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Dry Bean Rust Management in Southeastern Wyoming, 1995

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Abstract

This study was conducted during 1995 at the University of Wyoming Research and Extension Center, located near Torrington. Five foliar fungicide treatments were compared to a nontreated control for management of bean rust caused by the fungus Uromyces appendiculatus. The effect of bean rust management on seed yield and quality also was determined. All fungicide treatments significantly reduced both rust severity and foliar necrosis when compared to the nontreated control ($\underline{P}$<0.05). All fungicide treatments provided statistically equivalent levels of disease control ($\underline{P}$<0.05). The trend was observed that when the first fungicide application was delayed until 10 days after inoculum was first introduced into the plot, less disease resulted compared to fungicide applications initiated immediately before inoculum was introduced. Additional field work is needed to determine if this trend is real. All fungicide treatments resulted in significantly greater yields than the control ($\underline{P}$<0.05). However, there was no effect of fungicide treatment on seed test weight ($\underline{P}$<0.05). No phytotoxicity was observed from any of the foliar fungicide treatments.

Materials and Methods

The bean rust fungicide trial was conducted during 1995 at the University of Wyoming Research and Extension Center, located near Torrington. On June 2, the field plot was planted with the dry bean (Phaseolus vulgaris L.) variety 'Bill Z' at the rate of 62 pounds of seed per acre with 30-inch row spacings. Four corn rows were planted on June 13 to surround the plot area and to provide a more favorable environment for bean rust development caused by Uromyces appendiculatus. After plant emergence, treatment plots were laid out as a randomized complete block design with four replicates. Treatment plots measured 20-feet long by two-rows wide with a 5-foot in-row buffer and two spreader rows between plots. On July 12 and immediately following the first fungicide application, rust-infected plants from the greenhouse were transplanted into the spreader rows to ensure an inoculum source. No signs of bean rust were observed in the field plot prior to introducing the inoculum into the spreader rows. The field plot received overhead irrigation when needed. Weed and insect pests were not a problem in the field plot area.

The foliar fungicide treatments and their application rates are listed in Table 1. The active ingredient of each product is listed in Table 2. Fungicide applications were made on July 12, July 21, and August 2 and corresponded to a 40, 50, and 60-days-after-planting spray schedule, respectively. Products were applied using a backpack sprayer in a total spray volume of 34 gallons per acre at 25 psi boom pressure. The boom was equipped with four #8004 flat fan nozzles spaced at 20 inches.

Disease severity was assessed by counting the number of rust pustules per 0.5 inch diameter leaf disc. Ten terminal leaflets were randomly selected from the middle canopy of each plot on August 18 and 24. The 10 leaflets were placed in a stack and a cork borer (0.5 inch diameter) was used to punch 20 discs. The number of pustules per leaf disc was counted and the average number of pustules per leaf disc was computed. In addition, a visual estimate of foliar necrosis was taken on August 31 using the Horsfall-Barratt scale (0-11). The center 10 feet by two-rows for each plot was harvested by hand on September 25. Plants were air dried, then threshed for determination of total plot yield and 200-seed test weights.

All data were analyzed using PC-SAS in a two-way ANOVA with four replications. Data for the number of rust pustules per disc were transformed (square root) to correct for non-homogeneity prior to analysis. Data prior to transformation are presented in Table 1. Mean separation was done using Fisher's protected LSD ($\underline{P}$=0.05). After analysis, Horsfall-Barratt data were converted to percentages for presentation in Table 1.

Results and Discussion

Although rust initially developed slowly, by the end of August disease was severe with extensive leaf necrosis and defoliation evident. It also was evident from viewing the pattern of rust development in the field plot that spores produced by spreader rows played the major role in disease development. White mold (Sclerotinia sclerotiorum) was present throughout the field plot and may have confounded seed yield and/or seed quality results.

The effect of fungicide treatment on bean rust disease severity and yield is shown in Table 1. All fungicide treatments significantly reduced the number of rust pustules per leaf disc, when compared to the nontreated control, for collections made on both sampling dates ($\underline{P}$<0.05). Also, all fungicide treatments provided statistically equivalent levels of disease control ($\underline{P}$<0.05). The Bravo 720 treatment applied at 50 and 60 days after planting had the lowest number of pustules present on August 24. Because inoculum was placed in the spreader rows on July 12 (40 days after planting), applications made shortly after disease initiation may be more economical for rust management. However, this trend requires additional testing to determine if the observed differences are real. Visual ratings of foliar necrosis near the end of the growing season showed all fungicide treatments significantly reduced foliar necrosis ($\underline{P}$<0.05). All fungicide treatments significantly increased seed yields when compared to the control (P<0.05). However, seed weight was not significantly affected (P<0.05). No phytotoxicity was observed from any of the foliar fungicide treatments.

Acknowledgments

We gratefully acknowledge the assistance of the field crew at the Torrington Research and Extension Center.

Table 1. The effects of foliar fungicide applications on bean rust disease management (G.D. Franc, et al., Torrington, WY, 1995).

Treatment and application rate (product/A)	Application interval (days-after-planting)	Number of rust pustules/0.5 inch diameter leaf disc		% foliar necrosis	Seed yield and quality	
		Aug 18	Aug 24	Aug 31	lb/A	oz/200 seeds
1. Control (none)	NA	15.1 a*	38.4 a	86 a	1294.9 c	1.89 a
2. ICIA-5504 (0.125 lb)	40 & 50	4.3 b	13.2 b	56 b	1669.4 ab	2.00 a
3. Bravo Zn (3 pt)	40 & 50	2.1 b	8.0 b	50 b	1862.3 a	2.06 a
4. Bravo 720 (2 pt)	40 & 50	2.8 b	10.2 b	50 b	1578.9 b	2.03 a
5. Bravo 720 (2 pt)	50 & 60	1.7 b	2.8 b	46 b	1682.5 ab	2.10 a
6. Bravo Ultrex (1.8 lb)	40 & 50	1.4 b	8.3 b	46 b	1793.3 ab	2.06 a

*Treatment means followed by different letters differ significantly (Fisher's Protected LSD, P=0.05).

Table 2. The active ingredients of the foliar fungicides tested for bean rust disease management in southeastern Wyoming (G.D. Franc, et al., Torrington, WY, 1995).

Product	Manufacturer	Composition
Bravo 720 6F	ISK Biotech Corporation 5966 Heisley Rd. Mentor, OH 44061	54% Chlorothalonil
Bravo Ultrex	ISK Biotech Corporation	82.5% Chlorothalonil
Bravo Zn	ISK Biotech Corporation	40.4% Chlorothalonil
ICIA-5504 80WDG	Zeneca Ag. Products 1800 Concord Pike Wilmington, DE 19897	80% Methoxyacrylate

Dry Bean Foliar Disease Management in Southeastern Wyoming, 1996

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Abstract

This study was conducted at the University of Wyoming Research and Extension Center, near Torrington. Eight foliar fungicide treatments were compared to a nontreated control for management of bean rust caused by the fungus Uromyces appendiculatus. All fungicide treatments significantly reduced both rust severity and foliar necrosis when compared to the nontreated control ($\underline{P}<0.05$). On September 9, 109.0 rust pustules/disc were present in the nontreated control and the best fungicide treatment had 3.77 rust pustules/disc, a reduction in disease severity of more than 96 percent. Treatment with Folicur (6 fluid ounces) + Induce or IB11924 + Bravo Weather Stik resulted in significantly less disease than did treatment with Maneb + Champ ($\underline{P}<0.05$). All fungicide treatments resulted in lower disease severity (AUDPC) values when compared to the nontreated control ($\underline{P}<0.05$). The best treatment was Folicur (6 fluid ounces) + Induce which had a significantly lower AUDPC value than all other treatments except treatment with IB11924 + Bravo Weather Stik ($\underline{P}<0.05$). All fungicide treatments resulted in significantly greater yields and higher seed test weights than the nontreated control ($\underline{P}<0.05$). No phytotoxicity was observed from any of the foliar fungicide treatments.

Materials and Methods

The bean rust fungicide trial was conducted at the University of Wyoming Research and Extension Center, near Torrington. Plots were initially planted on May 22, however, due to cold, wet conditions, a poor stand resulted. On June 25, the field plot was replanted with dry beans (Phaseolus vulgaris L. variety Bill Z) at the rate of 62 pounds of seed per acre and at 30-inch row-center spacings. Four corn border rows were planted on May 22 to surround the plot area and to provide more favorable environmental conditions for bean rust development. After plant emergence, treatment plots were arranged in a randomized complete block design of nine treatments and four replications. Treatment plots measured 20-feet long by two-rows wide and a 5-foot in-row buffer and two spreader rows remained between plots. The field plot received overhead irrigation when needed and weeds and insect pests were controlled as necessary. All disease development was due to naturally occurring inoculum. Rust pustules were first detected on approximately August 8.

The foliar fungicide treatments and their application rates are listed in Tables 1 and 2. The active ingredients are listed in Table 3. All treatments were initiated on August 14, approximately six days after rust pustules were first observed in the field plots. Plants were in the early reproductive stage (R7). All fungicide treatments were applied on August 14 and a single re-application was made at the interval shown in Tables 1 and 2. Treatments made on the 7-to-10-day interval were reapplied on August 23 and treatments on the 14-day interval were reapplied on August 27. The nontreated control was treated with water only in an effort to standardize the plant injury that occurs during application. Fresh products, shipped during the spring of 1996, were used for all treatments. Products were applied using a backpack sprayer in a total spray volume of 42.5 gallons per acre at 30 psi boom pressure. The boom was equipped with four #8004 flat fan nozzles spaced at 20 inches.

Bean rust disease severity was assessed by counting the number of rust pustules per half-inch diameter leaf disc. Ten terminal leaflets from each treatment plot were randomly selected from the middle canopy on August 14 (immediately prior to treatment), 22, and 29 and September 9. The 10 leaflets were placed in a stack and a cork borer (0.5 inch diameter) was used to extract 20 discs. [On August 22, only 10 discs (one disc per leaflet) were counted.] The number of pustules per leaf disc was counted and the average number of pustules per leaf disc was calculated. Also, the area under the disease progress curve (AUDPC) was calculated using pustule counts over the four leaf-collection dates and the AUDPC was subjected to analysis of variance. The AUDPC value is a more complete representation of disease progress over time (total disease) versus pustule counts that represent total disease at a single point in time. Treatments that either reduce disease severity or delay disease development will result in a lower AUDPC value. In addition, a visual estimate of foliar necrosis due to cumulative effects of rust and white mold (Sclerotinia sclerotiorum) was taken on September 9 and 18 using the Horsfall-Barratt scale (0-11). The center 10-feet by two-rows for each plot was harvested by hand on October 5 and then threshed with a small plot combine for determination of total plot yield and the weight of 100 seeds.

All data were analyzed using PC-SAS in a two-way ANOVA with four replications. Data for the AUDPC were transformed ($\log_{10}$) to correct for non-homogeneity prior to analysis. Data prior to transformation are presented in Table 1. Mean separations were done using Fisher's protected LSD ($\underline{P}$=0.05). After analysis, Horsfall-Barratt data were converted to percentages for presentation in Table 1.

Results and Discussion

Although rust initially developed slowly, by the beginning of September disease was severe with extensive leaf necrosis and defoliation evident. White mold was scattered throughout the field plot and may have interacted with the rust to confound foliar necrosis, seed yield, and/or seed quality results.

The effects of fungicide treatments on bean rust disease severity and foliar necrosis are shown in Table 1. On August 22, treatments 2, 4, 5, 8, and 9 had significantly fewer rust pustules per leaflet disc than did the nontreated control ($\underline{P}$<0.05). By August 29, all fungicide treatments significantly reduced disease severity and, at this time, provided statistically equivalent levels of disease control ($\underline{P}$<0.05). On September 9, 109.0 rust pustules/disc were present in the nontreated control and the best fungicide treatment had 3.77 rust pustules/disc, a reduction in disease severity of over 96 percent. Treatments 5 (Folicur high rate + Induce) and 8 (IB11924 + Bravo Weather Stik) had significantly less disease than treatment 3 (Maneb + Champ) ($\underline{P}$<0.05). All fungicide treatments resulted in lower AUDPC values when compared to the nontreated control ($\underline{P}$<0.05). The best treatment was treatment 5 (Folicur high rate + Induce), which had a significantly lower AUDPC value than all other treatments except treatment 8 IB11924 + Bravo Weather Stik) ($\underline{P}$<0.05).

Visual ratings of foliar necrosis on September 9 and 18 included combined necrosis due to both white mold and rust. All fungicide treatments significantly reduced foliar necrosis when compared to the nontreated control and there were no significant differences among the various fungicide treatments ($\underline{P}$<0.05).

Treatment effects on seed yield and quality are shown in Table 2. Yield results correspond closely to the AUDPC values shown in Table 1. All fungicide treatments significantly increased seed yields when compared to the nontreated control ($\underline{P}$<0.05). Treatment 8 had the greatest yield and was significantly better than all treatments except treatment 5 ($\underline{P}$<0.05). All fungicide treatments significantly improved seed weight ($\underline{P}$<0.05). No phytotoxicity was observed from any of the foliar fungicide treatments.

Acknowledgments

We gratefully acknowledge the assistance of Kristin Kaser and Wendy Cecil-Loose and the field crew at the Torrington Research and Extension Center.

Table 1. The effect of foliar fungicide treatments on bean disease management (G.D. Franc, et al., Torrington, WY, 1996).

	Treatment & application rate (product applied per acre)	Trt. interval (days)	Number of rust pustules per half-inch diameter leaf disc			% foliar necrosis[1]		
			Aug 22	Aug 29	Sept 9	Sept 9	Sept 18	AUDPC[2]
1.	Nontreated Control	NA	2.78 ab[3]	5.58 a	109.00 a	59.5 a	95.3 a	668.0 a
2.	Maneb (2 lb)	7-10	1.33 cde	2.05 b	17.95 bc	11.5 b	59.5 b	125.9 bcd
3.	Maneb (2 lb) + Champ (0.65 pt)	7-10	1.63 a-d	2.00 b	28.30 b	8.5 b	59.5 b	184.3 b
4.	Folicur (4 fl oz) + Induce (1.5 pt/100 gal)	14	0.68 de	0.58 b	9.93 bc	12.0 b	64.0 b	64.5 cde
5.	Folicur (6 fl oz) + Induce (1.5 pt/100 gal)	14	0.05 e	0.40 b	3.77 c	9.0 b	55.0 b	24.5 f
6.	Bravo Zn (3 pt)	7-10	2.30 abc	2.35 b	10.40 bc	15.5 b	59.5 b	94.4 b-d
7.	Bravo Weather Stik (2 pt)	7-10	2.83 a	2.20 b	20.20 bc	14.5 b	59.5 b	150.7 bc
8.	IB11924 (2 pt) + Bravo Weather Stik (2 pt)	7-10	1.35 cde	1.15 b	6.28 c	10.3 b	50.0 b	54.0 ef
9.	Bravo Weather Stik (2 pt) + Quadris (0.125 lb)	14	0.53 de	1.25 b	9.55 bc	14.5 b	64.0 b	67.4 cde

[1] Data presented were converted to percentages from Horsfall-Barratt (0-11) data.

[2] Relative area under the disease progress curve, either decreased disease severity and/or later disease onset will contribute to a lower AUDPC value. Data were transformed ($\log_{10}$) prior to analysis.

[3] Treatment means followed by different letters differ significantly (Fisher's Protected LSD, P=0.05).

Table 2. The effect of foliar fungicide treatments on dry bean seed yield and quality (G.D. Franc, et al., Torrington, WY, 1996).

