Control of potato late blight with foliar application of phosphonate

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Abstract

Phosphonate, also known as phosphites, represents a class of fungicides that has activity against a number of fungi and has been associated with induced resistance. The efficacy of foliar applications of phosphonate against *Phytophthora infestans* was evaluated in potato field trials in 2007 and 2008 in Peruvian highlands. Potato varieties with horizontal resistance were used in theses trials because previous studies had shown that phosphonate works better when there is a measurable background level of host resistance. Phosphonate treatments alone or together with contact fungicide gave results similar to spray regimes involving both contact and systemic conventional fungicides. Phosphonate treatments gave sufficient control, even though they received fewer sprays than did treatments based on conventional practices. Based on an analysis of marginal rates of return, phosphonate appeared to be economically advantages over other treatments. Application of the Environmental Impact Quotient (EIQ) demonstrated reduced health and environmental risks of this class of disease control product.

Keywords: Phosphite, Environmental Quotient, horizontal potato varieties.

Introduction

One of the main problems of growing potato worldwide is the economic losses which occur due to late blight, which is caused by oomycete *Phytophthora infestans.* This pathogen can destroy all potato plants in few weeks under wet conditions. In recent years, highly aggressive strains of the pathogen —many insensitive to some popular synthetic fungicides—have surfaced and created new challenges for potato producers, making disease management efforts increasingly difficult (Powelson, 1998; Levy, 1983)

Several nonchemical options are available for managing this disease, including cultural practices, varietal resistance, and alternative sprays that inhibit disease development. Phosphonate (or as salts known as phosphites) in general can stimulate plant defense responses and is also active against oomycetes *in vivo* (Guest and Grant, 1991). In Argentina, phosphites applied to seed tubers of potato cultivars Shepody and Kennebec gave high levels of protection against *P. infestans*, intermediate protection against *F. solani* and low against *R. solani* (Lobato et al, 2008). These compounds pose a very low risk to human health and environment and therefore represent a potential alternative for use within an integrated crop management, especially potato varieties with some moderate resistance to *P. infestans.*

Materials and methods

Two field experiments were carried out between 2007 and 2009 in Huasahuasi (masl,   latitude), Junin, Peru. This place is one of the most important areas of continuous potato production in the Peruvian Central highlands and a location with high disease pressure. Previous studies indicated that the current *P. infestans* population in this place is dominated by the EC-1 clonal lineage and causes important economic losses to farmers (Bustamante, et al, 2008; Otazu, personnel communication).

Potato genotypes and fungicide treatments.

Three potato varieties (Amarilis, Serranita and Chucmarina) and one elite clone from CIP's breeding programme (CIP 386549.9) catalogued as horizontally resistant to late blight were used in the experiments. Fungicide treatments consisted of applications of phosphonate (T1), alternation of phosphonate and contact fungicide

(T2), local farmers' strategy (T3) and a control treatment without fungicide application (T4). Here local farmers' strategy refers to use of systemic and contact fungicides as farmers customarily do it, including the mixture of more than 2 active ingredients in the same application. In 2007, treatments T1 and T2 were based on a calendar of sprays every 9 days and in 2008 these treatments were based on sprays after each 30 mm of accumulated rainfall. The minimum number of days between sprays in both years was set at 5 days. All sprays programs were continued until plants reached senescence. All pesticides were applied with a backpack sprayer with hollow-cone nozzle and application volumes were standardized by applying until runoff. Backpack sprayer operating pressure was uniformly adjusted to 2 bars.

Experimental design and agronomic practices

The experiments were carried out in a strip-plot design with two major factors (fungicides and potato varieties) with 3 repetitions. The experimental units consisted of 30 plants in 2007 and 100 plants in 2008. Planting density was 0.9 m between rows and 0.35 – 0.40 m between plants. Fertilizer application was 140 kg N ha^{-1}, 120 Kg P ha^{-1} and 80 kg K ha^{-1}. Nematicide was applied at planting and insecticides were applied when necessary.

