugs, each 5 mm in diameter, taken from the margin of a 3-day-old culture of *P. erythroseptica* were added to each 50-ml plastic disposable sterile centrifuge tube (Fisher Scientific Co., Nepean, ON, Canada) containing 15 ml of autoclaved clarified V8 broth (34%). The tubes then were placed in darkness at 18°C for 3 days to allow growth of the pathogen. After 3 days, the V8 broth was decanted and the mycelium washed twice with 10 ml of sterile distilled water. Following the final wash, cultures were immersed in 10 ml of sterile pond water (26) and kept at 18°C under continuous fluorescent light for 24 h. After incubation, the pond water was replaced with 15 ml of fresh sterile pond water and cultures were incubated for 24 h at 18°C under continuous fluorescent light. The cultures were chilled at 9°C for 1.5 h following incubation and then placed in darkness at room temperature (22°C) for 30 min in order to encourage zoospore release (14,000 to 16,000 zoospores ml⁻¹). Zoo-

spores remain motile for about an hour at room temperature but, if kept at 9°C, will remain motile for 6 to 8 h, which facilitates plant or tuber inoculation studies (23). Late-season (August) inoculation was carried out according to the protocol of H. W. Platt and R. D. Peters (*unpublished*). Briefly, wooden dowels (2 cm in diameter) were used to punch a hole (10 cm deep) on each side of the plant next to the plant root zone. Inoculum (5 ml) was injected into each hole using a syringe and the holes were covered by pressing down onto the soil. Wetting of field soil in experimental plots for a period of 4 h prior to and 24 h after inoculation is critical to ensure that zoospores can swim to belowground plant tissues to cause infection. Water can be added to soils with irrigation (wherever available) or inoculation can be timed with natural rainfall events. For the 2005 trial, vine kill was done on 8 September for Shepody and 13 September for Russet Burbank. Shepody and Russet Burbank plots were harvested on 29 September. In 2006, vine kill was done on 11 September for both cultivars. Tubers of Shepody were harvested on 20 September and Russet Burbank tubers were harvested on 22 September.

Data collection and statistical analysis. Harvest was accomplished with a two-row digger and tubers were picked manually. Tubers were graded, and the number and weight of healthy and diseased tubers was recorded. Percentages of total tuber weight and number composed of diseased tubers were calculated. Data for each year were analyzed by analysis of variance (13) and, when a significant treatment effect was found, the test of least significant difference (LSD; $P = 0.05$) was used to separate means. Because no disease developed in uninoculated controls, they were excluded from the analysis. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

RESULTS

Field trial 1, 2005. In the 2005 field trial, metalaxyl-m applied at planting in-furrow was significantly ($P < 0.001$) more effective against pink rot than phosphite. The mean percentage of diseased tubers expressed as a percentage of the total number of tubers was 1.7% in plots treated with metalaxyl-m and 10.1% in plots treated with phosphite (Table 1). Similarly, the mean percentage of diseased tubers as a percentage of total tuber weight was 1.5% in plots treated with metalaxyl-m and 9.6% in plots treated with phosphite (Table 2). There was no significant reduction in disease severity due to phosphite application regardless of potato cultivar or method of inoculum application used. Disease incidence was significantly higher ($P < 0.001$) with the late-season inoculations than with at-planting in-furrow inoculations. The mean percentages of total num-

ber of diseased tubers in plots receiving the late-season inoculation for Shepody and Russet Burbank were 15.4 and 5.7%, respectively; they were 5.8 and 1.7%, respectively, in plots receiving the in-furrow inoculation (Table 1). Similarly, the mean percentages of total tuber weight composed of diseased tubers in plots receiving the late-season inoculation for Shepody and Russet Burbank were 14.6 and 5.3%, respectively; they were 5.11 and 1.53%, respectively, in plots receiving the in-furrow inoculation (Table 2). Between the two potato cultivars tested, Shepody was significantly ($P < 0.001$) more susceptible to pink rot than Russet Burbank. The mean percentage of total number and total tuber weight composed of diseased tubers for Russet Burbank was 3.7 and 3.4%, respectively, and 10.6 and 9.9%, respectively, for Shepody (Tables 1 and 2).