Treatment and application rate (product applied per acre)	Treatment interval[1] (days)	Seed yield and quality	
		cwt/A[2]	ozs. per 100 seeds
1. Nontreated control	NA	19.93[3] d	0.93 c
2. Maneb (2 lb)	7-10	24.72 c	1.09 b
3. Maneb (2 lb) + Champ (0.65 pt)	7-10	25.92 bc	1.10 b
4. Folicur (4 fl oz) + Induce (1.5 pt/100 gal)	14	27.11 bc	1.10 b
5. Folicur (6 fl oz) + Induce (1.5 pt/100 gal)	14	28.43 ab	1.14 ab
6. Bravo Zn (3 pt)	7-10	28.00 b	1.13 ab
7. Bravo Weather Stik (2 pt)	7-10	27.66 b	1.13 ab
8. IB11924 (2 pt) + Bravo Weather Stik (2 pt)	7-10	30.82 a	1.18 a
9. Bravo Weather Stik (2 pt) + Quadris (0.125 lb)	14	27.66 b	1.14 ab

[1] All treatments were applied twice.

[2] Represents combine-cleaned seed weight.

[3] Treatment means followed by different letters differ significantly (Fisher's Protected LSD, P=0.05).

Table 3. Active ingredients of the foliar fungicides tested for bean disease management in southeastern Wyoming (G.D. Franc, et al., University of Wyoming, 1996).

Product	Manufacturer	Composition
Bravo Zn	ISK Biotech Corporation 5966 Heisley Road Mentor, OH 44061	40.4% Chlorothalonil
Bravo Weather Stik	ISK Biotech Corporation	54% Chlorothalonil
IB11924	ISK Biotech Corporation	Chlorothalonil + Heterocycle
Maneb 75DF	Elf Atochem N. America, Inc. 2000 Market Street Philadelphia, PA 19103-3222	75% Mancozeb
Folicur 3.6F	Bayer Corporation P.O. Box 4913 Hawthorne Road Kansas City, MO 64120	39% tebuconazole
Induce	Bayer Corporation	Surfactant containing alkyl polyoxylkane ether, free fatty acids, and IPA
Champ	Agtrol Chemical Products 7322 SW Freeway, Suite 1400 Houston, TX 77074	37.5% Copper Hydroxide
Quadris 80WP	Zeneca Ag. Products 1800 Concord Pike Wilmington, DE 19897	80% Methoxyacrylate

Sugar Beet Seedling Disease Management with In-Furrow Fungicide Treatments, 1996

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Abstract

Field plots were established at the University of Wyoming Research and Extension Center at Torrington. Two in-furrow fungicide treatments were compared to a nontreated control for management of common seedling diseases of sugar beet. Plant stand was not significantly affected by treatment when compared to the nontreated control ($\underline{P}<0.05$). In-furrow fungicide treatment tended to reduce root decay and increased early-season root mass when compared to the nontreated control, although treatment effects were not significant ($\underline{P}<0.05$). None of the treatments significantly affected beet yield or the percentage of sugar when compared to the nontreated control ($\underline{P}<0.05$).

Materials and Methods

Field plots were established at the University of Wyoming Research and Extension Center at Torrington. Plots were arranged in a randomized complete design of three treatments and four replications. Each treatment plot was 40-feet long by four-rows wide and rows were spaced 30 inches. A 5-foot in-row nontreated buffer remained between plots. Prior to planting, the pesticide boxes of the John Deere 7300 planter were calibrated to apply the granular fungicide treatments. Plots were planted and treatments were applied on May 1, 1996. Sugar beet 'Monohikari' was planted at a one-inch seed depth at a population density of approximately 64,000 plants per acre. After all disease evaluations were completed, plants were thinned to approximately 32,000 plants per acre. Plots received overhead irrigation as needed throughout the growing season and weeds were controlled when necessary. On May 17, Betamix was applied (4.5 pints per acre) and plots were cultivated on June 18. Insects were not a problem during the 1996 growing season.

All crop and disease evaluation data were collected from the middle two rows of each treatment plot. For crop and yield data, two 15-foot sections were flagged for this purpose. Stand counts were conducted on May 15, 21, and 23 and June 5 and 11. On June 26, 10 randomly selected plants were removed from each treatment plot and assessed for both incidence and severity of root infection. The severity of root infection (surface area decayed) was estimated using the Horsfall-Barratt scale (0-11). After disease evaluations were completed, roots were oven-dried for dry weight determination. Beets were harvested on September 27 by hand digging. The total root yield and the percentage of sugar were determined from a 10-foot row subsample from each plot.

All data were analyzed with 'Pesticide Research Manager' and 'PC-SAS' in a two-way ANOVA with four replicates and three treatments. Mean separation was accomplished with an F-protected LSD, $\underline{P}=0.05$. Horsfall-Barratt data were analyzed directly, then converted to percentages for presentation in Table 1.

Results and Discussion

Environmental conditions were cool and wet during establishment of the plot. These conditions generally favor root infection and seedling damping-off by various fungi. All disease resulted from naturally occurring inoculum.

The effect of fungicide treatment on stand is shown in Table 1. For all sample periods, stand was not significantly affected by treatment when compared to the nontreated control ($\underline{P}<0.05$). Stands decreased slightly over time for all treatments. Disease incidence and severity data are shown in Table 2. None of the treatments significantly reduced disease incidence or severity ($\underline{P}<0.05$). The dry weights of these roots were not significantly affected ($\underline{P}<0.05$). A trend in the treatment means does show that the in-furrow treatments had less disease and greater root mass (dry weight) than the nontreated control. Treatment effects on sugar beet yield and the percentage of sugar are also shown in Table 2. None of the treatments significantly affected beet yield or sugar content ($\underline{P}<0.05$). Therefore, final root yields did not appear to be affected by early season root infections ($\underline{P}<0.05$). Although the incidence of early-season root infection was approximately 50 percent, decay (disease severity) was not extensive and plants appeared to recover. Also, reducing (thinning) the plant population would tend to equalize the plant population and may have preferentially removed the weakest plants, thus negating treatment effects.

Acknowledgments

We gratefully acknowledge the assistance of Kristin Kaser, Wendy Cecil-Loose, the field crew at the Torrington Research and Extension Center, and Holly Sugar for determining sugar content.

Table 1. The effect of in-furrow fungicide treatments on sugar beet stand establishment (G.D. Franc, et al., University of Wyoming, 1995).

Treatment and rate (product applied per acre)	Stand count per 15 feet of row				
	May 15	May 21	May 23	June 5	June 11
1. Nontreated control	72.3	72.0	72.5	69.6	68.1
2. Ridomil Gold 2.5 G (3 oz/1000 ft of row)	70.0	70.4	71.5	69.3	68.4
3. Ridomil 5G (3 oz/1000 ft of row)	68.5	70.1	71.0	69.4	68.0
ANOVA results	**n.s.[1]**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

[1]Differences among treatment means were not significant (Fisher's Protected LSD, $\underline{P}$=0.05).

Table 2. The effect of in-furrow fungicide treatments on sugar beet seedling disease development, root mass, yield, and sugar content (G.D. Franc, et al., University of Wyoming, 1995).

Treatment and rate (product applied per acre)	June 26[1]				
	Disease incidence (percent)	Disease severity (percent)[2]	Root dry weight (grams)	Beet yield (Tons/A)	Sugar (percent)
1. Nontreated control	52.3	2.1	30.2	26.6	15.4
2. Ridomil Gold 2.5 G (3 oz/1000 ft of row)	50.0	1.5	35.1	25.5	15.6
3. Ridomil 5G (3 oz/1000 ft of row)	42.5	1.5	31.3	28.2	15.3
ANOVA results	**n.s.[3]**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

[1] Treatment means are based on a subsample of 10 roots per treatment plot.
[2] The percentage of root surface-area decayed was estimated using the Horsfall-Barratt scale (0-11)
[3] Differences among treatment means were not significant (Fisher's Protected LSD, $\underline{P}$=0.05).

Table 3. Active ingredients of the granular fungicides tested for sugar beet seedling disease management (G.D. Franc, et al., University of Wyoming, 1995).

Product	Manufacturer	Composition
Ridomil Gold 2.5G	Ciba-Geigy Corporation 410 Swing Road Greensboro, NC 27409	2.5% Mefenoxam
Ridomil 5G	Ciba-Geigy Corporation	5.0% Metalaxyl

Potato Disease Management with In-Furrow, Seedpiece and Foliar Fungicide Treatments, 1995

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Abstract

This study was conducted at the University of Wyoming Research and Extension Center near Torrington during 1995. Several in-furrow and foliar treatment combinations were compared to a standard seedpiece treatment (PST plus bark) and a nontreated control for management of Rhizoctonia stem-canker and foliar early blight. Only one of the Folicur in-furrow treatments significantly reduced Rhizoctonia stem-canker development compared to PST plus bark and the nontreated control ($\underline{P}<0.05$). All Folicur in-furrow treatments and foliar fungicide treatments significantly reduced early blight disease severity by August 24, compared to the nontreated control ($\underline{P}<0.05$). Because a single Folicur in-furrow treatment reduced early blight disease severity measured late in the season, a residual systemic protection of foliage is suggested. Repeated foliar fungicide applications at 14-day intervals resulted in the greatest protection of foliage with significantly less foliar necrosis measured on September 8 ($\underline{P}<0.05$). No phytotoxicity from any treatment was observed in plots; however, plant height and plant vigor was generally reduced by Folicur and HGB-2468 treatments when compared to the nontreated control and PST plus bark. Tuber yield was not significantly affected by the different treatments ($\underline{P}<0.05$). Treatments had no significant effect on Fusarium dry rot development on stored tubers ($\underline{P}<0.05$). The incidence of alligator hide and proliferated lenticels, rated on tubers stored for one month, was not significantly affected ($\underline{P}<0.05$).

Materials and Methods

Field plots were established at the University of Wyoming Research and Extension Center near Torrington during 1995. The experimental design was a randomized complete block with four replicates. Treatment plots were 20-feet long by two-rows wide with 36-inch centers and were separated by two nontreated buffer rows. A 5-foot unplanted buffer area existed at the end of each treated row in the treatment plots. The field plot received overhead irrigation and weeds and insects were controlled.

In-Furrow Treatments: All potato seed (cultivar Shepody) was cut by hand and sorted for a uniform, approximately 2 ounce, seedpiece size 24 hours prior to planting. All treatments and the rates applied are listed in Table 1. The PST plus bark standard seedpiece treatment was applied immediately after cutting. On May 18 all plots were planted with the aid of a mechanical planter. The in-furrow Folicur treatments were applied in a 12-inch band over the top of the seedpieces immediately after planting and prior to soil coverage. Treatments were applied with a hand held spray bottle in a total volume of 12 fluid ounces per treatment.

Foliar Treatments: Foliar treatments were initiated on June 22 when plants were approximately 4 inches in height. For treatments requiring additional applications at 14-day intervals, applications were repeated on July 5 and 19 and August 2 and 17. Foliar treatments were applied with a backpack sprayer in a total spray volume of 39 gallons per acre at 30 psi boom pressure. The spray boom was equipped with four #8004 flat fan spray nozzles spaced at 20 inches.

Data Collection: Stand counts, estimated plant vigor rating, and an average plant height were determined for each plot. Total plot stand counts were taken on June 8, 13, 16, 22, and 30 and July 5. Vigor ratings (nontreated control = 5; more vigorous than control > 5; less vigorous than control < 5), which considered overall appearance of the crop, were taken on July 12, 18, and 26 and August 2. On July 5, 12, and 18 and August 10, heights (vine length) were measured for five plants selected at random for each treatment plot and an average was computed.

After plant emergence, 15 stems were randomly selected from each treatment plot and the percentage of stem surface-area cankered by Rhizoctonia (Rhizoctonia solani) was estimated using the Horsfall-Barratt scale (0-11). Early blight (Alternaria solani) severity was evaluated on August 2 and 24. Nine leaves were randomly selected from each plot: three each from the upper, middle, and lower third of the canopy. The number of early blight lesions on up to seven leaflets per leaf was counted and an average computed. The average number of lesions per leaflet was analyzed and this data is presented in Table 1. By September, extensive crop senescence made lesion counts difficult; however, treatment effects were visibly apparent. Plots were rated for percentage of foliar necrosis on September 8 using the Horsfall-Barratt scale (0-11).

Tuber harvest was done on October 10 with the aid of a single row mechanical harvester. The total yield and grade for each treatment plot were measured. Potato grades included US#1, grade B and culls. On October 12, 10 tubers (US#1) from each plot were placed into labeled paper bags and stored (42 degrees Fahrenheit) for approximately one month. On November 15, tubers were rated for the percentage of surface area affected by Fusarium dry rot (Fusarium spp.) using the Horsfall-Barratt scale (0-11). Ratings were also done for skin defects such as “Alligator Hide” and “Proliferated Lenticel” development that occurred prior to harvest.

Data Analysis: All data were analyzed with 'Pesticide Research Manager' and 'PC-SAS' in a two-way ANOVA with four replicates and seven treatments. Mean separations were accomplished with Fisher's protected LSD ($\underline{P}$=0.05). Horsfall-Barratt data were analyzed and then converted to percentages for presentation in the Tables.

Results and Discussion

Cool, wet conditions predominated immediately after planting. This delayed plant emergence until mid-June, a delay of approximately one week, and favored infection of emerging sprouts by R. solani.

Disease control data are shown in Table 1. Only the Folicur in-furrow treatment significantly reduced Rhizoctonia stem-canker development compared to the standard PST plus bark and the nontreated control ($\underline{P}$<0.05). The same rate of Folicur applied in-furrow treatment, plus a single foliar application of Folicur when the plants were 4 inches tall, was intermediate in reaction and did differ significantly from the control or treatment with PST plus bark ($\underline{P}$<0.05).

Early blight pressure was light to moderate due to hot, dry conditions during July and August. All Folicur in-furrow treatments as well as treatments receiving foliar fungicide applications significantly reduced early blight severity by August 24 when compared to the nontreated control ($\underline{P}$<0.05). The fact that a single Folicur in-furrow application protected foliage and significantly reduced early blight measured late in the season ($\underline{P}$<0.05), suggests that a residual systemic effect resulted from the in-furrow treatment. More testing is needed to determine if this treatment effect is real and its efficacy under conditions of greater early blight disease pressure. Repeated foliar applications of Folicur or HGB-2468 at 14-day intervals resulted in the greatest level of early blight control, especially the treatment with HGB-2468. Treatment with HGB-2468 significantly reduced early blight disease severity compared to all treatments except Folicur applied at 14 day intervals and the Folicur in-furrow treatment ($\underline{P}$<0.05). Foliar fungicide applications at 14-day intervals also delayed plant senescence and these treatments had significantly less foliar necrosis on September 8 when compared to all other treatments ($\underline{P}$<0.05).

No phytotoxicity was observed during repeated inspection of treatment plots. Treatments had no significant effect on plant stand (emergence rate) on any of the evaluation dates (data not shown) ($\underline{P}$<0.05). Data in Table 2 show fungicide treatments also had no significant effect on plant height and vigor on any of the evaluation dates ($\underline{P}$<0.05). However, the average plant height for treatments receiving Folicur or HGB-2468 was always less than the control or PST plus bark. Also, plant vigor for the same treatments was always less than the control and, with one exception on August 2, was always less than the vigor ratings for treatment with PST plus bark. Vigor ratings are influenced by plant height and are expected to be positively correlated with plant height measurements.