Evaluation of late blight in the field

The percentage of foliar infection was estimated visually at the plot level every 7 days for 9 – 11 times after plants had reached a minimum size of 15 to 25 cm and until plants reached senescence. The area under the disease progress curve (AUDPC) was calculated for each plot from the estimates of foliar infection using the midpoint method (Campbell and Madden, 1990). To help standardize AUDPC values across years, AUDPC values were transformed into the relative AUDPC (rAUDPC) as described by Fry (1978).

Evaluation of potato yield

Tubers were harvested at maturity between 110 -120 days after planting. Tubers were separated in commercial (> 40 g) and non-commercial (<40 g) size and weighed for each plot.

Statistical analysis

Data from each year were analyzed independently in order to explore two-way interactions between potato varieties and efficacy of phosphonate treatments. Statistical analyses were done using SAS 9.1 statistical software (SAS Institute Inc., Cary, NC). The benefits of alternative treatments were analyzed by partial budgeting as reported previously (CIMMYT 1988) and by using the Environmental Impact Quotient (EIQ), which was calculated to compare spraying programs as reported by Kovach (1992).

Results and discussion

Disease was severe each year as evidenced by the statistically high rAUDPC values for control treatments (Table 1). The farmer's strategy resulted in significantly lower rAUDPC values each year, but yields were more similar among phosphonate and farmer treatments. EIQ values were many times higher in farmers' treatment in 2007-2009 and this tendency was even more marked in 2008-2009.

There was also a marked difference in resistance among varieties, with Amarilis being the most susceptible both years (Table 2). We explored the variety by treatment interaction graphically (Figures 1 and 2). In the first year there was no clear interaction but in the second year, phosphonate appeared to work very poorly for cultivar Amarilis which only had adequate control with the farmer's strategy.

The Farmers' strategy involves expensive systemic fungicides and this lead to much high costs (data not shown). An analysis of partial budgets (currently underway) will potentially demonstrate that there are economic benefits to the use of phosphonate.

In conclusion, it appears that phosphonate has potential to manage late blight of potato but more information is needed about the potential variety specificity and whether augmentation with fungicides may be needed under some conditions.

Table 1. Effect of treatments on control potato late blight (*Phytophthora* infestans) and yield during two cropping seasons on farms in Huasahuasi, Peru

Season	Treatment	Sprays	rAUDPC	Commercial yield	EIQ
2007 -2008	Control (T4)	0	0.202 c	10.14 b	0.0
	Phosphonate (T1)	7	0.058 bc	17.22 a	12.93
	Phosphonate + Fungicide (T2)	7	0.076 b	12.32 b	40.54
	Farmers' strategy (T3)	7	0.054 a	17.29 a	107.87
2008 -2009	Control (T4)	0	0.317 c	55.53 b	0.0
	Phosphonate (T1)	9	0.120 b	77.36 ab	16.62
	Phosphonate + Fungicide (T2)	9	0.090 b	81.86 ab	43.88
	Farmers' strategy (T4)	7	0.000 a	108.10 a	255.44

Table 2. Effect of potato variety on severity of late blight and production of commercial tubers during two cropping seasons on farms in Huasahuasi, Peru

	2007-2008		2008 - 2009	
Variety/Clone	rAUDPC	Yield	rAUDPC	Yield
Amarilis	0.17 a	19.72 a	0.30 a	46.091 c
Serranita	0.06 b	13.099 ab	0.10 b	74.968 b
CIP 386549.9	0.05 b	10.173 b	-	-
Chucmarina	-	-	0.00 c	121.074 a

