Control of Phytophthora Rot with Metalaxyl in Established Asparagus

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ABSTRACT

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Field plots of asparagus (*Asparagus officinalis*) established in Yolo loam soil at Davis, CA, and infested with field soil containing *Phytophthora megasperma* var. *sojae* were sprayed with metalaxyl at rates of 0.56, 1.12, or 2.24 kg a.i./ha on either 10 January or 20 February 1983 or at 1.12 kg a.i./ha on both dates. The same treatments were repeated on either 29 November 1983 or 20 February 1984. Treatment with metalaxyl increased yield of marketable spears between 35 and 141% in 1983 and between 17 and 44% in 1984. Results of this trial and a second similar trial on peat soil in the San Joaquin Delta showed that one application of metalaxyl at 1.12 kg a.i./ha applied 7–14 days before the start of harvest resulted in the most cost-effective control of Phytophthora rot during the very wet 1983 season, but a split application of 1.12 kg a.i./ha applied in late autumn and again in early spring produced the highest yields in 1984. Application of metalaxyl to control Phytophthora rot during the winter months while the plants were dormant indicated that winter infections had relatively little effect on production. However, preharvest applications showed that yield losses caused by *Phytophthora* were greatest when infection occurred in the spring. A significant amount of spear and/or crown rot occurred below the soil surface, suggesting that the effect of *Phytophthora* on asparagus production in California has been underestimated in the past, especially in wet years.

Additional key word: fungicide

Yield losses in asparagus (*Asparagus officinalis* L.) caused by *Phytophthora* spp. were reported in California as early as 1938, when postharvest losses of 20–30% were recorded (1). More recent work showed that yield of asparagus was increased between 43% (5) and 141% (6) when Phytophthora rot was controlled by applying metalaxyl (Ridomil 2E) to the surface of asparagus beds before harvest.

Phytophthora spp., predominantly *P. megasperma* Drechs. var. *sojae* Hildebrand, can be isolated from asparagus fern stalks, crown tissue, and spears after heavy autumn rain and throughout the winter and spring months (1,2,5; P. G. Falloon, *unpublished*).

The objectives of this study were to determine 1) the optimum time and rate of application of metalaxyl for the control of Phytophthora rot of asparagus under field conditions and 2) the time of year (winter or spring) when *Phytophthora* has the greatest effect on production. A preliminary report of this work has been published (6).

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MATERIALS AND METHODS

Field plots were established at two locations in 1983. One trial was continued for a second year in 1984.

Trial A, 1983. Plots measuring 12.2 m long by 1.8 m wide were established in a commercial asparagus field on Coney Island, Contra Costa County, CA. The field had been planted with seedling transplants of the cultivar U.C. 157 during spring 1981. Beds were 0.9 m apart and plants were 0.3 m apart in the rows. *P. megasperma* var. *sojae* had been isolated from the soil (Egbert muck) using a seedling baiting technique (3) in December 1981 and from asparagus crowns and spears sampled during 1982. Metalaxyl was applied in about 950 L of water per hectare at rates of 0.56, 1.12, and 2.24 kg a.i./ha with a compressed CO_2 sprayer. A band 1.8 m wide was sprayed either in autumn (20 December 1982) or winter (22 February 1983) or on both dates. Control plots were not sprayed, and the treatments were replicated four times in a randomized complete block design.

Spear numbers (diseased or healthy) from the central row of each plot were recorded at weekly intervals starting on 1 March and ending on 28 March 1983. A plant count was made on 1 January 1983 after the first application and again during the following summer on 8 August 1983. Fresh weight of fern cut at ground level from a 6.1-m length of row was recorded on 8 August 1983.