The yield data in Table 3 show tuber yield and grade were not significantly affected by treatments (P<0.05). Low disease severity contributed to the lack of treatment effect on yield. Data for treatment effects on stored tubers are shown in Table 4. After approximately one month in storage, only a trace amount of Fusarium dry rot was found on tubers. Treatments had no significant effect on Fusarium dry rot severity (P<0.05). Treatments also had no significant effect on the skin defect called "Alligator Hide" or on proliferated lenticels (P<0.05). The active ingredient of each product tested is summarized in Table 5.

Acknowledgments

We gratefully acknowledge Bob Fornstrom of Lodgepole Farms in Pine Bluffs for providing seed potatoes used in this study. The assistance of the field crew at the Torrington Research and Extension Center was also greatly appreciated.

Table 1. The effects of in-furrow and foliar treatments on potato disease severity (G.D. Franc, et al., University of Wyoming, 1995).

		Number of early blight lesions per leaflet		Estimated percentage of: [1]	
	Treatment and rate (product/A)	Aug 2	Aug 24	Foliar necrosis Sept. 8	Stem surface-area cankered
1.	Nontreated control	0.04 b[2]	5.67 a	88 ab	8.0 ab
2.	PST plus bark, 16 oz/cwt of cut seed[3]	0.12 a	4.94 ab	90 ab	7.5 ab
3.	Folicur 3.6F, 0.184 fl oz/1000 ft row[3]	0.03 b	2.33 cd	88 ab	4.0 c
4.	Folicur 3.6F, 0.184 fl oz/1000 ft row[3] + Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	0.03 b	3.29 bc	86 b	5.0 bc
5.	Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	0.04 b	2.85 bc	94 a	9.0 a
6.	Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	0.02 b	1.56 cd	60 c	9.0 a
7.	HGB-2468, 24 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	0.01 b	0.52 d	50 c	6.5 abc

[1] Percentage data were converted from Horsfall-Barratt ratings.
[2] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, P=0.05).
[3] Treatments were applied directly to the seedpiece or in a 12-inch band in-furrow at planting.

Table 2. The effects of in-furrow and foliar treatments on potato plant development (G.D. Franc, et al., University of Wyoming, 1995).

	Plant height (inches)				Plant vigor (control=5)			
Treatment and rate (product/A)	July 5	July 12	July 18	Aug 10	July 12	July 18	July 26	Aug2
1. Nontreated control	12.7 a[1]	14.3 a	15.3 a	26.9 a	5.0 a	5.0 a	5.0 a	5.0 a
2. PST plus bark, 16 oz/cwt of cut seed[2]	11.8 a	14.3 a	14.7 a	26.2 a	5.1 a	5.3 a	4.9 a	4.5 a
3. Folicur 3.6F, 0.184 fl oz/1000 ft row[2]	10.9 a	12.4 a	13.1 a	24.5 a	4.1 a	4.5 a	4.5 a	4.1 a
4. Folicur 3.6F, 0.184 fl oz/1000 ft row[2] + Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	9.6 a	12.2 a	13.4 a	25.4 a	4.4 a	4.8 a	4.8 a	4.8 a
5. Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	10.1 a	12.3 a	12.3 a	21.7 a	3.8 a	4.0 a	4.1 a	3.5 a
6. Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	10.7 a	12.9 a	14.0 a	23.5 a	4.6 a	4.4 a	4.1 a	3.8 a
7. HGB-2468, 24 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	10.8 a	12.6 a	13.2 a	22.4 a	4.4 a	4.4 a	4.3 a	4.0 a

[1] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, P=0.05).
[2] Treatments were applied directly to seedpiece or in a 12-inch band in-furrow at planting.

Table 3. The effects of in-furrow and foliar treatments on potato tuber yields and grade (G.D. Franc, et al., University of Wyoming, 1995).

	Yield in each grade category (cwt/A)			
Treatment and rate (product/A)	US #1	B size	Culls	Total
1. Nontreated control	107.4 a[1]	23.0 a	91.4 a	221.8 a
2. PST plus bark, 16 oz/cwt of cut seed[2]	80.0 a	23.2 a	95.0 a	198.2 a
3. Folicur 3.6F, 0.184 fl oz/1000 ft row[2]	120.6 a	24.8 a	64.3 a	209.7 a
4. Folicur 3.6F, 0.184 fl oz/1000 ft row[2] + Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	129.0 a	26.0 a	74.0 a	229.0 a
5. Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	85.4 a	24.8 a	87.0 a	197.2 a
6. Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	131.4 a	28.8 a	76.3 a	236.5 a
7. HGB-2468, 24 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	118.7 a	21.6 a	75.0 a	215.3 a

[1] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, P=0.05).
[2] Treatments were applied directly to seedpieces or in a 12-inch band in-furrow at planting.

Table 4. The effects of in-furrow and foliar treatments on potato tuber dry rot (*Fusarium* spp.) and tuber defects (G.D. Franc, et al., University of Wyoming, 1995).

	Treatment and Rate (product/A)	Tuber surface area (%) with dry rot[1]	Percentage of tubers with [2]: Alligator hide	Proliferated lenticels
1.	Nontreated control	0.4 a[3]	2.5 a	5.0 a
2.	PST plus bark, 16 oz/cwt of cut seed[4]	0.6 a	2.5 a	12.5 a
3.	Folicur 3.6F, 0.184 fl oz/1000 ft row[4]	0.6 a	10.0 a	12.5 a
4.	Folicur 3.6F, 0.184 fl oz/1000 ft row[4] + Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	0.4 a	0.0 a	7.5 a
5.	Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) single foliar spray at 4-inch height	0.4 a	12.5 a	2.5 a
6.	Folicur 3.6F, 8 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	0.4 a	5.0 a	5.0 a
7.	HGB-2468, 24 fl oz/A + Induce 0.06% (V:V) foliar spray at 4-inch height, repeat at 14-day intervals	0.8 a	5.0 a	10.0 a

[1] Data were converted to percentages from Horsfall-Barratt (0-11) ratings. Dry rot was visually estimated and resulted from infection by *Fusarium* spp.
[2] Ten tubers were evaluated per treatment plot (40 tubers per treatment).
[3] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, $\underline{P}$=0.05).
[4] Treatments were applied directly to seedpieces or in a 12-inch band in-furrow at planting.

Table 5. The active ingredient of in-furrow and foliar treatments tested for potato disease management (G.D. Franc, et al., University of Wyoming, 1995).

Product	Manufacturer	Composition
PST plus bark	JR Simplot Company P.O. Box 15057 Boise, ID 83715	6% zinc ion manganese ethylene bisdithiocarbamate
Folicur 3.6F	Bayer Corporation P.O. Box 4913 Hawthorne Road Kansas City, MO 64120	39% tebuconazole
HGB-2468	Bayer Corporation	Proprietary; 610 grams of active ingredient per liter (a mixture of tebuconazole + chlorothalonil
Induce	Bayer Corporation	Surfactant containing alkyl polyoxylkane ether, free fatty acids and IPA

Potato Disease Management with Seedpiece and Foliar Fungicide Treatments, 1996

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Abstract

Field plots were established at the University of Wyoming Research and Extension Center near Torrington. A foliar fungicide and two seedpiece fungicide treatments were compared to a nontreated control for management of Rhizoctonia stem-canker and foliar early blight. None of the treatments significantly reduced Rhizoctonia stem-canker development compared to the nontreated control ($\underline{P}<0.05$). Treatments also had no effect on early blight disease severity compared to the nontreated control ($\underline{P}<0.05$). However, the foliar (Folicur) treatment was applied prior to early blight appearance and secondary spore spread and, therefore, was expected to have only residual effect on early blight development during the growing season. The Folicur treatment had the fewest early blight lesions present compared with the nontreated control and seedpiece-applied fungicides. No phytotoxicity from any treatment was observed in the plots; however, plant height was generally reduced by treatment with Folicur. Tuber yield and grade were not significantly affected by the different treatments ($\underline{P}<0.05$).

Materials and Methods

Field plots were established at the University of Wyoming Research and Extension Center near Torrington. he field plot location was planted with potatoes the previous year in an effort to elevate inoculum levels present in the soil. The experimental design was a randomized complete block with four replicates. Prior to planting, Dual II (1.5 pints product per acre) was mechanically incorporated into the field soil. Additionally, Prowl (1.5 pints product per acre) was applied prior to potato emergence. Treatment plots were 25-feet long by two-rows wide with 36-inch row-centers.Treated plots were separated by two nontreated buffer rows and a 5-foot nonplanted buffer remained between treatment plots. The field plot received overhead irrigation as needed and weeds and insects were controlled when necessary.

Seedpiece Treatments: All potato seed (cultivar Atlantic) was cut by hand 24 hours prior to planting and sorted for uniform (approximately 2 ounce) seedpiece size. Tops-MZ and LS109 seedpiece treatments were applied immediately after cutting. Thirty-five pounds of freshly cut seed were placed in a large plastic bag along with the proper amount of seedpiece treatment. Bags were sealed and rolled along the ground to ensure uniform coating of seedpieces. On May 8, all plots and buffer rows were planted with the aid of a mechanical planter. Seedpieces were placed at a 12-inch in-row spacing and with a row center of 36 inches. Exactly 50 seedpieces per plot were planted.

Foliar Treatment: The Folicur treatment was applied on June 11 (>95 percent plant emergence, potato plants were approximately 5 to 10 centimeters in height) and was reapplied 20 days later. Folicur was applied with the aid of a backpack sprayer in a total volume of 34 gallons per acre at 30 psi boom pressure. The spray boom was equipped with four #8004 flat fan spray nozzles spaced at 20 inches.

Data Collection: Stand counts, plant vigor, and an average plant height were determined for each plot. Stand (emergence) counts were taken on June 5, 12, 18, and 20. Vigor ratings (nontreated control = 5; more vigorous than control > 5; less vigorous than control < 5), which considered overall appearance of the crop, were taken on June 20 and 27 and July 1 and 10. On June 20 and 26 and July 12 and 25, heights (vine length) were measured for five randomly selected plants for each treatment plot and an average was computed.

On June 26 and August 1 and 23 five stems were randomly selected from each treatment plot and the percentage of below-ground stem surface-area cankered by Rhizoctonia (Rhizoctonia solani) was estimated using the Horsfall-Barratt scale (0-11). Early blight (Alternaria solani) severity was evaluated on August 1 and 23. Nine leaves were randomly selected from each plot; three each from the upper, middle, and lower third of the canopy. The number of early blight lesions was counted for up to seven leaflets per leaf, and an average was computed. The average number of lesions per leaflet was analyzed and this data is presented in Table 1.

Tubers were harvested on October 4 with the aid of a single row mechanical harvester. The total yield and tuber grade for each treatment plot (25-feet by two-row subsample) was measured. Potato grades included the categories US #1's (>10 ounces and <10 ounces), US #2's, grade B, and culls.

Data Analysis: All data were analyzed with 'Pesticide Research Manager' and 'PC-SAS' in a two-way ANOVA with four replicates and four treatments. Mean separations were accomplished with Fisher's protected LSD (P=0.05). Horsfall-Barratt data were analyzed, and then converted to percentages for presentation in the Tables.

Results and Discussion

Conditions at planting were favorable and a uniform stand was established. Most plants emerged during the first week of June with greater than 95 percent of the plants emerged by June 12.

Disease control data are shown in Table 1. Early blight pressure was light to moderate during 1996. None of the seedpiece or foliar fungicide treatments significantly reduced early blight disease severity compared to the nontreated control, for either sample date (P<0.05). However, the Folicur treatment was applied prior to early blight appearance and secondary spore spread, and, therefore, was expected to have little effect on early blight development later in the season. However, Folicur reduced the number of lesions per leaflet present on August 1 and by August 23, this trend was less pronounced. Treatments did not significantly affect Rhizoctonia stem-canker development for any of the sampling periods (P<0.05). Only the Folicur treatment had canker development equal or less than the nontreated control for all three sample periods.

Treatment effects on potato development are shown in Table 2. No phytotoxicity was observed during repeated inspection of treatment plots. Treatments had no significant effect on plant stand on any of the evaluation dates (P<0.05). Fungicide treatments also had no significant effect on plant height and vigor on any of the evaluation dates (P<0.05). However, the average plant height (vine length) for the Folicur treatment was always less than the nontreated control.

The yield data in Table 3 show tuber yield and grade were not significantly affected by treatments (P<0.05). Low disease severity contributed to the lack of treatment effect on yield. The active ingredient(s) of each product tested are summarized in Table 4.

Acknowledgments

We gratefully acknowledge Jim Allen of Western Potatoes in Alliance, Nebraska, for providing the seed used in this study. The assistance of Kristin Kaser, Wendy Cecil-Loose, and the field crew at the Torrington Research and Extension Center is also greatly appreciated.

Table 1. The effect of potato (cv. Atlantic) seedpiece and foliar treatment on disease severity (G.D. Franc, et al., University of Wyoming, 1996).

		Number of early blight leasions per leaflet		Estimated percentage of stem surface-area cankered[1]		
	Treatment and rate (product/A)	Aug 1	Aug 23	June 26	Aug 1	Aug 23
1.	Nontreated control	1.59	5.00	3.0	16.0	28.0
2.	Folicur 3.6 F (8 fl oz/A) + Induce (0.06% V:V) foliar spray at emergence, repeat after 20 days	0.94	4.06	2.0	16.0	19.5
3.	Tops-MZ (16 oz/cwt of cut seed)[2]	1.64	4.88	3.5	16.0	25.0
4.	LS109 (8 oz/cwt of cut seed)[2]	1.60	4.36	2.5	25.0	35.0
	ANOVA results	**n.s.[3]**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

[1] Percentage data for Rhizoctonia stem canker were converted from Horsfall-Barratt (0-11) ratings.
[2] Treatments were applied directly to the seedpiece prior to planting.
[3] Treatment means do not differ significantly (Fisher's Protected LSD, P=0.05).

Table 2. The effect of potato (cv. Atlantic) seedpiece and foliar treatment on plant development (G.D. Franc, et al., University of Wyoming, 1996).

	Number of early blight lesions per leaflet				Estimated percentage of stem surface-area cankered[1]			
Treatment and rate (product/A)	Jun 20	Jun 26	Jul 12	Jul 25	Jun 20	Jun 27	Jul 1	Jul 10
1. Nontreated control	30.5	41.8	47.9	62.9	5.0	5.0	5.0	5.0
2. Folicur 3.6 F (8 fl oz/A) + Induce (0.06% V:V) foliar spray at emergence, repeat after 20 days	29.1	39.6	46.0	56.4	4.8	5.0	4.5	4.5
3. Tops-MZ (16 oz/cwt of cut seed)[2]	30.5	39.2	50.4	59.8	5.3	5.0	5.0	4.8
4. LS109 (8 oz/cwt of cut seed)[2]	30.1	39.1	49.9	60.3	5.0	4.5	5.0	4.8
ANOVA results	**n.s.[3]**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

[1] Treatment means with values greater than '5' are more vigorous than the nontreated control.
[2] Treatments were applied directly to the seedpiece prior to planting.
[3] Treatment means do not differ significantly (Fisher's Protected LSD, P=0.05).

Table 3. The effect of potato (cv. Atlantic) seedpiece and foliar treatment on tuber yield and grade (G.D. Franc, et al., University of Wyoming, 1996).

