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Post-Harvest Applications of Phosphorous Acid Materials for Control of *Phytophthora infestans* and *Phytophthora erythroseptica* on Potatoes

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Abstract: The purpose of this study was to determine the value of select phosphorous acid materials compared to existing post-harvest materials in preventing tuber-to-tuber spread of *Phytophthora infestans* and *Phytophthora erythroseptica* during the mechanical harvesting and tuber transfer in a situation where the diseases are present at harvest. Products evaluated over two seasons were Phostrol, Rampart and ProPhyt; these were tested against Oxidate and Agclor 310 for control of late blight and pink rot. Tubers were treated with the control materials one or three hours post inoculation. Oxidate and Agclor 310 were ineffective in controlling either *P. infestans* or *P. erythroseptica*. All tested phosphorous acid materials provided complete control of both tested pathogens in 2005 and in 2006. In a second test, less than labeled rates provided less than complete control of *P. infestans*. Phosphorus acid materials have potential for post-harvest control of late blight and pink rot.

Key words: *Solanum tuberosum*, late blight, pink rot, potato storage

INTRODUCTION

Late blight, caused by *Phytophthora infestans* (Mont.) de Bary and pink rot, caused by *Phytophthora erythroseptica* Pethybr. are two devastating potato tuber diseases. These pathogens regularly cause loss in many potato production systems (Stark and Love, 2003). A figure of $3 million USD was reported in one production area as a result of a late blight epidemic in 1995 (Johnson *et al*., 1997) and regularly more than 10% of the cost of production is spent on late blight control (Guenthner *et al*., 2001). Metalaxyl had been the standard for control but with the advent of resistance to metalaxyl in both pathogens (Lambert and Salas, 1994; Smart and Fry, 2001), the material is no longer an effective control measure in many cases.

While these pathogens, especially *P. infestans*, spread rapidly in the field, there also can be substantial tuber-to-tuber spread during the mechanical harvesting and tuber transfer procedures (Lambert *et al*., 1998). Tuber-to-tuber spread is encouraged when tuber damage or skin damage occurs during mechanical harvesting and tuber transfer procedures. Reduction of tuber skinning and damage is one of the overriding factors to extend the time between vine kill and harvest. Tuber loss owing to these pathogens has occurred with skinned or damaged tubers have long been established (Bonde and Schultz, 1949). With these diseases present in the field, storage losses can occur well beyond what would be expected based on the pathogen level in the field. Mechanical damage during harvest and tuber transfer of pathogens continues to occur as do these diseases. Concerns on the effectiveness of the applications with respect to the timing of mechanical damage exist. Concerns on the effectiveness of reduced rates exist as well. Reports on the effectiveness by phosphorous acid materials for late blight and pink rot control have appeared. Most of the information is in-season applications and not post-harvest applications (Cooke and Little, 2001; Johnson *et al*., 2004; Mayton and Fry, 2006). Phosphorus acid materials were tested in a post-harvest situation against currently available materials Oxidate (hydrogen dioxide) and Agclor 310 (sodium hypochlorite). Hydrogen dioxide and sodium hypochlorite are currently used as post-harvest disinfestants for potato disease control. Phosphorus acid (phosphonate or phosphate) is the anionic metabolite of the systemic fungicide aluminum tris-O-ethyl phosphonate (fosetyl-Al) (Ouimette and Coffey, 1989). Phosphorous acid is effective in reducing oomycete diseases (Forster *et al*., 1998). The mode of action of phosphorous acid is not as a nutritional source but as systemic antifungal activity towards mycelial growth (Fenn and Coffey, 1989).

Phosphorous acid materials are now formulated for post-harvest use on potatoes (Johnson, 2007). The object of this study was to determine the value of phosphorous acid materials in preventing tuber-to-tuber spread of *P. infestans* and *P. erythroseptica* during the mechanical harvesting and tuber transfer in a situation where the diseases are present at harvest.

MATERIALS AND METHODS

In early October 2005 and in 2006, locally grown potato tubers cv. Shepody, from Northern Maine were harvested. All efforts were made to insure there was no existing pink rot or late blight present in any of the tubers.

In both years, within 7 days, the potato tubers were individually abraded. Abrasion was accomplished by holding a tuber against a belt sander operating at moderate speed. The abraded area encircled each tuber. The abrading simulated damage which may occur during mechanical harvesting and tuber transfer procedures. As the abrading completely removed the skin and exposed the tuber periderm, it mimicked skinning damage as well as more severe tuber damage. This also provided ideal infection sites for both pathogens. Immediately following abrading, the tubers were dampened to improve infection conditions and then inoculated with *P. erythroseptica* or *P. infestans* (US-8 genotype). Pathogen isolates were obtained from locally infected tubers on water agar. Isolates of *P. infestans* were transferred to V-8 agar and isolates of *P. erythroseptica* were transferred to potato dextrose agar. Cultures of the pathogens were macerated to prepare inoculum. A titer of approximately 50,000 propagules per mL of both pathogens was used to inoculate the abraded tubers. Propagules consisted of both sporangia and mycelial fragments. Each abraded test tuber was atomized with approximately 1 mL of the pathogen solution.

In both years, treatments included an untreated control, Oxidate (hydrogen dioxide) at the rate of 44 mL, Phostrol at the rate of 378 mL, Agclor 310 (sodium hypochlorite) at the rate of 1.4 mL, ProPhyt at the rate of 378 mL or at the rate of 757 mL. All treatment rates were per 907 kg of tubers. In 2006, the experiment was repeated where an additional treatment of Rampart at the rate of 378 mL 907 kg^{-1} was included. In both years, all treatments were applied atomized at a volume of 1900 mL 907 kg^{-1}. In both years, treatments were applied either 1 or 3 h post inoculation. Treatment timings of 1 and 3 h after exposure were chosen as the potential waiting periods between harvest and unloading in a commercial situation. Separate experiments were conducted with each pathogen.

