

## POST INFECTION ACTIVITY OF LATE BLIGHT FUNGICIDES ON POTATO STEMS

by

Dennis A. Johnson and Tom Cummings, Department of Plant Pathology,  
Washington State University

Late blight is a very explosive disease and management in the Columbia Basin depends on a combination of eliminating inoculum on seed tubers and potato tuber refuse (culls), proper irrigation management, adequate plant hilling to protect tubers from infection and timely and thorough applications of effective fungicides. Effective fungicides include chlorothalonil (Bravo, Terranil), mancozeb (Dithane DF, Manzate 200) metiram (Polyram 80DF), triphenyltin hydroxide (Super Tin), dimethomorph (Acrobat MZ), cymoxanil (Curzate), and propamocarb (Tattoo C).

Triphenyltin hydroxide (Super Tin) and Curzate should be mixed with a protectant fungicide such as metiram or mancozeb. Copper based fungicides by themselves are not effective in controlling late blight on potato foliage under disease conditions experienced in the Columbia Basin. Metalaxyl (Ridomil) is ineffective against the late blight strains in the Pacific Northwest. Ridomil prepacks that contain chlorothalonil or mancozeb are effective protectants against late blight, but it is the chlorothalonil and mancozeb and not the Ridomil that protects against late blight.

Fungicides are most effective when applications are made before infection. This is because most fungicides are protective and are not effective once the late blight fungus enters plant tissue. However, triphenyltin hydroxide has been reported to restrict sporulation and Acrobat MZ, Curzate, and Tattoo C may have some activity after infection has occurred. A knowledge of fungicide characteristics when applied after infection may be useful in selecting material to use when late blight is present in a field. A series of experiments were conducted in the greenhouse on potato stems and leaves previously inoculated with the late blight fungus to determine their effectiveness after infection.

### Materials and Methods

Stems of potted potato plants, cultivar Russet Burbank, were inoculated in two separate trials with isolates 3-366 (undetermined genotype, A-1 mating type) and CF-1 (US8) of *Phytophthora infestans*. Inoculum was increased on excised leaves of Russet Burbank at 18 C in humid chambers. Pre-flowering plants about 55 cm in height were inoculated by placing 0.05 ml of sporangium suspension containing 10,000 sporangia/ml on a 1 cm filter paper square and then on the main stem about 30 to 40 cm from the soil line. Inoculated plants were placed in a mist chamber for 18 hours and then in the greenhouse until lesions developed.

Lesions developed on inoculated stems within five days after inoculation. Plants with stem lesions were then treated or not treated (control) with one of five to seven fungicides or fungicide combinations six days after inoculation and again placed in the mist chamber for 18 hours.

---

This Presentation is part of the 1999 Proceedings of the Washington State Potato Conference and Trade Show.

Fungicide treatments were arranged in randomized complete blocks with eight replicates. Length that lesions expanded and quantity of sporangia were then determined on each infected stem. Lesions on stems were again treated with the same fungicides five to seven days after the first fungicide application (eleven to thirteen days after the original inoculation). Plants were placed in the mist chamber, removed after 18 hours, and then lesion expansion and quantity of sporulation determined.

Lesion expansion was determined by marking the upper edge of the lesion with a permanent marker before placement in the mist chamber and measuring the length of new lesion area with a ruler after removing plants from the chamber. Sporangia were quantified by cutting a 2-cm section of the stem with sporulation and placing in a spore fixative solution. They were then counted with a microscope and quantity per area of stem determined. The density of mass of sporangiophores and sporangia were rated from 0 to 4 as no visible sporulation, light, moderate, abundant, and very abundant, respectively.

Length of initial lesion size five days after inoculation was 5 to 8 cm on stems inoculated with isolate 3-366 and 1 to 2 cm on stems inoculated with CF-1. The second fungicide application was made seven and five days after the first fungicide application for isolates 3-366 and CF-1, respectively. Temperatures for both inoculations were 62° to 72° F in the mist chamber and 74° to 80° F during the day and 65° to 72° F during the night in the greenhouse.

In two additional experiments, potato leaves were inoculated with an US8 isolate of *Phytophthora infestans* and placed in a mist chamber for 12 hours. At 12, 24, 36, and 48 hours after inoculation, leaves were treated with one of four to five fungicides. Treatments were arranged as a randomized complete block with four replicates and three sub-treatments per replicate. Disease severity, incidence and quantity of spores were determined.