Trial B, 1983 and 1984. Plots measuring 7.3 m long by 3.7 m wide were established at the University of California, Davis, in a trial planting of the cultivar U.C. 157 that had been established in Yolo loam in 1977. Rows were 1.8 m apart and plants were 0.3 m apart in the row. Each plot was infested by spreading about 1 L of soil collected from the field in trial A over the row on 1 September 1983. Dams to minimize contamination between neighboring plots were made at the end of each plot by filling the furrows between the beds with soil. Metalaxyl was applied in about 1,400 L of water per hectare at rates of 0.56, 1.12, or 2.24 kg a.i./ha with a compressed CO_2 sprayer. A band 3.6 m wide was sprayed either during early winter (10 January 1983) or during late winter (20 February 1983) or on both dates at 1.12 kg a.i./ha only. Control plots were not sprayed, and the treatments were replicated four times in a randomized complete block design.

Plots were harvested three times each week for 77 days starting on 3 March and ending on 18 May 1983. The number of diseased and healthy spears was recorded, and the healthy spears were trimmed to 225 mm long, graded into marketable (basal diameter $\geq$5 mm) and reject (basal diameter $<$5 mm, deformed or open bracts) and weighed.

Summer fern was removed by hand from the plots on 28 November 1983, and the same treatments were applied to the same plots either during autumn (29 November 1983) or during winter (20 February 1984). Plants were harvested three times each week for 78 days starting on 15 February and ending on 2 May 1984. Fresh weight was measured on 2 September 1984 of fern cut at ground level from the middle row of each plot.

Climatological data. Rainfall data were collected from the Stockton Fire Station situated about 20 km from trial A and the University of California, Davis, Climatic Benchmark Station situated about 0.5 km from trial B. Trial A was analyzed as a $3 \times 3 + 1$ factorial and trial

B, as a 3 × 2 + 1 + 1 factorial. Data were subjected to analysis of variance and regression analysis. Differences between treatment means were determined, where appropriate, using an unrestricted least significant difference test.

RESULTS

Trial A. Metalaxyl treatments resulted in total increases of 69–128% more marketable spears than the control plots (Fig. 1). These differences were significant ($P = 0.01$). There were significant quadratic trends with increasing rate of metalaxyl. The r^2 values for autumn, winter, and autumn + winter applications were 0.996, 1.000, and 0.905, respectively. The highest numbers of marketable spears were from plots treated at 1.12 kg a.i./ha in winter or spring. A higher rate of application did not result in a significant yield increase.

There were significantly ($P = 0.01$) more diseased spears in control plots than in any other treatment (Fig. 1). A significant negative quadratic relationship existed between the number of diseased spears and increasing rates of metalaxyl for autumn ($r^2 = 0.981$, linear $r^2 = 0.774$), winter ($r^2 = 0.851$, linear $r^2 = 0.659$), and autumn + winter ($r^2 = 0.927$, linear $r^2 = 0.530$) applications. Fewest diseased spears were harvested from plots sprayed at any of the three rates in both autumn and winter.

There was no significant difference between treatments in survival of plants after fungicide applications or in fern fresh weight in August 1983.

Trial B. Yield of marketable spears was increased 35–141% from plots that were sprayed with metalaxyl in 1983 (Fig. 2A). There was a linear increase ($r^2 = 0.993$) in yield with increasing rates of metalaxyl for early winter application but a quadratic response ($r^2 = 0.999$, linear $r^2 = 0.692$) for late winter applications. Marketable yield was highest in plots sprayed at 1.12 kg a.i./ha either in late winter or in both early and late winter or at 2.24 kg a.i./ha either in early or late winter. The lowest yield from sprayed plants was from the 0.56 kg a.i./ha rate applied in early winter.

Figure 2B shows the number of healthy, diseased, and reject spears from each treatment in 1983. None of the early winter applications completely controlled the disease although the numbers of diseased spears decreased linearily ($r^2 = 0.950$) with increased rates of metalaxyl. No diseased spears were recorded from plots sprayed in late winter at 2.24 kg a.i./ha or at 1.12 kg a.i./ha applied both in early and late winter. There was a linear response ($r^2 = 0.993$) of the number of healthy spears to increased rates of metalaxyl for early winter applications and a quadratic response ($r^2 = 0.994$, linear $r^2 = 0.627$) for late winter applications. The most healthy spears were produced in plots sprayed once in late winter at either 1.12 or 2.24 kg a.i./ha, once in early winter at 2.24 kg a.i./ha, or split applications of 1.12 kg a.i./ha at both times. There was no significant difference between treatments in the number of reject spears. The total number of spears that emerged, i.e., number of healthy spears + number of diseased spears + number of reject spears, was 8–78% higher in plots sprayed with metalaxyl.