An additional study was performed in 2006. The study was conducted under the same conditions with Shepody tubers from the same harvest but only using *P. infestans*, the late blight pathogen. Treatments consisted of Rampart or Phostrol at the rate of 378 (full rate), 189 (half rate) or 95 mL (quarter rate) 907 kg^{-1} of tubers and an untreated control. All treatments were atomized at a volume of 1900 mL 907 kg^{-1}. Treatments were applied 1 and 3 h post inoculation. Full, half and quarter labeled rates were chosen to simulate either poor coverage or reduced rate of material applied.

In each case, experimental units consisting of 9.1 kg of abraded and inoculated tubers were arranged in a randomized complete block design and placed into a research storage and held at 13°C with a relative humidity greater than 95%. After 30 days of storage, the experimental units were removed and tubers individually peeled and evaluated for disease symptoms. Tubers were rated as either infected or not infected. With the high pathogen titer and warm storage conditions used in this study, presence or absence of rot was an effective disease rating. Tubers were either heavily diseased or not at all. Data were recorded on a percentage basis and analyzed untransformed with Fisher's LSD test.

RESULTS AND DISCUSSION

Existing materials for postharvest application, Oxidate and Agclor 310, at the applied rates tested, were ineffective in controlling either *Phytophthora infestans* (Table 1) or *P. erythroseptica* (Table 2). Similar results with Oxidate were found by Miller *et al.* (2006). Sauer and Burroughs (1986) reported poor results with low concentrations of sodium hypochlorite for control of

Table 1: Severity of late blight on Shepody potatoes after 30 days of storage (2005 and 2006 crop) as affected by phosphorous acid applications

		2005		2006	
		Late blight (%)		Late blight (%)	
Treatments	Rate* (mL)	1 h	3 h	1 h	3 h
Check	0	100.00	100.00	95.00	100.00
Agclor 310	1.4	100.00	100.00	31.25	67.50
Oxidate	44	98.00	84.25	41.25	40.00
Phostrol	378	0.00	0.00	0.00	0.00
ProPhyt	378	0.00	0.00	0.00	0.00
ProPhyt	757	0.00	0.00	0.00	0.00
Rampart	378			0.00	0.00
LSD value at alpha = 0.05		2.46	7.56	4.36	2.81

*: 907 kg^{-1}

Table 2: Severity of pink rot on Shepody potatoes after 30 days of storage (2005 and 2006 crop) as affected by phosphorous acid applications

		2005		2006	
		Pink rot (%)		Pink rot (%)	
Treatments	Rate* (mL)	1 h	3 h	1 h	3 h
Check	0	95.00	100.00	100.00	100.00
Agclor 310	1.4	58.00	65.00	92.50	93.75
Oxidate	44	100.00	74.50	100.00	100.00
Phostrol	378	0.00	0.00	0.00	0.00
ProPhyt	378	0.00	0.00	0.00	0.00
ProPhyt	757	0.00	0.00	0.00	0.00
Rampart	378			0.00	0.00
LSD value at alpha = 0.05		10.37	16.25	8.15	8.04

*: 907 kg^{-1}

Table 3: Severity of late blight on Shepody potatoes after 30 days of storage (2006 crop) with varied rates of phosphorous acid

		2006	
		Late blight (%)	
Treatments	Rate* (mL)	1 h	3 h
Check	0	100.00	100.00
Rampart	95	10.00	10.00
Rampart	189	0.00	0.00
Rampart	378	0.00	0.00
Phostrol	95	5.00	25.00
Phostrol	189	0.00	10.00
Phostrol	378	0.00	0.00
LSD value at alpha = 0.05		10.42	10.42

*: 907 kg^{-1}

Aspergillius spp. All full rate of tested phosphorous acid materials (Phostrol, ProPhyt and Rampart) provided complete control of both tested pathogens in 2005 and in 2006. This test was set up to mimic tuber transfer in a situation where the diseases are present at harvest. The abrasion damage was more severe than would be expected in a normal field situation; the tubers were exposed to a level of inoculum greater than would be expected in a normal field situation and then placed into very favorable conditions for disease development. Complete control under these conditions is significant and shows great potential for phosphorous acid use in commercial situations. The question of material effectiveness with inadequate coverage warrants additional study.

In the additional test performed in 2006, labeled rates completely controlled *P. infestans* as in the other studies conducted and reported here. At less than labeled rates, less than complete control of *P. infestans* was achieved. Rampart or Phostrol at one fourth rate (95 mL) failed to provide complete control of *P. infestans* at one or three hours post inoculation; Phostrol at half rate (189 mL) failed to provide complete control at three hours post inoculation. Again, the question of material effectiveness with reduced rates and combined with inadequate coverage warrants additional study.

All tested phosphorous acid materials at labeled rates provided excellent control in this test mimicking tuber-to-tuber spread. It can be postulated that other phosphorus acid materials would provide similar control of the pathogens (Table 3). The presence of disease with the reduced rates of both Rampart and Phostrol is a concern. Improper application leading to inadequate coverage may yield similar results. Inadequate coverage or reduced rates may give the appearance of nonperformance when in reality, application method or rate inconsistencies would be responsible. No clear break off point for the control can be determined from this study; however, most growers have a zero tolerance for late blight or pink rot in storage.

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