## Results

Lesion expansion was significantly ( $P = 0.05$ ) restricted with one and two applications of Acrobat MZ, Manex C8, and Polyram plus Super Tin when stems were previously infected with isolates 3-366 and CF-1 (US8). Two applications of Tattoo C were required to restrict lesions expansion (Table 1). Sporulation was significantly ( $P = 0.05$ ) reduced with one and two applications of Acrobat MZ and Manex C-8 in stems infected with both isolates. Sporulation was significantly ( $P = 0.05$ ) reduced one and two applications of Polyram plus Super Tin with stems infected with isolate CF-1. Sporulation was not significantly ( $P = 0.05$ ) reduced with one application of Tattoo C (Table 2). These results are similar as those obtained in a previous experiment (Table 3).

Manex C8 (Curzate + mancozeb) and Tattoo C, as measured by lesion development, had curative action on Russet Burbank leaves 12 and 24 hours after inoculation and as measured by inhibition of sporulation, had curative action up to 48 hours after inoculation (Figures 1 & 2).

## Discussion

Late blight is extremely hard to manage once the disease is present in a field. Microclimate conditions in potato fields after row closure are usually favorable for infection whenever the field is sprinkler irrigated.

Acrobat MZ, Manex C8, Curzate plus mancozeb (Manzate 200 or Dithane DF) and Polyram plus Super Tin would be effective fungicides to use in potato fields when late blight is present. Limiting lesion expansion and inhibiting sporulation on stems helps abate late blight outbreaks. Expanding lesions are potentially harmful to the potato crop because they are capable of producing sporangia as they expand during favorable environmental conditions. In contrast, new lesions developing from infecting sporangia are required to pass through a 4-day or longer latent period before they are capable of producing sporangia. Fewer tuber infections should also occur if sporulation is prevented in the crop canopy.

Using short application intervals, decreasing the frequency of sprinkler irrigation applications, and irrigating when the crop canopy will be wet the least amount of time also helps to slow late blight development once it is present in a field. With regard to fungicides, however, the economic and effective timing for fungicide applications is to begin before the disease is in the field.

**Table 1.** Mean length of stem lesion expansion when Russet Burbank potato stems with late blight lesions were treated with various fungicides at six and eleven to thirteen days after inoculation.

Fungicide	Rate/A	Lesion Expansion Length (cm) <sup>a</sup>			
		New A-1 Isolate 3-366		Strains US 8	
		6	6 & 13	6	6 & 11
Control	0	2.4a	2.6a	4.4a	3.1a
Quadris	1.15pt	2.2ab	1.9bc	-----	-----
Bravo WS	1.5pt	2.1abc	2.1b	4.3a	3.4a
Polyram	2.0lb	2.1abc	2.3ab	-----	-----
Tattoo C	2.3pt	1.9bc	0e	3.9ab	1.2bc
Acrobat MZ	2.25lb	1.7cd	1.6cd	2.0c	1.8b
Polyram ST	2lb/2.5oz	1.6d	1.4d	2.7bc	1.2bc
Manex C8	1.5lb	1.5d	0.3e	1.5c	0.3c

<sup>a</sup>Values are means of 8 replicates. Values followed by the same letter are not significantly different at  $P = 0.05$ , according to Duncan's multiple range test.

**Table 2.** Sporulation index and sporangia/cm stem when Russet Burbank potato stems with late blight lesions were treated with various fungicides of six and eleven to thirteen days after inoculation with one of two isolates of *Phytophthora infestans*.<sup>a</sup>

Fungicide	Isolate 3-366 <sup>b</sup>				Strain US8			
	6 days		6 & 13 days		6 days		6 & 11 days	
	Index <sup>c</sup>	S/cm <sup>d</sup>	Index <sup>c</sup>	S/cm <sup>d</sup>	Index <sup>c</sup>	S/cm <sup>d</sup>	Index <sup>c</sup>	S/cm <sup>d</sup>
Control	4a	117a	4a	77a	4a	----	4a	54a
Quadris	4a	99a	4a	36a	----	----	----	----
Bravo WS	4a	129a	4a	51a	4a	----	3.2b	22a
Polyram	4a	74a	4a	42a	----	----	----	----
Tattoo C	4a	111a	3.1b	19a	3.6a	----	1.3c	2b
Polyram ST	4a	117a	3.1b	41a	1.2b	----	1.3c	1bc
Acrobat MZ	1.3c	14b	1.6c	3b	0.3b	----	0.3d	0.3bc
Manex C8	1.9b	14b	0.8d	2b	0.3b	----	0.1d	0c

<sup>a</sup> Values are means of 8 replicates. Values followed by the same letter are not significantly different at  $P = 0.05$ , according to Duncan's multiple range test.

<sup>b</sup> New recombinant, A-1 mating type.

<sup>c</sup> Sporulation index: 0, 1, 2, 3, 4 = none, slight, moderate, abundant and very abundant sporulation, respectively.

<sup>d</sup> Sporangia/cm stem  $\times 10^{-3}$

**Table 3.** Mean length of stem lesion expansion and spore production when Russet Burbank stems with late blight lesions were either treated with various fungicides at six or at six and fifteen days after inoculation.