In 1984, yield of marketable spears responded quadratically to increased rate of metalaxyl applied either in late autumn ($r^2 = 0.837$, linear $r^2 = 0.173$) or late winter ($r^2 = 0.987$, linear $r^2 = 0.622$). Yield was highest in plots sprayed at 1.12 kg a.i./ha during late autumn and again in late winter (Fig. 3A).

Few diseased spears (<750/ha) were observed in any plot, and there was no significant difference between the treatments (Fig. 3B). The number of healthy spears was lowest in the control plots, and significant quadratic responses to increased rates of metalaxyl were recorded for both late autumn ($r^2 = 0.918$, linear $r^2 = 0.219$) and later winter applications ($r^2 = 0.889$, linear $r^2 = 0.558$). There was no significant difference

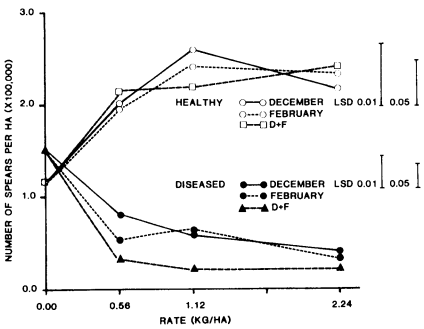

Fig. 1. Number of diseased and marketable spears from plots treated with metalaxyl at 0.56, 1.12, or 2.24 kg a.i./ha in autumn (20 December 1982) or winter (22 February 1983) or on both dates (D+F) on Coney Island in 1983.

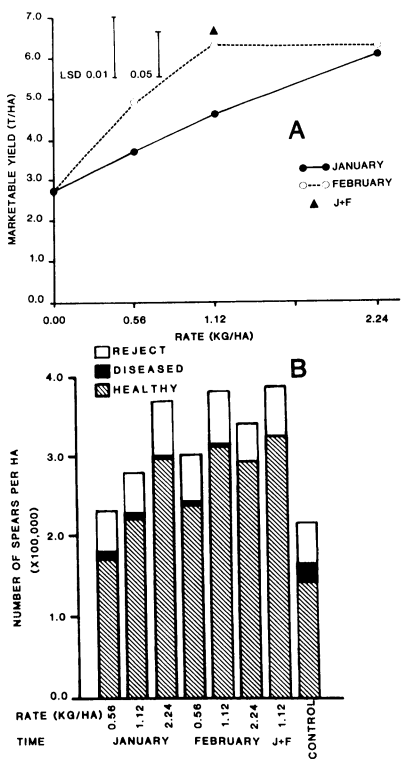

Fig. 2. Effect of metalaxyl applied at rates of 0.56, 1.12, or 2.24 kg a.i./ha in early winter (10 January 1983) or late winter (20 February 1983) or at 1.12 kg a.i./ha on both dates (J+F) on **(A)** marketable yield and **(B)** numbers of diseased, marketable, and reject spears at Davis in 1983.

