Timing and Root Absorption Affecting Efficiency of Metalaxyl in Controlling *Phytophthora infestans* on Potato in Northwestern Washington State

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ABSTRACT

Easton, G. D., and Nagle, M. E. 1985. Timing and root absorption affecting efficiency of metalaxyl in controlling *Phytophthora infestans* on potato in northwestern Washington State. Plant Disease 69:499-500.

Late blight of potato (cultivar White Rose) was controlled in plots where metalaxyl applied 18 hr previously to foliage was washed into the soil by rain and sprinkler irrigation. Foliage application gave less effective control in plots where a plastic tarp on the soil surface prevented entry of metalaxyl into the soil, where it could be absorbed by roots. Control of late blight was better and yields were significantly higher in plots sprayed before late blight appeared than in plots sprayed after late blight developed on leaves. Foliage sprays prevented most tuber rot from late blight at harvest. For maximum control of *P. infestans*, metalaxyl should be applied to foliage before symptoms appear. The fungicide is then washed off the leaves by rain or sprinkler irrigation and absorbed by the roots.

In northwestern Washington State, late blight of potato, caused by *Phytophthora infestans* (Mont.) de Bary, occurs annually. In 1979 at Mt. Vernon, WA, during a low-rainfall year (about 60% of average), five foliage sprays of metalaxyl (Ridomil) applied every 2 wk for a total of 1 kg a.i./ha failed to control *P. infestans* effectively (1). During that year, rainfall washed very little metalaxyl off foliage for absorption by roots (1); however, metalaxyl did reduce foliage blight when applied as a dust to cut seed pieces at about 1.2 kg a.i./ha (1 kg of 5% dust/q of seed). We assumed, therefore, that metalaxyl was better absorbed by roots than by leaves. In greenhouse studies, ^{14}C-labeled metalaxyl applied to foliage of seedlings of tomato and avocado was not translocated in sufficient amounts to control *P. cinnamomi* Rands (5). In another study, better late blight protection occurred if metalaxyl was applied to soil rather than foliage (4). Metalaxyl applied to diseased foliage has been reported to act as an eradicant of *P. infestans* and to control the organism within 2 days (2). This paper reports a study of timing and method of metalaxyl application to promote absorption by either potato foliage or roots for the most effective control of *P. infestans*.

Washington State University, College of Agriculture and Home Economics, Pullman, WA 99164, Scientific Paper 6876, Project 1709.

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Accepted for publication 2 January 1985 (submitted for electronic processing).

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MATERIALS AND METHODS

Tests were conducted near Mt. Vernon, WA, on a Puget silt loam soil on the very susceptible potato cultivar White Rose. Sprays of metalaxyl were applied to foliage both before and after late blight occurred. Late blight control and tuber production were compared in plots where treatments were applied to foliage over polyethylene-tarped and untarped plots. Tarps prevented most metalaxyl runoff from reaching the soil to be absorbed by the roots. Plots with no metalaxyl application served as control treatments. Plots were 2.7 m wide (three rows) by 6.1 m long, and all chemical, tarping, and control treatments were arranged in a randomized complete block design with five replicates.

The field was planted on 18 May. On 21 June, when plants were 10–15 cm high, 0.01-mm clear polyethylene tarps 8.5 m wide by 9.2 m long were laid over plots to be sprayed later with metalaxyl either before or after late blight had occured. Plants were pulled through slits cut in the tarps. Earth dams were made in the furrows at the ends of the plots under the tarps to prevent water runoff from going under the tarps. On 30 June, before late blight appeared, and again on 27 July, after late blight was present, plots with and without tarping were sprayed with metalaxyl at 0.28 kg a.i./ha in 233 L/ha of water at 24 psi at 1.6 km/hr with a hand-carried, gas-engine-powered sprayer with boom. On 27 July only, shortly after late blight first appeared, plots to be sprayed after late blight occurred were sprayed with the same rate of metalaxyl. Sprays of metalaxyl were not repeated after 27 July because the disease was controlled effectively on treated plots through the first part of September.

About 18 hr after each foliage application, metalaxyl was washed off foliage in plots with and without plastic tarps by a solid-set sprinkler-irrigation system. This system applied 1–2 cm of water at 45 psi through 0.36-cm-diameter orifices during a 1.5-hr period. Equal amounts of water were also applied to unsprayed plots. Water applied was calculated from 7-cm-diameter catch bottles in the irrigated plots. Plant defoliation and death caused by late blight were measured five times at 2-wk intervals starting on 27 July. Measurements were based on a scale of 0 = no foliar lesions to 10 = all leaves infected and plants completely defoliated. Precipitation data for June through October were extracted from records of a weather station within 0.8 km from the testing site. On 30 September, foliage was killed with the desiccant dinoseb applied at 5.6 kg/ha in 467 L/ha of water. All foliage was dead at harvest on 25 October. Yields were taken from the center row of each plot. Tubers were washed and graded, and the weight of those with late blight was recorded before they were discarded. Blightfree tubers were held at 3–5 C until March to measure development of additional tuber rot.

A rill-irrigation system was designed to irrigate the plots underneath the tarps but was not needed because of a natural underground water supply.

Orthogonal comparisons were used to test significance of treatment means at $P = 0.01$ (3).