Fungicide	Rate product/ acre	Day of Fungicide Application After Inoculation <sup>a</sup>			
		Six <sup>b</sup>		Six and Fifteen <sup>c</sup>	
		Lesion expansion length (cm)	Sporulation Index <sup>d</sup>	Lesion expansion length(cm)	Sporulation Index
Control	---	20.3 a	4 a	27.7 a	4.0 a
Curzate 50wp/ Manzate 200DF	4 oz 1.75 lb	19.4 a	3 b	23.7 ab	2.6 b
Bravo WS6F	1.5 pt	18.9 ab	3 b	21.3 ab	3.2 ab
Tattoo C	2.3 pt	18.1 ab	3 b	25.3 ab	2.8 b
Polyram 80 DF/ Super Tin 80 WP	2 lb 2.5 oz	13.5 bc	3 b	18.5 b	3.0 ab
Acrobat MZ	2.25 lb	11.1 c	1 b	24.0 ab	1.0 c

<sup>a</sup> Values followed by the same letter are not significantly different at  $P = 0.05$

<sup>b</sup> Values are means of 8 replicates

<sup>c</sup> Values are means of 4-6 replicates

<sup>d</sup> Sporulation index: 1,2,3,4, = 4,000, 15000, 23000, and 50000 sporangia/cm of infected stem

Postinfec2

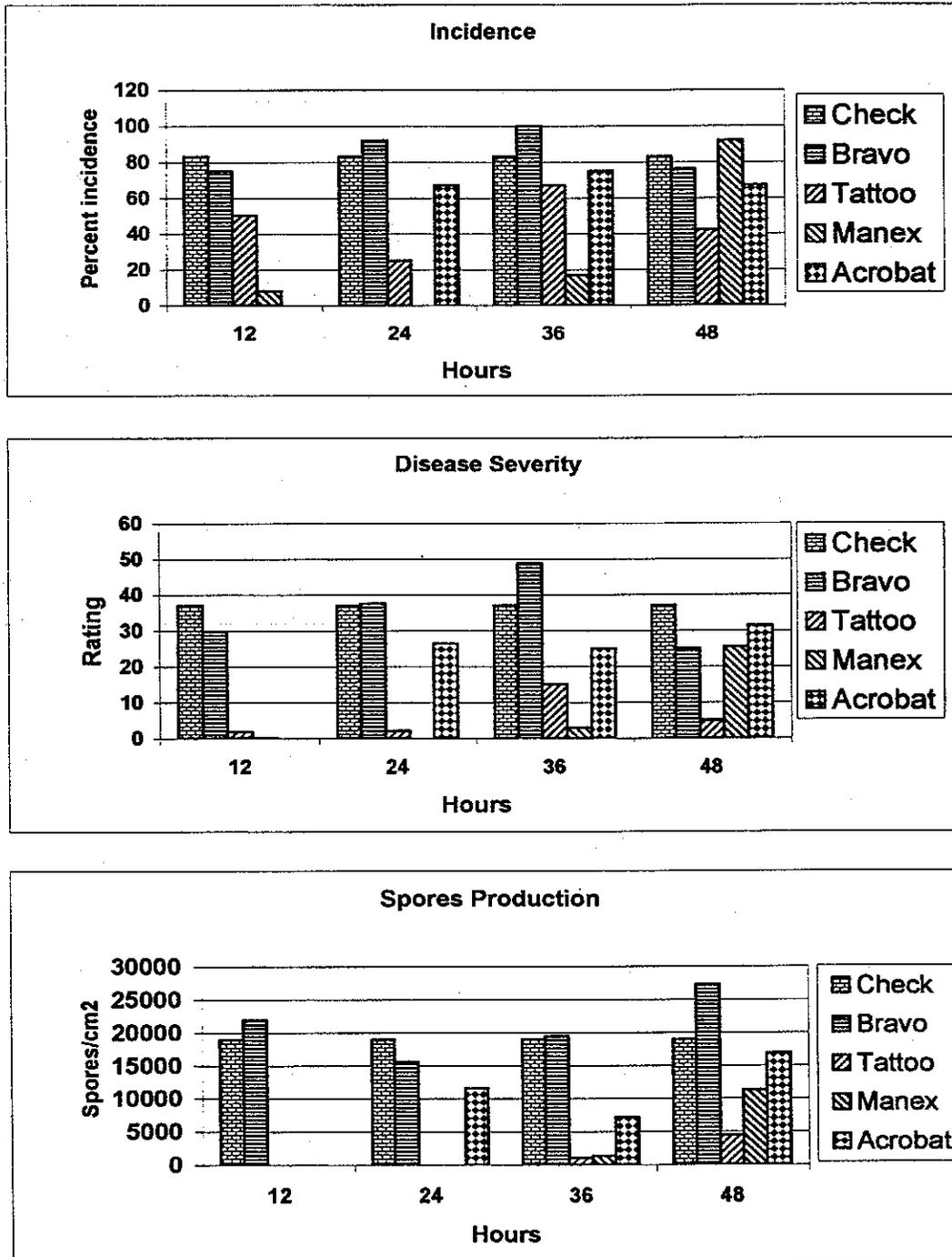


Figure 1. Post infection activity of four fungicides when applied to potato leaves 12, 24, 36, and 48 hours after inoculation with *Phytophthora infestans*.