	Yield in each grade category (cwt/A)						
	US #1						
Treatment and rate (product/A)	>10 oz	<10 oz	Total	US #2	Grade B	Culls	Total
1. Nontreated control	60.2	223.6	283.8	20.1	9.3	34.4	347.7
2. Folicur 3.6 F (8 fl oz/A) + Induce (0.06% V:V) foliar spray at emergence, repeat after 20 days	91.8	211.0	302.8	9.0	9.8	41.0	362.6
3. Tops-MZ (16 oz/cwt of cut seed)[1]	82.7	198.8	281.6	15.2	11.9	23.1	331.7
4. LS109 (8 oz/cwt of cut seed)[1]	77.5	201.3	278.8	5.6	7.6	29.5	321.5
ANOVA results	**n.s.[2]**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

[1] Treatments were applied directly to the seedpiece prior to planting.
[2] Treatment means do not differ significantly (Fisher's Protected LSD, P=0.05).

Table 4. The active ingredients of seedpiece and foliar treatments tested for potato disease management (G.D. Franc, et al., University of Wyoming, 1996).

Product	Manufacturer	Composition
Folicur 3.6F	Bayer Corporation P.O. Box 4913 Hawthorne Road Kansas City, MO 64120	39% tebuconazole
Induce	Bayer Corporation	Surfactant containing alkyl polyoxylkane ether, free fatty acids and IPA
Tops-Mz	Gustafson, Inc. 1400 Preston Rd., Suite 400 Plano, TX 75093	2.5% Thiophanate-methyl 6% zinc ion and mangenese ethylene bisdithicarbamate
LS 109	Gustafson, Inc.	No information available

Foliar Fungicide Tests for Potato Early Blight Management, 1995

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Abstract

This field trial was conducted during 1995 at the University of Wyoming Research and Extension Center at Torrington. Seventeen fungicide treatments were compared to a nontreated control for potato early blight (Alternaria solani) management on cultivar Shepody. All fungicide treatments, except Bravo 720 (1.5 pt/A) on August 31, significantly reduced disease severity on both rating dates (August 18 and 31 when compared to the control ($\underline{P}<0.05$). Treatment with ICIA-5504 generally resulted in the least number of lesions per leaflet and was significantly better than several of the other fungicides tested ($\underline{P}<0.05$). Visual ratings of foliar necrosis demonstrated the effect of early blight on plant senescence, with 80 percent foliar necrosis observed in the control on September 8. All fungicide treatments significantly delayed foliar senescence when compared to the control ($\underline{P}<0.05$). Tuber yield was not significantly affected by treatment ($\underline{P}<0.05$). Phytotoxicity was not observed from any of the foliar fungicide treatments.

Materials and Methods

This field trial was conducted at the University of Wyoming Research and Extension Center located near Torrington. The field plot was planted with potato cultivar Shepody on May 1, 1995. Shepody is a medium maturing cultivar that is susceptible to most potato diseases and is grown for the fresh market and for processing. The field plot was irrigated via an overhead sprinkler as needed during the growing season, and weed and insect pests were controlled.

Treatment plots were laid out after plant emergence. A randomized complete block design of 18 treatments and four replications was used for the study. Each plot was 20-feet long by 2-rows wide on 36-inch centers. A 5-foot nontreated in-row buffer plus one buffer-row remained between plots. Foliar treatments were applied with a backpack sprayer in a total spray volume of 39 gallons per acre at a boom pressure of 30 psi. The sprayer boom was equipped with four #8004 flat-fan spray nozzles spaced at 20 inches.

Foliar treatments and their application rates are listed in Tables 1 and 2. The active ingredient of each fungicide is listed in Table 3. All treatments were initiated shortly after early blight lesions were observed in the field plot. Treatments 1-5, 11-15, and 18 were applied five times at 7 to 10 day intervals. The application dates were July 26 and August 3, 10, 17, and 25. Treatments 6 through 10 were applied four times and these applications were made on the first four dates listed above. Treatments 16 and 17 were also applied four times and applications were made on July 26, August 3, 10, and 25. Treatments 16 and 17 were intended to be on a 14-day interval; however, they were applied in error on August 3. Non-treated control plots received 'water only' on treatment application days to standardize the foliar damage that occurs when making applications. Fresh products, shipped during 1995, were used for all treatments except Super Tin and ICIA-5504, which used product left from previous years. Sprinkler irrigation of the field plot typically occurred within one to two days following each foliar application.

Early blight development in the field relied on naturally occurring inoculum. All disease severity and yield data were collected from the two rows in the treatment plots. Disease severity was measured by counting the number of early blight lesions per leaflet for collections made on August 3, 18, and 31. Leaf collections were conducted by randomly selecting nine leaves from each plot: three each from the upper, middle, and lower third of the canopy. The number of early blight lesions on up to seven leaflets per leaf was counted and an average was calculated. The average number of lesions per leaflet was used in analysis and data presentation. By September, extensive crop senescence and foliar necrosis made lesions difficult to count. However, treatment effects were still readily apparent. Therefore, plots were visually rated with the Horsfall-Barratt scale (0-11) for the percentage of foliar necrosis present on September 8. Tuber harvest was done on October 10 with the aid of a single row mechanical harvester. The total yield and grade for each treatment plot (15-feet by two-row subsample) were measured. Potato grades included the categories US #1, grade B, and culls.

All data were analyzed with 'Pesticide Research Manager' and 'PC-SAS' in a two-way ANOVA with four replications and 18 treatments. To correct for non-homogeneity of the data, data were transformed (square root) prior to analysis when necessary. Non-transformed data is presented in the tables. Mean separation was accomplished with Fisher's protected LSD at $\underline{P}$=0.05. Horsfall-Barratt data were analyzed directly and then converted to percentages for presentation in Table 1.

Results and Discussion

Environmental conditions following planting were unusually cool and wet, which delayed plant emergence until approximately June 10. As a consequence, seedpiece decay and Rhizoctonia stem-cankering resulted in a moderate stand as well as plants with poor vigor throughout the remainder of the growing season. Early blight development resulted from naturally occurring inoculum. Due to hot and dry conditions during July and August, early blight disease pressure was light to moderate. For example, the lesion count per leaflet for nontreated control plots was 37.3 and 28.1 in 1992 and 1993, respectively. These numbers are compared with 11.75 lesions per leaflet for the collection made in control plots on August 31 during the 1995 study. The cultivar tested will influence disease severity, as well as environmental conditions and inoculum availability.

Early blight lesions first appeared in the field plot on approximately July 25. The fungicide treatments that were applied and disease severity data are presented in Table 1. On August 3, there were no significant differences among treatment means for the number of early blight lesions per leaflet ($\underline{P}<0.05$). However, by August 18 all treatments significantly reduced early blight disease severity compared to the nontreated control ($\underline{P}<0.05$). Treatment with the experimental product ICIA-5504 was significantly better than treatments 3, 5, 7, 8, 15, and 17, which include several standard product formulations ($\underline{P}<0.05$). On August 31, with the exception of treatment 7 (Bravo 720, four applications), all treatments significantly reduced disease severity compared to the control ($\underline{P}<0.05$). At this time, treatment 18 (ICIA-5504) continued to have the least number of lesions per leaflet, although it was statistically equivalent to treatments 3, 4, 5, 8, 9, 10, 11, 12, and 14 ($\underline{P}<0.05$).

A statistical contrast was done to determine if significant differences in disease severity existed between treatments applied a maximum of four times (seven-day intervals) and those for which five applications (seven-day intervals) were made. This analysis was done with data collected August 31. Although a trend existed for treatments applied five times to have less disease compared to treatments applied a maximum of four times (3.68 versus 4.62 lesions per leaflet, respectively), the difference was not significant ($\underline{P}=0.08$). Because different fungicides were used in both groups, it is difficult to determine if the trend toward reduced disease resulted from differences in fungicide efficacy and/or if the trend resulted from the frequency of protectant sprays. Only Bravo 720 was common to both groups and these two treatments did not differ significantly ($\underline{P}<0.05$).

Visual estimates of foliar necrosis made on September 8 demonstrate the effect of early blight on plant senescence, with 80 percent of the foliage necrotic for the nontreated control. All fungicide treatments significantly delayed senescence compared to the nontreated control ($\underline{P}<0.05$). The percentage of foliar necrosis ranged from 15 to 50 for fungicide treated plots. Treatment 18 (ICIA-5504) had the greatest percentage of foliage remaining green late in the season and was significantly better than most of the other fungicides tested ($\underline{P}<0.05$).

The data in Table 2 show tuber yield and grade were not significantly affected by the foliar fungicide treatments ($\underline{P}<0.05$). Treatment with ICIA-5504 resulted in the greatest yields for the US#1 and total tuber yield categories. Poor stand and poor plant vigor, as well as low to moderate disease pressure, may have confounded yield effects due to early blight control.

Acknowledgments

We gratefully acknowledge Bob Fornstrom of Lodgepole Farms in Pine Bluffs for providing the seed potatoes used for this study. The assistance of the field crew at the Torrington Research and Extension Center is greatly appreciated.

Table 1. The effects of foliar fungicide applications on potato early blight disease severity and foliar necrosis (G.D. Franc, et al., University of Wyoming, 1995).

Treatment and application rate (product/A)	Application interval	Early blight lesions per leaflet			% Foliar necrosis[1]
		Aug 3	Aug 18	Aug 31	Sept 8
1. Nontreated control (water only)	NA	0.13 a[2]	1.46 a	11.75 a	80 a
2. Penncozeb 75DF (2 lb)	7 day	0.20 a	0.47 bc	6.55 bc	47 bc
3. Penncozeb 75DF (2 lb) + Super Tin 4F (2.5 fl oz)	7 day	0.13 a	0.51 b	3.46 c-g	31 cde
4. TD-2343-02 3.5F (3.42 pt)	7 day	0.03 a	0.24 bc	4.23 c-g	36 b-e
5. TD-2343-02 3.5F (3.42 pt) + Super Tin 4F (2.5 fl oz)	7 day	0.15 a	0.58 b	2.28 fg	38 b-e
6. IB-11925 (1.75 pt)	7 day, 4 max[3]	0.12 a	0.22 bc	5.11 b-e	38 b-e
7. Bravo 720 (1.5 pt)	7 day, 4 max	0.19 a	0.53 b	7.92 ab	45 bcd
8. Bravo Ultrex (1.4 lb)	7 day, 4 max	0.14 a	0.50 b	3.14 d-g	31 cde
9. Bravo Zn (2.2 pt)	7 day, 4 max	0.19 a	0.37 bc	3.86 c-g	36 b-e
10. IB-11522 (1.5 pt)	7 day, 4 max	0.09 a	0.23 bc	3.34 c-g	28 ef
11. EXP 10673A (2 pt) + Latron CS-7 (0.25% V:V)	7 day	0.08	0.26 bc	2.26 efg	17 fg
12. EXP 10673A (3 pt) + Latron CS-7 (0.25% V:V)	7 day	0.17 a	0.25 bc	1.96 g	28 ef
13. EXP 10625A (0.25 lb)	7 day	0.20 a	0.39 bc	5.68 bcd	41 b-e
14. EXP 10625A (0.5 lb)	7 day	0.26 a	0.39 bc	3.71 c-g	30 def
15. Bravo 720 (0.75 pt, 1.5 pt)[4]	7 day	0.21 a	0.44 b	4.75 b-f	36 b-e
16. EXP 10370A (1.5 lb) + Latron CS-7 (0.25% V:V)	14 day	0.14 a	0.39 bc	6.69 bc	45 bcd
17. Rovral 4F (1.5 pt) + Latron CS-7 (0.25% V:V)	14 day	0.17 a	0.64 b	5.60 bcd	50 b
18. ICIA-5504 80WDG (0.125 lb)	7 day	0.14 a	0.11 c	1.83 g	15 g

[1] Data presented were converted to percentages from Horsfall-Barratt scale (0-11) data.
[2] Treatment means followed by different letters differ significantly (Fisher's Protected LSD, $\underline{P}$=0.05).
[3] A maximum of four applications was made.
[4] The low rate was only applied on the first application date, prior to row closure, and the high rate was applied during subsequent applications.

Table 2. The effect of foliar fungicide application for potato early blight control on potato yield and quality (G.D. Franc, et al., University of Wyoming, 1995).

Treatment and application rate (product/A)	Application interval	Yield in each grade category (cwt/A)			
		US#1	B Size	Culls	Total
1. Nontreated control (water only)	NA	32.2 a[1]	21.4 a	93.7 a	147.3 a
2. Penncozeb 75DF (2 lb)	7 day	30.9 a	26.7 a	78.9 a	136.5 a
3. Penncozeb 75DF (2 lb) + Super Tin 4F (2.5 fl oz)	7 day	39.6 a	26.9 a	91.6 a	158.0 a
4. TD-2343-02 3.5F (3.42 pt)	7 day	33.0 a	25.8 a	53.5 a	132.4 a
5. TD-2343-02 3.5F (3.42 pt) + Super Tin 4F (2.5 fl oz)	7 day	41.0 a	25.7 a	94.0 a	160.6 a
6. IB-11925 (1.75 pt)	7 day, 4 max[2]	44.8 a	29.6 a	100.7 a	179.0 a
7. Bravo 720 (1.5 pt)	7 day, 4 max	43.7 a	27.2 a	96.2 a	167.1 a
8. Bravo Ultrex (1.4 lb)	7 day, 4 max	40.4 a	31.2 a	98.0 a	169.6 a
9. Bravo Zn (2.2 pt)	7 day, 4 max	49.1 a	20.9 a	90.6 a	160.7 a
10. IB-11522 (1.5 pt)	7 day, 4 max	46.0 a	21.8 a	115.3 a	183.1 a
11. EXP 10673A (2 pt) + Triton (0.25% V:V)	7 day	51.5 a	21.2 a	95.6 a	177.8 a
12. EXP 10673A (3 pt) + Titron (0.25% V:V)	7 day	39.3 a	23.0 a	91.2 a	170.3 a
13. EXP 10625A (0.25 lb)	7 day	42.8 a	27.8 a	96.7 a	187.3 a
14. EXP 10625A (0.5 lb)	7 day	43.7 a	29.0 a	104.4 a	177.2 a
15. Bravo 720 (0.75 pt, 1.5 pt)[3]	7 day	50.2 a	25.3 a	110.2 a	185.7 a
16. EXP 10370A (1.5 lb) +Triton (0.25% V:V)	14 day	39.2 a	25.2 a	85.7 a	150.0 a
17. Rovral 4F (1.5 pt) +Triton (0.25% V:V)	14 day	39.3 a	25.3 a	76.2 a	140.9 a
18. ICIA-5504 (0.125 lb)	7 day	62.7 a	26.3 a	111.9 a	200.9 a

[1] Treatment means followed by different letters differ significantly (Fisher's Protected LSD, $\underline{P}$=0.05).
[2] A maximum of four applications was made.
[3] The low rate was only applied on the first application date, prior to row closure, and the high rate was applied during subsequent applications.

Table 3. The active ingredients and manufacturer of fungicides tested for potato early blight management in Wyoming (G.D. Franc, et al., University of Wyoming, 1995).