Field trial 2, 2006. In the 2006 field trial, results were similar to those obtained in 2005, with the exception of an overall lower pink rot incidence. Metalaxyl-m applied in-furrow was significantly ($P < 0.001$) more effective against pink rot than phosphite. The mean percentage of diseased tubers expressed as a percentage of the total number of tubers was 1.3% in plots treated with metalaxyl-m and 3.1% in plots treated with phosphite (Table 3). Similarly, the mean percentage of diseased tubers as a percentage of total tuber weight was 1.2% in plots treated with metalaxyl-m and 2.8% in plots treated with phosphite (Table 4), a percentage that is similar to the one obtained in an inoculated control with no fungicide treatment. Disease incidence was significantly higher ($P < 0.001$) with the late-season inoculations than with at-planting in-furrow inoculation. The mean percentage of total number of diseased tubers in plots receiving late-season inoculation for Shepody and Russet Burbank were 5.6 and 2.2%, respectively; they were 2.3 and 0.2% in plots receiving the in-furrow inoculation (Table 3). Similarly, the mean percentage of total tuber weight composed of diseased tubers in plots receiving the late-season inoculation for Shepody and Russet Burbank were 5.4 and 2.2%, respectively; they were 1.3 and 0.2% in plots receiving the in-furrow inoculation (Table 4). Between the two potato cultivars tested, Shepody was significantly ($P < 0.001$) more susceptible to pink rot than Russet Burbank. The mean percentage of total number and total tuber weight composed of diseased tubers for Russet Burbank was 1.2 and 1.2%, respectively, and 3.9 and 3.3%, respectively, for Shepody (Tables 3 and 4).

DISCUSSION

The results of our trials over 2 years substantiate that metalaxyl-m applied at planting in-furrow is a viable option for control of pink rot caused by metalaxyl-m-sensitive strains of *P. erythrosectica*. However, phosphite applied in-furrow did not

provide disease control. The use of metalaxyl-m for pink rot control is supported by our results and those obtained in other studies (21,33,38).

Pink rot of potato has developed into a disease of immense economic importance in North America. Existence of metalaxyl-resistant strains of *P. erythrosectica* has negatively affected the ability of metalaxyl to control pink rot in both the field and storage (14,18,34). The present study was conducted in order to evaluate the efficacy of phosphite applied at planting in-furrow and compare it with metalaxyl, the only fungicide registered for pink rot control in Canada. In-furrow application of metalaxyl resulted in a significant reduction in pink rot incidence in Shepody and Russet Burbank tubers. This fungicide was effective in controlling a metalaxyl-m-sensitive strain of *P. erythrosectica* which was isolated from infected potato originating in New Brunswick. These results are in agreement with those obtained by other

scientists which provide further proof that metalaxyl continues to be the most effective means of controlling the disease (24,26,33,38). In-furrow application of phosphate slightly reduced the incidence of pink rot, but the rate of reduction was not statistically significant. It may have suppressed this inoculum somewhat by direct contact, but certainly was not taken up by plant tissues in sufficient quantities to provide any lasting benefits. No variation was noted in fungicide efficacy between the 2 years of this study.

Tubers of Russet Burbank were less susceptible to pink rot than tubers of Shepody. Previous studies that evaluated the response of different potato cultivars to pink rot revealed that Russet Burbank was the least susceptible to pink rot while Shepody was the most susceptible (23,25,30). Therefore, our results are in agreement with these earlier reports.