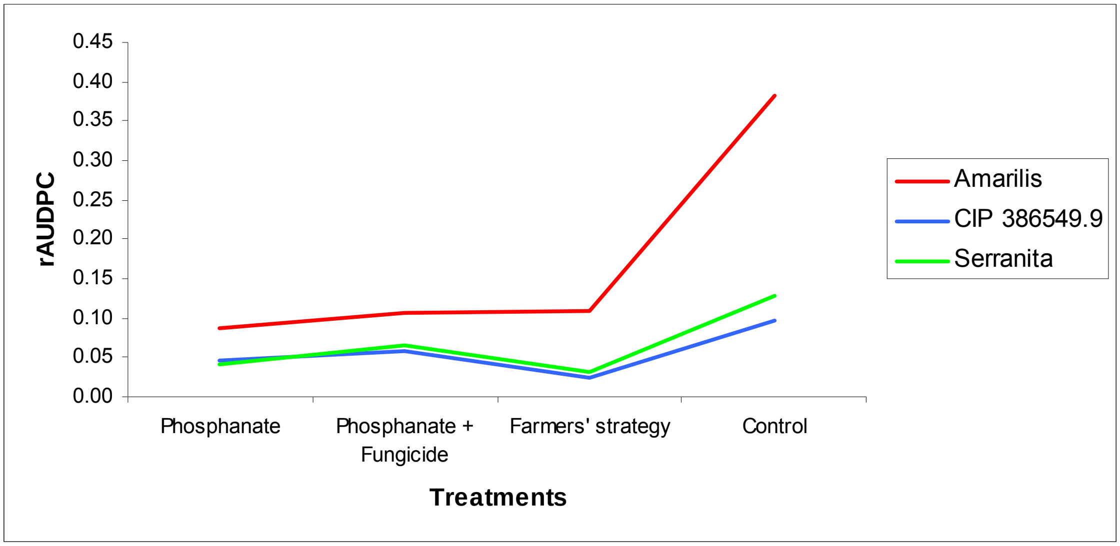

Figure 1. Resistance to Late blight in potato varieties during 2007 – 2008 growing season

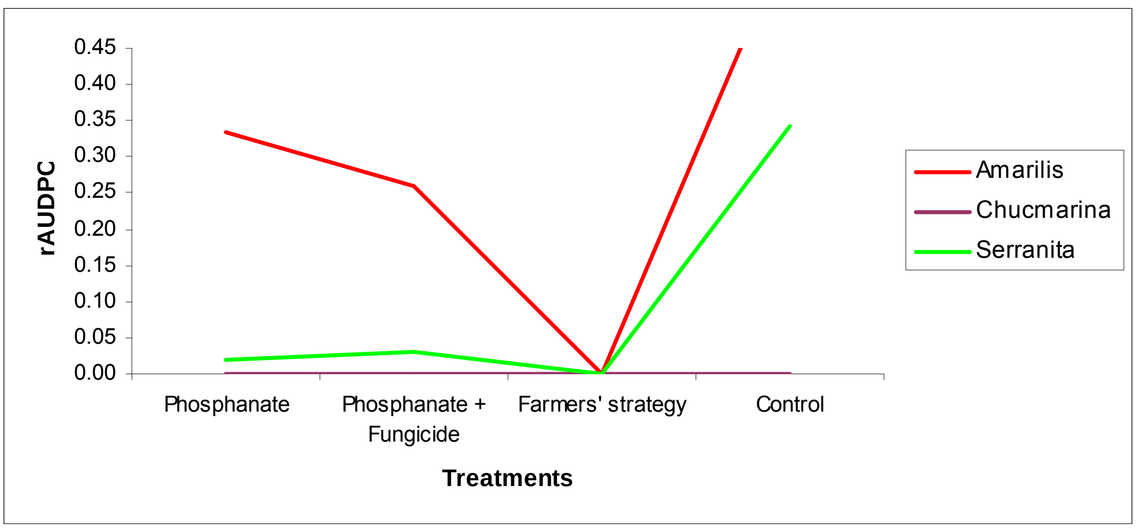

Figure 2. Resistance to Late blight in potato varieties during 2008 -2009 growing season

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