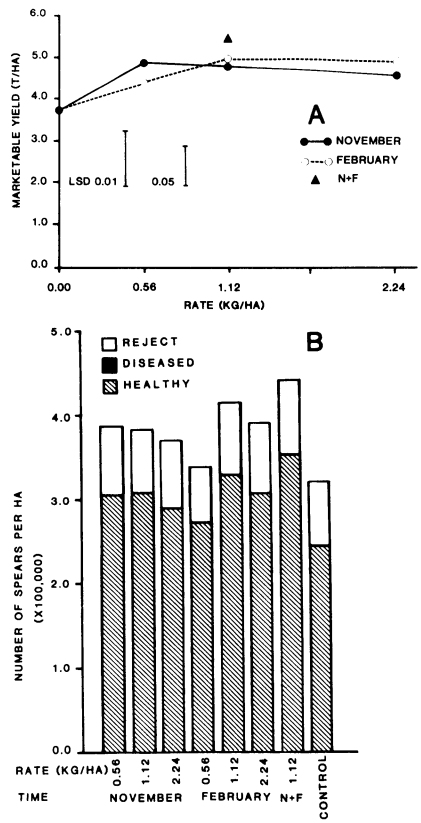

Fig. 3. Effect of metalaxyl applied at rates of 0.56, 1.12, or 2.24 kg a.i./ha in autumn (29 November 1983) or winter (20 February 1984) or at 1.12 kg a.i./ha on both dates (N+F) on **(A)** marketable yield and **(B)** numbers of diseased, marketable, and reject spears at Davis in 1984. Numbers of diseased spears were too low to be shown.

Table 1. Precipitation at Stockton Fire Station and Davis for November through May during 1983–1984

	Precipitation (mm)		
	Stockton	Davis	
Month	1983	1983	1984
November	132	145	164
December	76	69	167
January	115	152	10
February	113	160	32
March[a]	172	219	26
April[a]	74	71	9
May[a]	15	10	0
Total	697	826	408

[a] Harvest months.

between treatments in the number of reject spears, but the total number of spears that emerged was 6–37% higher in sprayed plots. There was no significant difference between treatments in fresh weight of fern recorded in 1984.

DISCUSSION

Rainfall data (Table 1) show that there was considerably more rain during the harvest season in 1983 than in 1984. For example, in 1983 at Davis, 300 mm of rain fell during the harvest season and 526 mm fell in the 4 mo before harvest, whereas in 1984, only 77 mm fell between January and May inclusive. Consequently, very few *Phytophthora*-infected spears were observed in 1984 compared with 1983.

Symptoms of Phytophthora rot were observed on senescing summer fern stalks after heavy rains at Davis in November 1983 (164 mm). Despite further rain in December (167 mm) after the first metalaxyl applications, no yield advantage was gained from autumn over late winter applications. This was also shown at Davis and on Coney Island during the 1983 harvest season, when no advantage in yield or number of spears was evident in comparisons of early and late winter applications. This may indicate that Phytophthora rot during the winter months while the asparagus plants were dormant had relatively little effect on productivity of the plants during the following harvest season, but Phytophthora rot had a major effect on production during spear emergence in the spring, especially under wet field conditions.

Because there was no difference between late winter metalaxyl application rates of 1.12 or 2.24 kg a.i./ha at Davis or on Coney Island, one application at 1.12 kg a.i./ha applied 7–14 days before the harvest season started would have resulted in the most cost-effective control of Phytophthora rot of asparagus in 1983 on both a high-organic-matter soil (Coney Island) and a mineral soil (Davis). A preharvest application of 1.30 kg a.i./ha was more effective than 0.65 kg a.i./ha on established asparagus on mineral soils in New Zealand (7). However, when a wet winter was followed by a relatively dry spring, e.g., at Davis in 1984, a split application of metalaxyl applied as soon as the fern is removed in the winter and again before harvest in the spring may give the best results. Further work is required to determine the optimum combination of rates for a split application.

There was no difference in plant survival or fern fresh weight between treatments in 1982 on Coney Island or in fern fresh weight between treatments at Davis in 1984 despite the marked increase in yield of marketable spears in treated plots. Other trials at Davis (P. G. Falloon, *unpublished*) have shown that Phytophthora rot of established asparagus has little immediate effect on plant survival or vigor of summer fern growth.

Because a higher total number of spears was recorded in plots treated with metalaxyl in both years at Davis, a significant amount of spear and/or crown rot must have occurred below the soil surface in control plots and was therefore undetected. This has been shown in other trials at Davis (5; P. G. Falloon, *unpublished*) and suggests that the effect of *Phytophthora* on asparagus production in California has probably been underestimated in the past, especially in wet years.

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