Potato growers commonly have applied metalaxyl to the foliage when daughter

Table 1. Number of tubers showing pink rot symptoms expressed as percentages of the total number of tubers, 2005

Treatment or cv. ^u	Russet Burbank		Shepody		Mean ^x
	In-furrow ^v	Late season ^w	In-furrow ^v	Late season ^w	
Control	1.8	8.1	10.9	17.4	9.5 a
Phostrol	3.0	6.7	5.8	25.1	10.1 a
Ridomil Gold	0.1	2.5	0.7	3.6	1.7 b
Mean ^y	1.7	5.7	5.8	15.4	...
Mean ^z	3.7 b		10.6 a		...

^u Fungicide treatments were applied in-furrow. Data for the uninoculated untreated control are not included in the table.

^v Inoculum of *Phytophthora erythrosectica* applied as a vermiculite slurry in-furrow at planting.

^w Inoculum of *P. erythrosectica* applied as a zoospore drench in soils adjacent to plants in late August.

^x Treatment means across cultivars and inoculation methods. Means in the column followed by the same letter are not significantly different according to a protected test of least significant difference (LSD). Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

^y Means for inoculation method by cultivar. Analysis of main effects demonstrated that the late-season inoculation yielded significantly ($P < 0.001$) more disease than the in-furrow inoculation method. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

^z Grand means for each cultivar. Means in the row followed by the same letter are not significantly different according to a protected test of LSD. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

Table 2. Weight of tubers showing pink rot symptoms expressed as percentages of the total tuber weight, 2005

Treatment or cv. ^u	Russet Burbank		Shepody		Mean ^x
	In-furrow ^v	Late season ^w	In-furrow ^v	Late season ^w	
Control	1.8	7.3	9.6	16.8	8.9 a
Phostrol	2.8	6.2	5.4	23.9	9.6 a
Ridomil Gold	0.1	2.5	0.3	3.2	1.5 b
Mean ^y	1.5	5.3	5.1	14.6	...
Mean ^z	3.4 b		9.9 a		...

^u Fungicide treatments were applied in-furrow. Data for the uninoculated untreated control are not included in the table.

^v Inoculum of *Phytophthora erythrosectica* applied as a vermiculite slurry in-furrow at planting.

^w Inoculum of *P. erythrosectica* applied as a zoospore drench in soils adjacent to plants in late August.

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^y Means for inoculation method by cultivar. Analysis of main effects demonstrated that the late-season inoculation yielded significantly ($P < 0.001$) more disease than the in-furrow inoculation method. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

^z Grand means for each cultivar. Means in the row followed by the same letter are not significantly different according to a protected test of LSD. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

tubers are approximately 20 mm in diameter, but with limited success (11,33). Most tuber infections originate at the stem end following stolon infection (24). Consequently, applications of metalaxyl at planting may be more appropriate than timed foliar applications to circumvent tuber infection by this pathway. In earlier studies, where various application methods were examined, it was noted that the greatest level of pink rot control was attained with at-planting in-furrow application of metalaxyl (33). Plots receiving metalaxyl in-furrow recorded the lowest proportion of cull potato tubers and least number of tubers with general decay symptoms at harvest compared with other treatments (11,33). Despite the advantages of the in-furrow treatment in reducing disease incidence, the question arises whether continued soil applications of metalaxyl potentially could increase the risk of resistant populations of *P. erythroseptica* developing more so than with foliar applications.

According to Urech (35), the possibility of resistance to phenylamide developing in a soilborne organism is considered to be lower than for an airborne organism. Even so, several regions have reported resistance to metalaxyl in isolates of *P. erythroseptica* (14,18,29). Soil applications of persistent fungicides are known to increase the selection pressure for resistant strains (5).

This is the first study where products of this type have been challenged in the field using the late-season field inoculation method, which mimics late-season zoospore release in wet soils. Among the two inoculum application methods used, the late-season application of pink rot inoculum yielded more disease than the in-furrow application and, hence, provided a more rigorous test of product efficacy. Disease incidence was higher in 2005 than in 2006. This variation is likely due to wet weather conditions that were prevalent before and after application of inoculum in late August of 2005. Approximately 28

mm of rain was received the day before the late-season inoculation was made and 12 mm during and after inoculation. This probably allowed more zoospores to swim and reach target tubers, hence causing more disease. This is in agreement with results obtained by Gundersen and Inglis (16). In the 2006 trial, no rain was received before or after the late season inoculations were made; therefore, water was applied to the plots before and after inoculation (approximately 10.70 liters per 9.14-m row).