Product	Manufacturer	Composition
Penncozeb 75DF	Elf Atochem North America, Inc. 2000 Market Street Philadelphia, PA 19103-3222	75% Mancozeb
TD-2343-02 3.5F	Elf Atochem North America, Inc.	34% Mancozeb
Super Tin 4F	Griffin Corporation P.O. Box 1847 Valdosta, GA 31603-1847	Fentin Hydroxide
Bravo 720	ISK Biotech Corporation 5966 Heisley Road Mentor, OH 44061	54% Chlorothalonil
Bravo Zn	ISK Biotech Corporation	40.4% Chlorothalonil
Bravo Ultrex	ISK Biotech Corporation	82.5% Chlorothalonil
IB-11522	ISK Biotech Corporation	Chlorothalonil
IB-11925	ISK Biotech Corporation	Proprietary
Rovral 4F	Rhone Poulenc, Inc. 2 T.W. Alexander Drive P.O. Box 12014 Research Triangle Park, NC 27709	Iprodione
EXP 10673A	Rhone Poulenc, Inc.	14% Iprodione 29% Chlorothalonil
EXP 10625A	Rhone Poulenc, Inc.	Proprietary
EXP 10370A	Rhone Poulenc, Inc.	50% Iprodione
Latron CS-7	Rohm and Haas Company 100 Independence Mall West Philadelphia, PA 19105	Adjuvant; 60% blend of alkylaryl polyethoxylate and sodium salt of alkylsulfonatedalkylate plus 40% constituents ineffective as adjuvants
ICIA-5504 80WDG	Zeneca Inc. Agricultural Products 1800 Concord Pike Wilmington, DE 19897	80% Methoxyacrylate

Foliar Fungicide Tests for the Management of Potato Early and Late Blight, 1996

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Abstract

This field trial was conducted at the University of Wyoming Research and Extension Center at Torrington. Twenty-three foliar fungicide treatments were compared to a nontreated control for potato early blight (Alternaria solani) management on cultivar Atlantic. Disease was light to moderate during 1996. By August 14, all treatments, except Maneb (2 lbs/A), significantly reduced disease severity when compared to the control ($\underline{P}<0.05$). All treatments resulted in lower relative disease (AUDPC) values when compared to the nontreated control ($\underline{P}<0.05$). Due to low disease pressure, most fungicide treatments performed in a similar manner. All treatments, except EXP10673A (1 qt/A) when co-applied with Kinetic or Omni oil, delayed foliar senescence ($\underline{P}<0.05$). Tuber yield and quality were not significantly affected by treatment ($\underline{P}<0.05$). Phytotoxicity was not observed from any of the foliar fungicide treatments. Late blight (Phytophthora infestans) developed in the field plots by mid-season due to naturally occurring inoculum. However, symptoms developed very slowly and data were not collected.

Materials and Methods

The location of the field trial was at the University of Wyoming Research and Extension Center, near Torrington. Prior to planting, Dual II at 1.5 pints per acre was mechanically incorporated into the field plot area and Prowl at 1.5 pints per acre was applied prior to potato emergence. Potato (Solanum tuberosum L.) cultivar Atlantic was planted on May 8 and 10. Atlantic is a main season cultivar that is susceptible to most potato diseases and is grown primarily for the potato chip market. Seedpieces were placed at a 12-inch in-row spacing and row centers were at 36 inches.

After plant emergence, a randomized complete block design of 24 treatments and four replications was established. Each treatment plot was 20-feet long and four-rows wide. A 5-foot nontreated in-row buffer remained between plots. Plots received overhead irrigation when needed, and insects and weeds were controlled as necessary.

The foliar fungicide treatments and their application rates are listed in Tables 1 and 2. Foliar fungicide applications were made on July 17 and 26 and August 5, 14, and 23. This schedule represented the approximate time of first early blight lesion appearance followed by 10-day application intervals. All Quadris treatments were rotated with Bravo Weather Stik (1.5 pints per acre) on the final application date, August 23. Nontreated control plots received only water on treatment application days to standardize the foliar damage that occurs when making applications. Fresh products, shipped during the spring of 1996, were used for all treatments. All treatments were applied with the aid of a backpack sprayer in a total volume of 43 gallons per acre at a boom pressure of 29 psi. The boom was equipped with four #8004 flat fan spray nozzles spaced at 20 inches.

Only the middle rows of each plot were treated and all data were collected from the middle rows of the plots. Early blight disease severity was measured by calculating the average number of lesions per leaflet for leaves collected on July 16 and August 1, 14, and 22. The collection made on July 16 was to determine initial disease levels in the field prior to treatment applications. Nine leaves were randomly selected from each treatment plot (three leaves each from the top, middle, and bottom third of the canopy) and the number of early blight lesions, on up to seven leaflets from each leaf, was counted. The average number of lesions per leaflet was used in analysis and data presentation. For an additional measurement of fungicide efficacy, the relative area under the disease progress curve (AUDPC) was calculated from lesion counts for each treatment plot over the four leaf collection dates. This calculated value was subjected to analysis of variance. The AUDPC value is more complete representation of disease progress over time versus lesion counts which measure disease progress at a single point in time. Treatments that either reduce disease severity or delay disease development will result in a lower AUDPC value.

By September, extensive crop senescence and foliar necrosis made lesion counts difficult; however, treatment effects were still apparent. Plots were visually rated using the Horsfall-Barratt scale (0-11) to estimate the percentage of foliar necrosis present on September 4. Tubers were harvested on October 4 with the aid of a single-row mechanical harvester. The total yield and grade for each treatment plot (15-feet by two-row subsample) were measured. Potato grades included the categories US #1's (>10 oz and <10 oz), US #2's, culls, and grade B.

All data were analyzed with 'Pesticide Research Manager' and 'PC-SAS' in a two-way ANOVA with four replicates and 24 treatments. Mean separation was accomplished with Fisher's protected LSD, $\underline{P}$=0.05.

Results and Discussion

Environmental conditions at planting were favorable and a uniform stand was established by the first week of June. Early blight disease development resulted from naturally occurring inoculum, and disease pressure during 1996 was light to moderate. As a comparison, the number of early blight lesions per leaflet in the nontreated control by late August was 37.3 and 28.1 in 1992 and 1993, respectively, and was only 3.2 lesions per leaflet for the 1996 study. Late blight (Phytophthora infestans) developed in the field plots by mid-season due to naturally occurring inoculum; however, symptoms developed very slowly and meaningful data were not collected.

Early blight lesions first appeared in the field plot on approximately July 16 and all fungicide applications were initiated on July 17. The fungicide treatments and disease severity data are presented in Table 1. On August 1, only treatments 7, 8, 19, and 22 had significantly less disease than the nontreated control ($\underline{P}<0.05$). However, the low incidence of disease at this early point make meaningful comparisons difficult. By August 14, all treatments except treatment 3 (Maneb 75DF at 2 pounds per acre) significantly reduced disease severity when compared to the control ($\underline{P}<0.05$). By August 22, all treatments had significantly less disease ($\underline{P}<0.05$). Also, all treatments resulted in lower total (relative) disease (AUDPC) when compared to the nontreated control ($\underline{P}<0.05$). Some of the best treatments for early blight control included those with iprodione plus chlorothalonil (treatment 7), chlorothalonil alone (treatments 20 and 22), or methoxyacrylate (treatment 13). However, due to the light disease pressure, little statistical differentiation occurred among most fungicide treatments ($\underline{P}<0.05$). All treatments, except EXP10673A when co-applied with Kinetic or Omni oil, delayed senescence when compared to the nontreated control ($\underline{P}<0.05$). Phytotoxicity was not observed from any of the foliar fungicide treatments.

Tuber yield and grade were not significantly affected by treatment ($\underline{P}<0.05$). The lack of treatment effect was probably due to low disease pressure. However, fungicide application tended to reduce the yield of oversized tubers (> 10 ounces) in the US#1 grade since only two of the 23 treatments exceeded the nontreated control. In contrast, 21 of the 23 treatments exceeded the nontreated control for yield of the US#1 grade less than 10 ounces. Also, 16 of the 23 treatments exceeded the total yield of US#1 grade tubers when compared to the nontreated control.

Acknowledgments

We gratefully acknowledge Jim Allen of Western Potatoes in Alliance, Nebraska, for providing seed potatoes used in this study. The assistance of Kristin Kaser and Wendy Cecil-Loose and the field crew at the Torrington Research and Extension Center was also greatly appreciated.

Table 1. The effects of foliar fungicide applications on potato early blight disease severity and foliar necrosis (G.D. Franc, et al., University of Wyoming, 1996).

	Early blight lesions per leaflet				% Foliar necrosis-
Treatment and application rate (product/A)	Aug 1	Aug 14	Aug 22	AUDPC	Sept 4[1]
1. Control (nontreated)	0.53 ab	1.12 a	3.16 a	29.48 a	94.0 a
2. Penncozeb 75DF (2 lb)	0.32 bc	0.41 cd	0.95 bcd	11.63 cde	73.5 bcd
3. Maneb 75DF (2 lb)	0.68 a	0.90 ab	1.03 bc	21.55 b	73.5 bcd
4. Penncozeb 75 DF (2 lb) + SuperTin 80W (0.156 lb)	0.32 bc	0.54 bcd	0.40 c-f	10.97 cde	50.0 cde
5. TD-2343-02 3.5F (3.43 pt)	0.30 bc	0.62 bc	1.22 b	14.67 cd	59.5 b-e
6. EXP10673A 4.5SC (1 qt)	0.38 abc	0.39 cd	0.61 b-f	11.24 cde	80.5 bc
7. EXP10673A 4.5SC (1.125 qt)	0.19 c	0.27 cd	0.29 ef	6.40 e	50.0 cde
8. EXP10673A 4.5SC (1 qt) + Kinetic (0.125% V/V)	0.20 c	0.35 cd	0.87 b-f	9.36 cde	83.0 ab
9. EXP10673A 4.5SC (1 qt) + Omni oil (1% V/V)	0.46 abc	0.64 bc	0.76 b-f	15.06 c	83.0 ab
10. EXP10731A 60WP (1.875 lb) + Kinetic (0.125% V/V)	0.45 abc	0.28 cd	0.82 b-f	11.59 cde	65.0 b-e
11. EXP10731A 60WP (1.875 lb) + Omni oil (1% V/V)	0.24 bc	0.39 cd	0.37 def	8.63 de	69.0 bcd
12. Quadris 80 WP (0.125 lb) + Kinetic (0.125% V/V)[3]	0.21 bc	0.43 cd	0.44 c-f	8.85 cde	59.5 b-e
13. Quadris 80 WP (0.1875 lb) + Kinetic (0.125% V/V)[3]	0.26 bc	0.30 cd	0.37 def	7.98 e	59.5 b
14. Quadris 80WP (0.25 lb) + Kinetic (0.125% V/V)[3]	0.26 bc	0.51 bcd	0.51 c-f	10.50 cde	65.0 b-e
15. Quadris 80 WP (0.3125 lb) + Kinetic (0.125% V/V)[3]	0.42 abc	0.45 cd	0.23 f	10.85 cde	59.5 b-e
16. Bravo Weather Stik 6SC (1.5 pt)	0.31 bc	0.34 cd	0.42 c-f	9.19 cde	69.0 bcd
17. Bravo Weather Stik 6SC (0.75, 1.0, and 1.5 pt)[4]	0.36 abc	0.52 bcd	0.54 c-f	11.73 cde	65.0 b-e
18. Bravo Zn 4.17SC (2.2 pt)	0.33 bc	0.28 cd	0.43 c-f	9.02 cde	40.5 de
19. Bravo Zn 4.17SC (1.0, 1.6, and 2.2 pt)[4]	0.17 c	0.48 cd	0.65 b-f	9.41 cde	50.0 cde
20. Bravo Ultrex 82.5WP (1.4 lb)	0.25 bc	0.30 cd	0.38 def	7.89 e	65.0 b-e
21. Bravo Zn 4.17SC (1.0 pt) + Quadris 80WP (0.125 lb)	0.35 bc	0.19 d	0.45 c-f	8.31 de	31.0 e
22. IB11522 (1.5 pt)	0.17 c	0.28 cd	0.32 def	6.16 e	46.0 de
23. Bravo Zn 4.17SC (2.0 pt) + Super Tin 80W (0.156 lb)	0.31 bc	0.31 cd	0.47 c-f	9.29 cde	50.0 cde
24. IB14121 (2.0 pt)	0.29 bc	0.44 cd	0.40 c-f	9.53 cde	56.0 b-e

[1] Data presented were converted to percentages from Horsfall-Barratt scale (0-11) data.
[2] Treatment means followed by different letters differ significantly (Fisher's Protected LSD, P=0.05).
[3] The final fungicide application, after four applications of Quadris 80WG, was made with Bravo Weather Stik 6SC (1.5 pt/A).
[4] The low rate was only applied on the first application date, prior to row closure; the middle rate on the second date, with increase in row closure; and the high rate was applied on subsequent applications.

Table 2. The effects of foliar fungicide applications on potato early blight disease control on potato yield and quality (G.D. Franc, et al., University of Wyoming, 1996).

Treatment and application rate (product/A)	Yield in each grade category (cwt/A)[1]						
	US #1			US #2	Grade B	Culls	Total
	>10 oz	<10 oz	Total				
1. Control (nontreated)	70.4	181.0	251.4	13.5	12.1	21.8	298.8
2. Penncozeb 75DF (2 lb)	64.3	207.5	271.8	7.2	10.4	15.3	304.6
3. Maneb 75DF (2 lb)	51.0	226.9	277.9	9.3	12.5	10.3	310.0
4. Penncozeb 75 DF (2 lb) + SuperTin 80W (0.156 lb)	62.9	194.6	257.5	9.5	10.2	12.8	290.0
5. TD-2343-02 3.5F (3.43 pt)	48.8	201.3	250.1	8.1	11.9	9.7	279.8
6. EXP10673A 4.5SC (1 qt)	39.0	204.6	243.6	8.9	14.5	11.7	278.7
7. EXP10673A 4.5SC (1.125 qt)	47.4	213.1	260.5	10.5	11.5	16.6	299.4
8. EXP10673A 4.5SC (1 qt) + Kinetic (0.125% V/V)	54.2	201.3	255.5	2.2	13.9	12.6	284.3
9. EXP10673A 4.5SC (1 qt) + Omni oil (1% V/V)	39.0	187.1	226.1	11.4	9.9	15.3	262.6
10. EXP10731A 60WP (1.875 lb) + Kinetic (0.125% V/V)	89.5	170.3	259.8	6.2	13.6	18.8	298.4
11. EXP10731A 60WP (1.875 lb) + Omni oil (1% V/V)	57.6	191.3	248.9	10.3	11.6	18.0	288.8
12. Quadris 80 WP (0.125 lb) + Kinetic (0.125% V/V)[2]	59.1	200.2	259.3	7.4	10.0	16.9	293.6
13. Quadris 80 WP (0.1875 lb) + Kinetic (0.125% V/V)[2]	48.0	225.2	273.2	4.7	8.5	13.3	299.7
14. Quadris 80WP (0.25 lb) + Kinetic (0.125% V/V)[2]	67.0	179.9	246.9	2.2	9.9	16.7	278.7
15. Quadris 80 WP (0.3125 lb) + Kinetic (0.125% V/V)[2]	52.6	216.2	268.9	8.2	8.8	15.1	300.9
16. Bravo Weather Stik 6SC (1.5 pt)	58.4	199.8	258.2	4.8	11.5	9.6	284.1
17. Bravo Weather Stik 6SC (0.75, 1.0, and 1.5 pt)[3]	41.6	181.7	223.4	5.9	9.8	18.1	257.1
18. Bravo Zn 4.17SC (2.2 pt)	77.7	191.7	269.3	7.9	9.0	19.5	305.8
19. Bravo Zn 4.17SC (1.0, 1.6, and 2.2 pt)[3]	71.5	223.1	294.6	2.8	12.0	18.8	328.2
20. Bravo Ultrex 82.5WP (1.4 lb)	56.5	183.2	239.7	7.6	14.8	23.1	285.1
21. Bravo Zn 4.17SC (1.0 pt) + Quadris 80WP (0.125 lb)	70.3	194.8	265.1	6.4	12.2	24.3	308.0
22. IB11522 (1.5 pt)	70.7	198.8	269.5	13.1	12.7	7.9	303.2
23. Bravo Zn 4.17SC (2.0 pt) + Super Tin 80W (0.156 lb)	54.3	203.8	258.1	1.7	12.4	16.2	288.4
24. IB14121 (2.0 pt)	62.8	199.4	262.2	11.8	11.1	16.6	301.8

[1] Treatment means did not differ significantly (Fisher's Protected LSD, $\underline{P}$=0.05).