RESULTS AND DISCUSSION

Very wet weather favorable for late blight occurred during the experiment. Mean temperatures and rainfall were 16.5 C and 9.1 cm in June, 16.1 C and 6.8 cm in July, 17.2 C and 2.8 cm in August, 13.4 C and 8.9 cm in September, and 9.7 C and 4.3 cm in October. Late blight lesions on foliage appeared on 27 July, and untreated plots were completely defoliated by late August.

Metalaxyl applied to foliage had significantly reduced foliage late blight and tuber rot at harvest and had significantly increased total yield and the percentage of No. 1 tubers (Table 1). Metalaxyl sprays initiated before late blight symptoms occurred significantly reduced foliage late blight appearing by 27 July and 10 August and increased yield significantly more than metalaxyl applied

Table 1. Control of *Phytophthora infestans* and production of potato cultivar White Rose by metalaxyl (MET) applied to foliage under regimes of spray timing, tarping, and irrigation

	Late blight foliage disease index[t]					Percent late blight tuber rot (25 Oct.)	Percent U.S. No. 1 tubers	Yield (q/ha)
	July	August		September				
Orthogonal comparison	27	10	24	7	22			
MET before[u]	0.4	0.6	1.4	5.2	7.8	5.3	75	496*
MET after[v]	0.9*[w]	1.1*	1.5	5.3	8.2	5.4	77	411
MET before, tarped[x]	0.5	0.8	1.8*	6.6*	8.9*	7.1	73	436
MET before, not tarped	0.3	0.3	1.0	3.8	6.7	3.8	77	556*
MET after, tarped	1.0	1.5*	1.9*	6.7*	9.0*	5.0	79	365
MET after, not tarped	0.7	0.7	1.1	3.9	7.3	5.8	75	456*
MET[y]	0.6	0.8	1.5	5.3	8.0	5.5	76*	453*
No MET	1.7*	4.2*	8.8*	10.0*	10.0*	15.2*	70	199
Tarped only, no MET	1.7	4.2	8.8	10.0	10.0	15.2	70	199
Not tarped, no MET	3.8	6.0	9.2	10.0	10.0	16.5	68	179
MET-sprinkled[z]	0.8	0.9	1.6	5.4	7.7	7.0	75	469
MET-not sprinkled	0.5	0.8	1.4	5.2	8.3	3.7	77	437
Sprinkled only, no MET	1.0	4.3	8.8	10.0	10.0	16.3	71	192
Not sprinkled, no MET	0.7	4.1	8.8	10.0	10.0	14.1	69	206

[t] Index of 0–10, where 0 = no foliar lesions and 10 = all leaves infected and plants completely defoliated.
[u] Foliage sprayed on 30 June before late blight lesions appeared and again on 27 July at 0.28 kg a.i./ha at 24 psi.
[v] Foliage sprayed (0.28 kg a.i./ha at 24 psi) on 27 July after late blight appeared.
[w] Mean with asterisk in pair is significantly different at $P = 0.01$ by F test.
[x] Plots covered with 0.01-mm clear polyethylene tarp with plants growing through slits to prevent metalaxyl runoff from reaching roots.
[y] Mean of all metalaxyl treatments.
[z] Plots sprinkler-irrigated (1–2 cm) 18 hr after every metalaxyl spray to wash fungicide from leaves.

after the appearance of late blight. Plots tarped to prevent most metalaxyl sprayed on foliage from reaching the soil after sprinkler irrigation had significantly more late blight on foliage and significantly less yield than similarly treated untarped plots whether metalaxyl was sprayed before or after late blight symptoms appeared. A control treatment of an additional sprinkler irrigation to plots sprayed and not sprayed with metalaxyl had no effect on late blight or potato production. Likewise, the presence of tarps had no effect on late blight or potato production. No additional late blight tuber rot developed in storage from any treatment by 14 March 1984.

Control of foliage late blight by foliar sprays of metalaxyl was more effective when the chemical was washed into the soil, where it could be absorbed by roots. This observation agrees with our previous findings that foliage sprays of metalaxyl gave no control during a low-rainfall year when little if any metalaxyl was washed off leaves into the soil (1). One application of metalaxyl over seed pieces at planting (at a higher rate) gave control equal to or better than that obtained with foliage applications (G. D. Easton, *unpublished*). In Ohio, a single, in-furrow application of metalaxyl at planting was also reported to control late blight on foliage and rot on tubers (4). Metalaxyl apparently needs to be either washed off foliage by precipitation or supplemental irrigation or be applied to soil or seed pieces at planting for subsequent uptake by roots to provide maximum control of *P. infestans*.

Foliage sprays of metalaxyl in tarped plots gave some control of *P. infestans* in the high-rainfall year 1983. Control could have been due to absorption of metalaxyl through leaves or stems or to absorption by roots of runoff that escaped down the stems into the soil through slits in the tarps.

Metalaxyl has been reported to act as an eradicant of *P. infestans* and to control the organism within 2 days (2). Under severe late blight conditions, however, metalaxyl needs to be applied before appearance of the disease to be most effective.

ACKNOWLEDGMENTS

We wish to thank the Washington State Potato Commission and Ciba-Geigy Agricultural Division for products and grants to support this study.

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