Phosphite is registered in the United States for the control of oomycetes. In-furrow application is one of the application methods stated on the product label. However, in our 2-year study, phosphite applied in-furrow at recommended label rates was not effective in controlling pink rot. In a study published by Johnson et al. (17), foliar application of phosphorous acid-based fungicides was slightly more effective against pink rot than in-furrow application and, in some cases, three foliar applications were required to obtain some disease suppression (17,20). Similar results of lower activity of phosphorous acid-based products in controlling pink rot were obtained when using nonwounded and wounded potato tubers inoculated with *P. erythroseptica* (8,38). Phosphonate is translocated both upward and downward due to its mobility in the xylem and phloem (10). This systemic property permits its use as a foliar spray for control of root rots caused by *Phytophthora* spp. and other oomycetes (6). It has been suggested that phosphorous acid could be a more effective chemical for pink rot control when infections occur by natural openings, stolons, or roots, rather than wounds (17). It is likely that the in-furrow application of phosphite in our study did not provide adequate quantities of fungicide to reach plant tissues to confer disease suppression. Further studies are necessary to identify the most effective means of phosphite application and also to identify specific conditions that limit its effectiveness.

Table 3. Number of tubers showing pink rot symptoms expressed as percentages of the total number of tubers, 2006

Treatment or cv. ^u	Russet Burbank		Shepody		Mean ^x
	In-furrow ^v	Late season ^w	In-furrow ^v	Late season ^w	
Control	0.4	2.7	3.7	6.3	3.3 a
Phostrol	0.1	2.9	2.3	7.3	3.1 a
Ridomil Gold	0.2	0.9	1.0	3.2	1.3 b
Mean ^y	0.2	2.2	2.3	5.6	...
Mean ^z	1.2 b		3.9 a		...

^u Fungicide treatments were applied in-furrow. Data for the uninoculated untreated control are not included in the table.

^v Inoculum of *Phytophthora erythroseptica* applied as a vermiculite slurry in-furrow at planting.

^w Inoculum of *P. erythroseptica* applied as a zoospore drench in soils adjacent to plants in late August.

^x Treatment means across cultivars and inoculation methods. Means in the column followed by the same letter are not significantly different according to a protected test of least significant difference (LSD). Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

^y Means for inoculation method by cultivar. Analysis of main effects demonstrated that the late-season inoculation yielded significantly ($P < 0.001$) more disease than the in-furrow inoculation method. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

^z Grand means for each cultivar. Means in the row followed by the same letter are not significantly different according to a protected test of LSD. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

Table 4. Weight of tubers showing pink rot symptoms expressed as percentages of the total tuber weight, 2006

Treatment or cv. ^u	Russet Burbank		Shepody		Mean ^x
	In-furrow ^v	Late season ^w	In furrow ^v	Late season ^w	
Control	0.2	2.9	1.6	6.4	2.8 a
Phostrol	0.1	2.8	1.6	6.8	2.8 a
Ridomil Gold	0.2	0.8	0.6	3.0	1.2 b
Mean ^y	0.2	2.2	1.3	5.4	...
Mean ^z	1.2 b		3.3 a		...

^u Fungicide treatments were applied in-furrow. Data for the uninoculated untreated control are not included in the table.

^v Inoculum of *Phytophthora erythroseptica* applied as a vermiculite slurry in-furrow at planting.

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^z Grand means for each cultivar. Means in the row followed by the same letter are not significantly different according to a protected test of LSD. Data were transformed prior to analysis ($\log[x + 1]$); raw means are presented.

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