[2] The final fungicide application, after four applications of Quadris 80WG, was made with Bravo Weather Stik 6SC (1.5 pt/A).

[3] The low rate was applied on the first application date, prior to row closure, the middle rate on the second date, with increase in row closure; and the high rate was applied on subsequent applications.

Table 3. The active ingredients and manufacturer of fungicides tested for potato early blight management in Wyoming (G.D. Franc, et al., University of Wyoming, 1995).

Product	Manufacturer	Composition
Penncozeb 75DF	Elf Atochem North America, Inc. 2000 Market Street Philadelphia, PA 19103-3222	75% Mancozeb
Maneb 75DF	Elf Atochem North America, Inc.	75% Maneb
TD-2343-02 3.5F	Elf Atochem North America, Inc.	34% Mancozeb
Super Tin WP80	Griffin Corporation P.O. Box 1847 Valdosta, GA 31603-1847	80% Fentin Hydroxide
Bravo Weather Stik	ISK Biotech Corporation 5966 Heisley Road Mentor, OH 44061	54% Chlorothalonil
Bravo Zn	ISK Biotech Corporation	40.4% Chlorothalonil
Bravo Ultrex	ISK Biotech Corporation	82.5% Chlorothalonil
IB-11522	ISK Biotech Corporation	Chlorothalonil
IB-14121	ISK Biotech Corporation	Chlorothalonil + Organotin compound
EXP 10731A	Rhone Poulenc, Inc. 2 T.W. Alexander Drive P.O. Box 12014 Research Triangle Park, NC 27709	20% Iprodione 40% Chlorothalonil
EXP 10673A	Rhone Poulenc, Inc.	14% Iprodione 29% Chlorothalonil
Kinetic	Rhone Poulenc, Inc.	Adjuvant
Omni oil	Rhone Poulenc, Inc.	Adjuvant
Quadris 80WG	Zeneca Inc. Agricultural Products 1800 Concord Pike Wilmington, DE 19897	80% Methoxyacrylate

Bacterial Ring Rot Symptom Development in Selected Potato Cultivars, 1995

Gary D. Franc, William L. Stump, Jack T. Cecil,* and Gary Leever** Department of Plant, Soil, and Insect Sciences, *Torrington Research and Extension Center, and the **Potato Certification Association of Nebraska

Abstract

Twelve potato varieties were evaluated for Bacterial Ringrot (*Clavibacter michiganensis* subsp. *sepedonicus*) symptom development as a diagnostic aid for growers and seed certification field inspectors. Field trials were conducted at the University of Wyoming Research and Extension Center at Torrington in 1995. After inoculation of seedpieces at the time of planting, all cultivars except Russet Burbank had at least one plant with foliar symptoms observed by August 18. Differences in the degree and type of symptoms expressed were evident among the cultivars tested. Chieftain, LaBelle, FL 1291 and Fontenot exhibited typical foliar symptoms in over 60 percent of the plants, whereas Ranger Russet, Russet Burbank, and Chipeta symptomatology was delayed and reduced. The other varieties tested were intermediate in foliar symptom expression. Although Russet Burbank failed to develop foliar symptoms, plants had a positive stem squeeze and exhibited tuber symptoms, demonstrating that infection had occurred. Fontenot, Shepody, and Chipeta had no detectable tuber symptom development. Tuber symptom development did not appear related to foliar symptom development. Inoculation with the ringrot bacterium did not appear to affect emergence rate, final stand, plant height, and early season vigor. A field day to demonstrate results to growers was held September 1, 1995.

Materials and Methods

The experiment was conducted at the University of Wyoming Research and Extension Center located near Torrington. The experimental design was a split plot design with the 12 potato varieties as main treatments plots with four replicates. Main plots were split with positive or negative ringrot (*Clavibacter michiganensis* subsp. *sepedonicus*) seedpiece inoculation treatments. Main plots were one-row by 18-feet and planted to one of the following varieties: Ranger Russet, Russet Burbank, Snowden, Fontenot, LaRouge, Shepody, Russet Norkotah, Atlantic, FL 1291, LaBelle, Chieftain, and Chipeta. Potato seedpieces were obtained from the state of Nebraska Seed Potato Certification program. All seedpieces were planted on May 18, 1995. Subplot treatments were inoculated by placing cut seedpieces into either sterile water (treatment A) or sterile water to which *Clavibacter michiganensis* subsp. *sepedonicus* had been added (treatment B). Each subplot was 9-feet long and planted with seven seedpieces. All treatment A seedpieces were planted prior to treatment B seedpieces to avoid cross contamination. The split plot arrangement allowed for direct side-by-side comparison of inoculated and noninoculated treatments for each variety.

The field plot was watered by overhead irrigation when needed, and weeds and insects controlled when needed. Plots were protected from early blight by two applications of Bravo Zn during August.

Treatment plots were observed periodically throughout the growing season. Stand counts were taken on June 13, 16, 23, and July 5. Plant heights of two randomly selected plants per subplot were measured on July 12, and plant vigor was estimated (0 worst to 10 best, treatment A = 5) on July 12 and 18. Plants were visually rated for foliar symptom development on July 18 and August 11, 18, and 24. Plants that developed typical ringrot symptoms were indicated by flags at the time of observation. On September 15, up to six stems were selected from each treatment B subplot in replicate 1 and subjected to a stem squeeze test for positive bacterial signs. On October 11, 10 tubers were randomly selected from each treatment B subplot and a vascular squeeze conducted on tubers cut at the stem end.

Results and Discussion

The effects of ringrot inoculation on plant growth and development are shown in Table 1. Final stand counts were relatively unaffected by inoculation ($\underline{P}<0.05$). For example, stand counts for Russet Norkotah and Atlantic were slightly reduced by inoculation when compared to the water only treatment ($\underline{P}<0.05$). However, FL 1291 and Chieftain varieties stands were slightly reduced by the water only treatment when compared to inoculation with the ringrot bacterium ($\underline{P}<0.05$). These results probably indicate that stand reductions are due to random effects and are not treatment effects.

Plant heights measured on July 12 displayed no clear trend due to ringrot inoculation. Half of the varieties had some reduction in plant height for treatments inoculated with ringrot, but this effect was not significant ($\underline{P}<0.05$). Ringrot inoculation also had no significant effect on early season plant vigor, except for Snowden where the inoculated treatment had a significantly lower vigor rating when compared to the water only treatment ($\underline{P}<0.05$).

Results for foliar ringrot symptom development in the plots is shown in Table 2. Foliar symptoms may have been present in the plots by July 18; however, symptom expression was very mild and was not considered adequate for diagnosis of ringrot. All varieties except Ranger Russet, Russet Burbank, Shepody, and Chipeta exhibited some weak interveinal chlorosis (IVC) at this time. By August 11, IVC was more evident with Snowden, Russet Norkotah, Atlantic, LaBelle, and Chieftain exhibiting one or more plants with strong symptom expression. By August 18, all varieties except Russet Burbank had at least one plant with foliar ringrot symptoms. Russet Burbank remained asymptomatic throughout the season and never exhibited foliar symptoms. However, plants were infected based on the stem squeeze and the presence of tuber symptoms (tuber vascular squeeze). Despite extensive foliar symptom development for some of the varieties, only a small number of tubers expressed symptoms. Although Fontenot, Shepody, and Chipeta had foliar symptoms and a positive stem squeeze, no tuber symptoms were observed for the 40 tubers tested. Results for tuber symptom development is shown in Table 3.

Large differences in symptom development were evident for the potato varieties tested. This presents a unique challenge for growers and field inspectors attempting to detect bacterial ringrot symptoms in the field. Although most varieties developed foliar symptoms at approximately the same time, the number of plants expressing foliar symptoms varied greatly and tuber symptoms were infrequent.

Table 1. Potato variety growth and development response following seedpiece inoculation with the ringrot bacterium *Clavibacter michiganensis* subsp. *sepedonicus* (CMS).

	Final stand* July 5		Plant height (cm) July 12		Plant vigor July 18	
Variety tested	water only	water + CMS	water only	water + CMS	water only	water + CMS
1. Ranger Russet	7.0 a**	7.0 a	41.1	39.1	5.0 ab	4.8 ab
2. Russet Burbank	7.0 a	7.0 a	44.8	40.9	5.0 ab	4.8 ab
3. Snowden	7.0 a	7.0 a	40.1	36.3	5.0 ab	4.0 c
4. Fontenot	7.0 a	7.0 a	40.9	43.3	5.0 ab	4.8 ab
5. LaRouge	7.0 a	7.0 a	37.6	38.4	5.0 ab	4.8 ab
6. Shepody	7.0 a	7.0 a	40.5	43.4	5.0 ab	5.0 ab
7. Russet Norkotah	7.0 a	6.5 a	34.4	34.6	5.0 ab	4.5 b
8. Atlantic	7.0 a	6.8 ab	42.5	41.3	5.0 ab	4.8 ab
9. FL 1291	6.5 b	7.0 a	45.5	43.3	5.0 ab	4.8 ab
10. LaBelle	7.0 a	7.0 a	41.0	40.1	5.0 ab	5.0 ab
11. Chieftain	6.8 ab	7.0 a	39.8	39.9	5.0 ab	5.3 a
12. Chipeta	7.0 a	7.0 a	42.9	46.8	5.0 ab	5.0 ab

* A total of seven seedpieces were planted per treatment subplot.

**Treatment means followed by different letters differ significantly (Duncan's multiple range test, P=0.05).

Table 2. The development of typical foliar ringrot symptoms and stem squeeze results inoculation of seedpieces with *Clavibacter michiganensis* subsp. *sepedonicus*.

Variety tested*	Percentage of plants with symptoms				Stem squeeze results	Foliar symptoms observed by September 15**
	Aug 11	Aug 18	Aug 24	Sept 15		
1. Ranger Russet	0.0	3.6	3.6	14.3	+	IVC, W
2. Russet Burbank	0.0	0.0	0.0	0.0	+	None
3. Snowden	3.6	21.4	25.0	32.1	+	IVC, MN
4. Fontenot	0.0	32.1	60.7	64.3	+	IVC, MN, IVN, W, N
5. LaRouge	0.0	28.6	53.6	53.6	+	IVC, MN, IVN, W
6. Shepody	0.0	3.6	10.7	10.7	+	IVC, ED
7. Russet Norkotah	21.4	57.7	57.7	57.7	+	IVC, MN, IVN, W, S, LR, N
8. Atlantic	11.0	40.4	40.4	44.1	+	IVC, MN, IVN, W
9. FL 1291	0.0	28.6	35.7	60.7	+	IVC, MN, IVN, W, C
10. LaBelle	7.1	50.0	64.3	64.3	+	1VC, MN, IVN, W
11. Chieftain	10.7	96.4	96.4	96.4	+	IVC, MN, IVN, W, LR
12. Chipeta	0.0	3.6	10.7	28.6	+	IVC, W

* Cut seedpieces (seven seedpieces x four replications) for each variety were inoculated with pathogenic *Clavibacter michiganensis* subsp. *sepedonicus* cells. Seedpieces inoculated with sterile water only were used for comparison.
** Designations used are: IVC = interveinal chlorosis, MN = marginal necrosis of leaflets, IVN = interveinal necrosis, W = wilt, C = general chlorosis, S = stunting, LR = leaf roll, N = general necrosis, ED = early dwarf.

Table 3. The development of ringrot symptoms in tubers harvested from inoculated potato seedpieces.

Cultivar tested	Presence (+) or absence(-) of tuber ringrot symptoms (Oct. 11)
1. Ranger Russet	+(1)*
2. Russet Burbank	+(3)
3. Snowden	+(1)
4. Fontenot	-(0)
5. LaRouge	+(1)
6. Shepody	-(0)
7. Russet Norkotah	+(2)
8. Atlantic	+(2)
9. FL 1291	+(3)
10. LaBelle	+(2)
11. Chieftain	+(4)
12. Chipeta	-(0)

* The number of symptomatic tubers found out of 40 tubers randomly selected from each inoculated variety.

Bacterial Ring Rot Symptom Development in Selected Potato Cultivars, 1996

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Abstract

Field plots were established to aid ring rot diagnosis by growers and seed certification personnel. Five potato cultivars were evaluated for bacterial ring rot (Clavibacter michiganensis subsp. sepedonicus) symptom development under two different environmental conditions. Identical field trials were conducted at the University of Wyoming in Laramie, and at the University of Wyoming Research and Extension Center at Torrington. Seedpiece inoculation with the ring rot bacterium generally had no effect on plant emergence and growth early in the season, prior to foliar symptom development. Foliar ring rot symptoms became evident for Russet Norkotah, FL1831 and FL1867 by early August at both field sites and were not apparent until late August for Russet Burbank and Sangre. The location of field sites influenced foliar and tuber symptom expression, with plants at the Laramie site exhibiting a greater incidence of foliar and tuber symptoms than plants grown at the Torrington site. Symptom expression in the variety FL1831 was greatly influenced by site. Russet Burbank had the least foliar symptom expression and was the most vigorous in appearance late in the growing season at either site. Sangre had the greatest percentage of plants that expressed foliar symptoms; however, symptoms did not develop until late in the growing season. Russet Norkotah and FL1867 behaved similarly in terms of symptom expression and early senescence. Psyllid injury was extensive for some cultivars planted at the Laramie site and made evaluations difficult. All cultivars had at least one plant with a positive stem squeeze and/or typical tuber symptoms. Tuber subsamples from each plot are being held for several months at 45 degrees Fahrenheit to determine symptom development during storage.

Materials and Methods

This experiment was conducted at two sites in Wyoming. The sites were selected to provide two different environmental conditions for plant growth and ring rot symptom development. One site was at the University of Wyoming Research and Extension Center located near Torrington (about 4104 feet msl). Environmental conditions at Torrington are typical of irrigated potato production areas of the

West Central High Plains. The second site was established at the University of Wyoming in Laramie, WY (about 7200 feet msl). Climatic conditions at Laramie are similar to those of the San Luis Valley potato production area in Colorado and are characterized by cool temperatures, intense solar radiation, and a growing season.

The experimental design was a split plot design with the five potato cultivars as main treatment plots with four replicates. Main plots were split with noninoculated (A) or inoculated (B) seedpiece treatments for ring rot development. Main plots were one row by 20 feet and planted to one of the following varieties: Russet Burbank, Sangre, Russet Norkotah, FL1831, and FL1867. Potato seedpieces were obtained from the following sources: Western Potato (Russet Burbank), Colorado State University Potato Certification Service (Sangre and Russet Norkotah), and Frito-Lay, Inc., (FL1831 and FL1867). All seedpieces were cut by hand and inoculated on May 7, 1996. Cut seedpieces were immediately treated by dipping into either sterile water (treatment A, noninoculated) or sterile water to which macerated tubers infected with Clavibacter michiganensis subsp. sepedonicus (CMS) were added (treatment B, inoculated). The source of CMS (rifampicin marker) was symptomatic tubers stored from the 1995 growing season that were macerated in a blender. All noninoculated treatments were completed prior to inoculated treatments, to minimize the risk of cross contamination. After treatment, seedpieces were held at 45 degrees Fahrenheit until planting. The Torrington plot was planted on May 10 and the Laramie plot was planted on May 16, 1996. Each subplot was 10-feet long and planted with seven seedpieces. All treatment A seedpieces were planted prior to treatment B seedpieces to avoid cross contamination. The split plot arrangement allowed for side-by-side comparison of inoculated and noninoculated treatments for each cultivar.