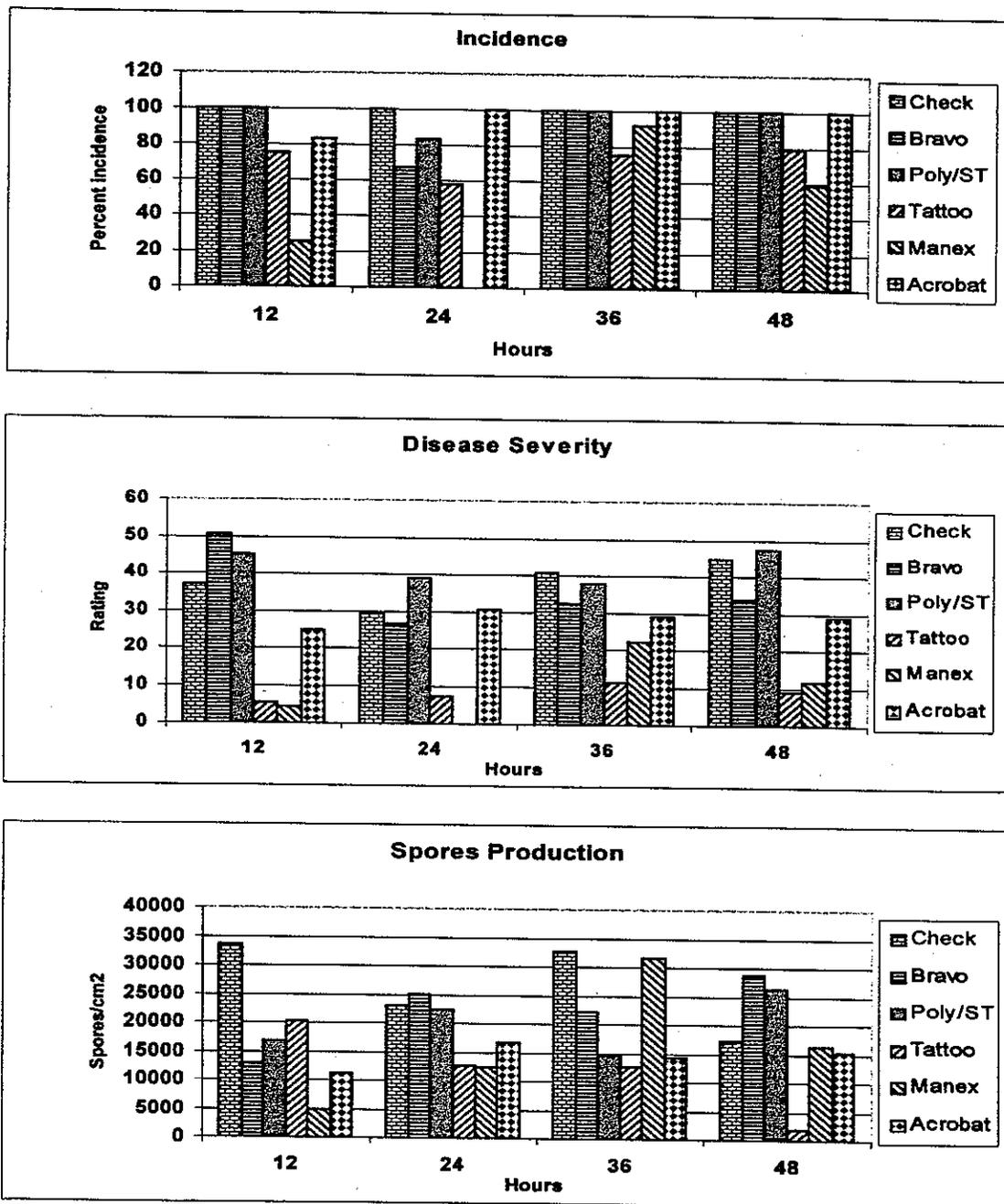


Figure 2. Post infection activity of five fungicides when applied to potato leaves 12, 24, 36, and 48 hours after inoculation with *Phytophthora infestans*.