Plots were watered by overhead irrigation and weeds and insects were controlled when necessary. Plots were protected from early blight by several applications of Bravo Weather Stik in July and August. A low incidence of late blight was observed in the Torrington plots late in the season.

Treatment plots were observed periodically during the growing season and ring rot symptom expression was recorded. Stand counts for Torrington were taken on June 5, 11, and 18 and Laramie on June 10, 12, 17, and 19 and July 3. Plant height (vine length) of each plant per subplot was measured in Torrington on June 20 and 26 and in Laramie on June 25 and July 3. Plant vigor was estimated (0 worst to 10 best, treatment A=5) in Torrington on June 20 and 26 and July 1, 10, and 17 and in Laramie on June 25 and July 3. Plants were visually rated for foliar symptoms in Torrington on July 23 and August 2, 8, and 27 and Laramie on July 22, August 6 and 26, and September 6. On September 18 in Torrington, and on September 11 in Laramie, up to four stems were selected from each treatment B subplot (from replication #1) and subjected to a stem squeeze (bacterial ooze) test for bacterial ring rot signs. Plots were hand harvested in Torrington on September 26 and on September 24 in Laramie. Twenty externally sound (healthy-appearing) tubers were selected at random from each subplot, placed in paper bags and stored at 45 degrees Fahrenheit. After approximately one month of storage, 10 tubers were selected from each subplot and a vascular squeeze conducted on tubers cut at the stem end. The remaining 10 tubers were placed back into cold storage for further testing at a later date.

All data were analyzed with 'PC-SAS' in a split plot ANOVA with four replicates and five cultivars by two treatment levels. Each location was analyzed separately. If the appropriate effects or interactions were significant ($\underline{P}<0.05$), means of interest were compared with the least square means method.

Results and Discussion

The effects of ring rot inoculum on plant growth and development are shown in Tables 1-3. Inoculation with CMS had no affect on final stand counts (Table 1) ($\underline{P}<0.05$). Final stand counts, averaged over cultivar and location, were 6.9 and 7.0 (maximum = 7) for noninoculated and inoculated treatments, respectively. Inoculation with CMS had no significant effect on vine length, when compared to the noninoculated treatment at the Laramie site (Table 2, $\underline{P}<0.05$). However, at the Torrington site, inoculation with CMS significantly increased the average vine length (treatment A = 30.56 cm, treatment B = 32.39 cm) ($\underline{P}<0.05$). As expected, vine length differed significantly among cultivars ($\underline{P}<0.05$). Statistical groupings of vine lengths are; Russet Burbank = FL1867 > Russet Norkotah > FL1831 = Sangre ($\underline{P}<0.05$). In general, plants tended to be larger at the Torrington field site for corresponding treatments. Plant vigor measurements are shown in Table 3. There were no significant treatment effects on vigor at the Torrington site ($\underline{P}<0.05$). In Laramie, a significant inoculation by variety interaction was detected ($\underline{P}<0.05$). The relevance of the interaction is not known. In general, potato plant growth and development early in the season is not adversely affected by seedpiece inoculation with CMS and noninoculated versus inoculated treatments appeared similar.

Results for foliar ring rot symptom development for Torrington and Laramie are shown in Tables 4 and 5, respectively. By August 2 at the Torrington site, plants were expressing foliar symptoms for Russet Norkotah (3.6 percent), FL1831 (3.7 percent) and FL1867 (3.6 percent). Symptoms at this time were mild and consisted of interveinal chlorosis, wilt, and early dwarfing (Russet Norkotah). By August 8, the incidence of symptom expression increased in Russet Norkotah and FL1867 to 21.4 percent. Sangre and Russet Burbank did not express foliar symptoms until August 27. Russet Burbank had 14.3 percent of the plants exhibiting weak symptoms and Sangre, a cultivar that typically exhibits strong foliar symptoms, had 42.9 percent of the plants expressing on this date. Russet Norkotah and FL1867 were similar in response and exhibited foliar symptoms in 35.7 percent of the plants with vine senescence and death occurring readily. FL1831 was more similar to Russet Burbank in growth habit and symptom expression than was FL1867. FL1831 expressed strong "classic" interveinal chlorosis ring rot symptoms. All cultivars, except Russet Burbank, exhibited a positive stem squeeze at the Torrington site.

Plants grown at the Laramie site had 55.7 percent of the plants expressing foliar symptoms on the final evaluation date versus 30.2 percent at Torrington. At Laramie, foliar symptoms developed in Russet Norkotah, FL1831, and FL1867 by August 6, and by August 26, all cultivars exhibited foliar ring rot symptoms. Psyllid-toxin injury was extensive at Laramie, and appeared to make foliar ring rot symptoms more difficult to read in the Russet Norkotah plots. Moderate psyllid injury was also noted in FL1867. It is not known how the psyllid injury interacts with the expression of foliar ring rot symptoms among cultivars. All cultivars had a greater percentage of plants exhibiting foliar ring rot symptoms at the Laramie site when compared to the corresponding treatment at the Torrington site. All cultivars had a positive stem squeeze at the Laramie site.

Data for ring rot expression in stored tubers are shown in Tables 4 and 5. The varietal main effect was not significant at either location ($\underline{P}<0.05$). As with foliar symptom expression, the incidence of tuber symptom expression was greatest at Laramie versus Torrington, with an average of 30.7 percent and 7 percent symptomatic tubers, respectively. However, more rotted tubers were found in the field at the time of harvest in Torrington than at the Laramie site. Environmental conditions may have favored decay of infected tubers, and, because only visibly sound tubers were harvested, the incidence of tuber symptom expression may have been underestimated for the Torrington site. Similar to foliar symptom expression, tuber symptom expression for FL1831 was very sensitive to location. For tubers harvested from the Torrington site, no symptomatic FL1831 tubers were found after one month of cold storage compared to 42.5 percent detected for tubers from the Laramie site. Russet Burbank appeared to be the least affected by location in terms of tuber symptom expression. Tuber subsamples from each plot are being held for several months at 45 degrees Fahrenheit to determine symptom development as storage continues.

As with previous studies, differences in ring rot symptom development were evident for the potato cultivars tested and environmental conditions can be a major influence on ring rot symptom expression. Coupled with the fact that seedpiece inoculation with CMS had no effect on early-season potato growth and development, ring rot detection in the field is a great challenge for growers and field inspectors.

Table 1. Plant emergence and stand following seedpiece inoculation with *Clavibacter michiganensis* subsp. *sepedonicus* (CMS) (G.D. Franc, et al., University of Wyoming (1996).

	Torrington final stand (June 18)*		Laramie final stand (July 3)*	
Variety tested	water only	water + CMS	water only	water + CMS
1. Burbank Russet	7.0	7.0	7.0	7.0
2. Sangre	6.5	7.0	7.0	7.0
3. Russet Norkotah	7.0	7.0	6.5	7.0
4. FL 1831	7.0	6.8	7.0	7.0
5. FL 1867	7.0	7.0	7.0	7.0

* Exactly seven seedpieces were planted per treatment subplot.

Table 2. Plant growth response following seedpiece inoculation with the ring rot bacterium *Clavibacter michiganensis* subsp. *sepedonicus* (CMS) (G.D. Franc, et al., University of Wyoming (1996).

	Torrington Vine length (cm) on June 26		Laramie Vine length (cm) on July 3	
Variety tested	water only	water + CMS	water only	water + CMS
1. Burbank Russet	36.8	39.0	26.2	29.0
2. Sangre	23.1	27.0	26.6	23.1
3. Russet Norkotah	32.0	32.5	22.8	22.4
4. FL 1831	25.0	25.5	22.0	22.5
5. FL 1867	36.1	38.1	27.8	30.5

Table 3. Potato vigor response following seedpiece inoculation with the ring rot bacterium *Clavibacter michiganensis* subsp. *sepedonicus* (CMS) (G.D. Franc, et al., University of Wyoming (1996).

	Torrington Plant vigor* on July 17		Laramie Plant vigor* on July 3	
Variety tested	water only	water + CMS	water only	water + CMS
1. Burbank Russet	5	5.00	5	5.00
2. Sangre	5	5.25	5	4.25
3. Russet Norkotah	5	4.50	5	5.50
4. FL 1831	5	5.25	5	4.75
5. FL 1867	5	4.75	5	5.75

* Rated on a scale of 1 to 10 (0 worst to 10 best, noninoculated (water only) = 5).

Table 4. Ring rot detection at Torrington following seedpiece inoculation with *Clavibacter michiganensis* subsp. *sepedonicus* (G.D. Franc, et al., University of Wyoming (1996).

Torrington site	Percentage of plants expressing foliar symptoms			Range of visual symptoms observed*	Stem squeeze	Percentage of tubers expressing symptoms**
Variety tested	Aug 2	Aug 8	Aug 27		Sept 18	
1. Burbank Russet	0.0	0.0	14.3	ED, IVC, LR, N, C, W	-	15.0
2. Sangre	0.0	0.0	42.9	IVC, MN, LR, N, W	+	2.5
3. Russet Norkotah	3.6	21.4	35.7	ED, IVC, MN, LR, N, W	+	10.0
4. FL 1831	3.7	3.7	22.2	IVC, N, W	+	0.0
5. FL 1867	3.6	21.4	35.7	IVC, MN, LR, N, C, W	+	7.5
Site average	**2.2**	**9.3**	**30.2**			**7.0**

* Symptom code: ED = early dwarfing, IVC = interveinal chlorosis, IVN = interveinal necrosis, MN = marginal necrosis, LR = leaf roll, N = necrosis, C = chlorosis, W = wilt, S = stunting.

** After one-month storage at 45 degrees Fahrenheit. The harvest date was September 26.

Table 5. Ring rot detection at Laramie following seedpiece inoculation with *Clavibacter michiganensis* subsp. *sepedonicus* (CMS) (G.D. Franc, et al., University of Wyoming (1996).

Laramie site	Percentage of plans expressing foliar symptoms			Range of visual symptoms observed*	Stem squeeze	Percentage of tubers expressing symptoms**
Variety tested	Aug 6	Aug 26	Sept 6		Sept 11	
1. Burbank Russet	0.0	7.1	32.1	ED, IVC, MN, LR, N, C, W	+	14.2
2. Sangre	0.0	7.1	71.4	IVC, IVN, MN, LR, W	+	33.6
3. Russet Norkotah	14.3	35.7	42.8	IVC, IVN, MN, LR, S	+	25.6
4. FL 1831	10.7	57.1	78.6	IVC, IVN, MN, LR, S	+	42.5
5. FL 1867	25.0	42.9	53.6	ED, IVC, IVN, MN, LR, W	+	37.5
Site average	**10.0**	**30.0**	**55.7**			**30.7**

* Symptom code: ED = early dwarfing, IVC = interveinal chlorosis, IVN = interveinal necrosis, MN = marginal necrosis, LR = leaf roll, N = necrosis, C = chlorosis, W = wilt, S = stunting.

** After one-month storage at 45 degrees Fahrenheit. The harvest date was September 24.

Potato Vine Desiccant Efficacy and Tuber Quality Effects, 1995

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Abstract

Nine treatments were compared to a nontreated control for pre-harvest desiccation of potato vines (cv. Norkotah). All foliar applications were made on August 30, 1995. Vines were green and vigorous when treatments were applied. Within the first 24 hours following application, and on all subsequent data collection dates, all vine desiccation treatments significantly increased foliar necrosis compared to the nontreated control ($\underline{P}<0.05$). Also within the first 24 hours, Diquat and Cyclone treatments resulted in significantly more foliar necrosis than the other treatments, except for TD-2335-02 (5 pt/A) plus ammonium sulfate ($\underline{P}<0.05$). After 24 hours, treatments with TD-2335-02 plus ammonium sulfate generally resulted in the greatest percentage of foliar necrosis followed by DES-I-CATE then Diquat and Cyclone, with TD-2335-02 (applied alone) treatments resulting in the least amount of foliar necrosis. In general, when the rate of TD-2335-02 was increased, foliar necrosis also increased. After 24 hours, TD-2335-02 plus ammonium sulfate treatments always resulted in significantly greater foliar necrosis than the corresponding TD-2335-02 treatments that lacked ammonium sulfate ($\underline{P}<0.05$). The relative effects of all treatments on stem necrosis were similar to those measured for foliar necrosis. None of the treatments significantly affected vascular (stem-end) discoloration of tubers ($\underline{P}<0.05$).

Materials and Methods

The vine desiccant field trial was conducted on a commercial potato field located near LaGrange. The field plot area was planted with cultivar 'Norkotah' on June 10, 1995. The plot area was irrigated via an overhead sprinkler and normal commercial production practices were followed throughout the growing season. The experimental design was a randomized complete block design with 10 treatments and four replicates. Each plot was 20-feet long by four-rows wide with a between-row spacing of 36 inches and a 5-foot nontreated in-row buffer remaining between plots. Treatments were applied to the middle two rows with a backpack sprayer in a total spray volume of 39 gallons per acre at 30 psi boom pressure. The spray boom was equipped with four #8004 flat fan spray tips spaced at 20 inches.

All vine desiccation treatments were applied on August 30 at the rates shown in Table 1. Potato vines were green at the time of application. Data was collected by rating vines for foliar necrosis using the Horsfall-Barratt scale (0-11). Data to establish the baseline necrosis present prior to treatment application were collected on August 30. After treatments were applied, plots were rated for foliar necrosis on August 31 and September 1, 6, 8, and 18. The percentage of stem necrosis (percentage of stems dead) was also rated on September 6, 8, and 18.

Tubers were harvested on September 22. Ten tubers were randomly selected from the center four hills of each treatment plot. On September 27, tubers were rated for stem-end discoloration of the vascular tissue, using the Horsfall-Barratt scale (0-11). The stem-end of each tuber was removed with a knife and the percentage of the vascular ring discolored was visually estimated. Horsfall-Barratt data were converted to percentage values using the appropriate conversion tables prior to presentation in Table 1.

All data were analyzed with 'Pesticide Research Manager' in a two-way ANOVA with four replicates and 10 treatments. Mean separation was done, using Duncan's Multiple Range Test ($\underline{P}<0.05$).

Results and Discussion

Results for the vine desiccation treatments are summarized in Table 1. Because vines were green when treatments were applied, this trial was a moderately rigorous test of vine desiccant activity. Sunny conditions prevailed during the time when treatments were applied. Because the products tested are activated by sunlight, the sunny conditions may have reduced their activity. This is due to rapid death of plant cells, which can reduce product movement and distribution in the plant prior to activation. This is especially true with Diquat and Cyclone and to a lesser extent with endothall containing products such as DES-I-CATE and TD-2335-02.

Within the first 24 hours following application, and on all subsequent data collection dates, all treatments significantly increased foliar necrosis when compared to the nontreated control ($\underline{P}<0.05$). Also, within the first 24 hours following application, Diquat and Cyclone treatments had the greatest activity and resulted in significantly more foliar necrosis than the other treatments, except for TD-2335-02 (5 pt/A) plus ammonium sulfate ($\underline{P}<0.05$). After 24 hours, treatment with TD-2335-02, at both the 5 and 6 pints per acre rates plus ammonium sulfate, resulted in the greatest percentage of foliar necrosis and these treatments were significantly better than either Diquat or Cyclone, except on September 18 ($\underline{P}<0.05$). Treatments with TD-2335-02 plus ammonium sulfate generally resulted in the greatest percentage of foliar necrosis followed by DES-I-CATE then Diquat and Cyclone, with TD-2335-02 (applied alone) resulting in the least amount of foliar necrosis. By September 18, all treatments except TD-2335-02 (applied alone) treatments were statistically equivalent to TD-2335-02 (6 pints per acre) plus ammonium sulfate, which had the greatest percentage of foliar necrosis ($\underline{P}<0.05$).

In general, when the rate of TD-2335-02 applied alone and when co-applied with ammonium sulfate increased from 4 to 6 pints per acre, foliar necrosis also increased. However, the rate effect is not as pronounced for TD-2335-02 applied with ammonium sulfate as it is for treatments where TD-2335-02 was applied alone. After 24 hours, TD-2335-02 applied alone at 6 pints per acre always resulted in greater foliar necrosis than the 4 and 5 pints per acre application rates and was significantly different for two of the data collection dates ($\underline{P}<0.05$). Treatment means for TD-2335-02 (applied alone) at 4 and 5 pints per acre rates never differed significantly ($\underline{P}<0.05$). The addition of ammonium sulfate to TD-2335-02 treatments greatly increased desiccant activity. After 24 hours, TD-2335-02 treatments amended with ammonium sulfate always resulted in significantly greater foliar necrosis when compared to similar rates of TD-2335-02 applied alone ($\underline{P}<0.05$).

All treatments significantly increased stem necrosis when compared to the nontreated control ($\underline{P}<0.05$). Treatment with TD-2335-02 at 5 and 6 pints per acre plus ammonium sulfate had significantly more stem necrosis than Diquat and Cyclone on and September 6 and 8 ($\underline{P}<0.05$). By September 18 many of the treatments were similar when stem necrosis ratings were compared ($\underline{P}<0.05$). In general, treatments with TD-2335-02 plus ammonium sulfate resulted in the greatest stem necrosis followed by DES-I-CATE, Cyclone, and Diquat, and treatments with TD-2335-02 (applied alone) have the least stem necrosis, especially at the 4 and 5 pints per acre rates. Regrowth of new stems from axillary buds occurred in some treatment plots, especially those treated with TD-2335-02 plus ammonium sulfate or Cyclone. The reason for this is not entirely clear, but may have resulted from the rapid death of foliage which allowed axillary buds to break dormancy and grow before vine death.

Similar to the results observed for foliar activity, increased rates of TD-2335-02 from 4 to 6 pints per acre, when applied alone or co-applied with ammonium sulfate, resulted in increased stem necrosis. The addition of ammonium sulfate to TD-2335-02 treatments usually significantly increased the percentage of stem necrosis when similar TD-2335-02 rates are compared ($\underline{P}<0.05$).

None of the treatments significantly affected vascular (stem end) discoloration of tubers ($\underline{P}<0.05$).

Acknowledgments

The use of field plot space and the assistance provided by Curtis Meier of LaGrange is greatly appreciated.

Table 1. The effects of foliar treatments on potato (cv. Norkotah) foliage and stem desiccation and tuber quality (G.D. Franc and W.L. Stump, University of Wyoming, 1995).

Treatment and application rate (product/A)	Percentage of foliage necrotic and rating date[2]						Percentage of stems necrotic and rating date[2]			SED[2,3] (%)
	8/30	8/31	9/1	9/6	9/8	9/18	9/6	9/8	9/18	9/27
1. Nontreated control	7.5a[4]	7.5c	7.5e	7.5f	7.5d	27.0d	2.0d	2.0e	10.5e	8.8a
2. TD-2335-02 (6 pt)	6.0a	23.5b	55.0bc	69.0bc	64.0d	67.0bc	23.5abc	31.0bcd	59.5bcd	8.0a
3. TD-2335-02 (5 pt)	6.0a	23.5b	40.5d	50.0de	55.0c	59.5c	15.0c	31.0bcd	50.0cd	9.5a
4. TD-2335-02 (4 pt)	8.5a	21.0b	40.5d	45.0e	50.0c	59.5c	15.0c	21.0d	40.5d	8.5a
5. TD-2335-02 (6 pt) + Amm. sulfate[5]	10.5a	23.5b	69.0a	85.5a	88.5a	87.0a	40.5a	46.0ab	83.0a	8.0a
6. TD-2335-02 (5 pt) + Amm. sulfate	7.5a	28.0ab	69.0a	85.5a	88.0a	85.5a	40.5a	56.0a	76.5ab	9.5a
7. TD-2335-02 (4 pt) + Amm. sulfate	8.5a	17.0b	61.5ab	79.5a	79.5b	83.0a	37.0ab	40.5abc	73.5abc	10.5a
8. DES-I-CATE (2 gal)	7.5a	21.0b	59.5ab	78.0ab	76.5b	80.0ab	28.0abc	37.0bc	69.0abc	8.0a
9. Diquat (1 pt) + X77 (0.125 percent V:V)	10.5a	40.5a	55.0bc	62.0cd	64.0c	76.5ab	21.0bc	28.0cd	65.0a-d	11.5a
10. Cyclone (1 pt) + X77 (0.125 percent V:V)[6]	10.5a	40.5a	48.0cd	62.0cd	64.0c	80.0ab	17.0c	28.0cd	73.5abc	7.0a

[1] Treatments were applied on August 30 in a total volume of 39 gallons per acre with #8004 tips and 30 psi at the sprayer boom.

[2] Data presented are Horsfall-Barratt values (scale 0-11) converted to percentages using the appropriate conversion tables.

[3] Stem-end discoloration (SED) was rated by estimating the percentage of the tuber vascular tissue discolored (10 tubers were rated per treatment plot).

[4] Treatment means followed by different letters differ significantly (P=0.05). Duncan's multiple range test was used for mean separation.

[5] Ammonium sulfate (Amm. Sulfate) was applied at the rate of 5 lbs a.i./A.

[6] Cyclone was only included in this study for experimental purposes and served as a positive check. All labels must carefully be reviewed for proper chemical use on potatoes and other crops.

Potato Vine Desiccant Efficacy and Tuber Quality Effects, 1996

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Abstract

This study was conducted at the University of Wyoming Research and Extension Center during 1996 near Torrington. Six treatments were compared to a nontreated control for pre-harvest defoliation of potato vines (cv. Atlantic) and for their effects on tuber bruising and skin-set. All desiccation treatments resulted in significantly more foliar necrosis (defoliation) within 24 hours of application than did the nontreated control ($\underline{P}<0.05$). Treatments did not significantly increase the area under the desiccation progress curve (ADPC, the measure of relative desiccation over time for foliar necrosis ($\underline{P}<0.05$), probably because considerable defoliation occurred in the nontreated control plots due to the presence of late blight, early blight, and natural vine senescence. Treatments significantly increased stem death compared to the nontreated control ($\underline{P}<0.05$). Pre-harvest vine desiccation reduced tuber injury that occurred during harvest and significantly reduced the incidence of medium bruising ($\underline{P}<0.05$). Data for early and late blight, tuber decay will be collected after tubers are stored for several months.

Materials and Methods

Field plots were established at the University of Wyoming Research and Extension Center near Torrington during 1996. Dual II (1.5 pints product per acre) was mechanically incorporated into field soil prior to planting. On May 11, potato cultivar 'Atlantic' was planted with the aid of a mechanical planter. After emergence, a randomized complete block with four replicates and seven treatments were established. Treatment plots were 20-feet long by two-rows wide with 36-inch centers and were separated by two nontreated buffer rows. A 5-foot in-row nontreated buffer existed between treatment plots. The field plot received overhead irrigation as needed, and weeds and insects were controlled when necessary.

Foliar desiccation treatments were applied on August 26 at the rates shown in Table 1. Potato vines were green at the time of application with an average of 7 percent foliar necrosis present in the field prior to treatment. Treatments were applied with a backpack sprayer in a total spray volume of 43 gallons per acre at 35 psi boom pressure. The spray boom was equipped with four #8004 lat-an spray nozzles spaced at 20 inches.

Data were collected by rating vines for foliar necrosis (defoliation) using the

Horsfall-Barratt scale (0-11). Vines were rated on August 26 (prior to application and two hours after application), 27 (at 21 and 24 hours after application), and 29 and September 4 and 9. As an additional measure of vine-kill efficacy, the "area under desiccation progress curve" (ADPC) was calculated to provide a relative measure of foliage loss foliar necrosis) over time. Treatments that cause necrosis more quickly (i.e., are faster acting) or cause more final necrosis, or both, will result in a greater ADPC value. The percentage of stems dead was rated on August 29 and September 4, 9, and 18. An ADPC value was also computed for relative stem necrosis. Vine regrowth was evaluated on September 18 as a percentage of hills with at least one stem initiating regrowth using the Horsfall-Barratt scale.

Post-harvest Tuber Tests: Tubers were harvested on October 1 with the aid of a single row mechanical harvester. From the center of each treatment plot, three sets of 20 tubers were individually bagged and labeled (A, B, or C) for post-harvest skin-set and tuber quality evaluations.

One of the benefits of vine desiccation is to reduce tuber storage diseases such as early and late blight. Because early blight development in tubers results from infection through broken skin, treatments that promote skin-set prior to harvest will reduce tuber losses in storage. On October 2, group "A" tubers were dipped into a water suspension that contained early blight spores (Alternaria solani) at a concentration of 2,000 spores/ml. These tubers were then stored in a 45 degrees Fahrenheit cold room for later observations for tuber early blight development. Group "B" spores were dipped in water only and were also stored at the same environmental conditions. Tubers were rated for the incidence and severity of early blight and late blight decay after several months in storage.

The remaining group "C" tubers were washed and air-dried prior to rating tuber harvest-related injury. Ten tubers were dipped into a catechol solution (56 grams per 1 gallon) and rated for skinning and the incidence of shatter bruise (slight, medium, and severe). The remaining 10 tubers were rated for the incidence of Rhizoctonia infection (black scurf "alligator hide," and proliferated lenticels using a scale of one to three (1=slight, 2=moderate, and 3=severe occurrence). Five of these tubers were used to measure skin-set (skin shear-strength) (ounces per inch) with a modified torque-wrench as developed by Halderson and Henning (1993). The modified torque-wrench was placed on each tuber with a 17 pound force applied to a 0.60-inch-diameter rubber stopper (#1 size) and then twisted until the skin "slipped." Each tuber was tested at three positions along the equatorial region and an average reading was calculated.

Data Analysis: All data were analyzed with 'PC-SAS' in a two-way ANOVA with four replicates and seven treatments. Mean separations were accomplished with Fisher's protected LSD ($\underline{P}$=0.05). Horsdall-Barratt data were analyzed and then converted to percentages for presentation in the Tables.

Results and Discussion

Most foliar necrosis (7 percent average) present in plots prior to treatment applications was attributed to the presence of early blight and late blight. Vine desiccation effects on foliar necrosis are summarized in Table 1. Within 24 hours of application, all treatments significantly increased foliar necrosis when compared to the nontreated control ($\underline{P}<0.05$). Treatments 2 and 3 (TD2335 @ 4 and 6 pints per acre +AMS) had significantly more foliar necrosis than treatments 4 through 7 ($\underline{P}<0.05$). Nine days after application, there were no statistical differences between the treatments and the nontreated control ($\underline{P}<0.05$). However, all treatments had a greater percentage odegress Fahrenheit the necrotic foliage than did the control. At 14 days after application, foliar necrosis of the nontreated control (93 percent) approximated the average necrosis measured in the treated plots (97 percent). Although differences among the ADPC values were not significant ($\underline{P}<0.05$), all treated plots had a greater relative foliar necrosis present than did the nontreated control. The rapid senescence and necrosis of plants in the nontreated plots masked treatment effects as the study progressed.

Vine desiccation effects on stem death are summarized in Table 2. All treatments had significantly more stem necrosis present than did the nontreated control for all data collection dates (3, 9, and 14 days after application) ($\underline{P}<0.05$). Three days after application, treatment 3 (TD2335 6 pt/A+AMS) had significantly more vine necrosis present than any other treatments ($\underline{P}<0.05$). At 9 and 14 days after application, all treatments were statistically equivalent ($\underline{P}<0.05$). Also, all treatments had greater ADPC values for relative stem necrosis than the nontreated control ($\underline{P}<0.05$). Although vine regrowth occurred in some treatment plots, treatments did not differ significantly ($\underline{P}<0.05$).

Although all treatments were statistically similar for vine-kill efficacy it should be pointed out that only treatments 2 and 3 had 100 percent foliar necrosis, the greatest percentage of stems dead, and a low percentage of stem regrowth. This treatment effect is an important consideration for managing late blight. Because late blight requires green tissue for sporulation, the presence of green tissue during tuber harvest will increase the risk of tuber infection and storage losses.

The effects of vine desiccation treatments on tuber characteristics are summarized in Table 3. Treatment effects on skin-set (shear-strength), tuber skinning, Rhizoctonia scurf, and proliferated lenticels were not significant ($\underline{P}<0.05$). The incidence of medium bruising was significantly affected with all treatments having less bruise than the nontreated control ($\underline{P}<0.05$). However, the incidence of slight, severe, and total bruise was not affected by treatment ($\underline{P}<0.05$). The interval between vine-kill and harvest may have been too great (three weeks), allowing for sufficient skin-set in the nontreated control to mask efects due to desiccation treatments. The presence of both late blight and early blight in the plots also may have confounded treatment effects.

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Table 1. The effects of foliar vine desiccation treatments on potato (cv. Atlantic) foliage necrosis (G.D. Franc, et al., University of Wyoming, 1996).

	Percentage of foliage necrotic and rating interval after application[1]						
Treatment and application rate (product/A)	2 hr	21 hr	24 hr	3 day	9 day	14 day	ADPC[2]
1. Nontreated control	8.5a[3]	12.0 a	12.0 c	17.0 c	56.0 a	93.0 a	73.3 a
2. TD2335 2SC (4 pt/a) + Ammonium Sulfate (5 lb/A)	5.5 a	20.0 a	72.5 a	88.0 a	95.5 a	100.0 a	118.9 a
3. TD2335 2SC (6 pt/a) + Ammonium Sulfate (5 lb/A)	3.5 a	23.5 a	69.0 a	91.5 a	94.0 a	100.0 a	119.2 a
4. TD2335 2SC (4 pt/a) + Dyne-Amic (0.56 percent V:V)	6.5 a	17.0 a	36.0 b	69.0 b	76.5 a	91.5 a	93.4 a
5. TD2335 2SC (6 pt/a) + Dyne-Amic (0.56 percent V:V)	6.0 a	20.0 a	50.0 b	73.5 b	94.0 a	98.0 a	110.6 a
6. Diquat 2EC (1 pt/A) + X-77 (0.125 percent V:V)	8.0 a	31.0 a	45.0 b	46.0 b	92.0 a	97.0 a	101.6 a
7. Cyclone 2.5SC (1 pt/A) + X-77 (0.125 percent V:V)	10.3 a	36.0 a	50.0 b	56.0 b	93.0 a	97.0 a	104.8 a

[1] Percentage data were convered from Horsfall-Barratt ratings.
[2] Area under the desiccation progress curve.
[3] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, P=0.05).

Table 1. The effects of foliar vine desiccation treatments on potato (cv. Atlantic) stem necrosis (G.D. Franc, et al., University of Wyoming, 1996).

	Percentage of stems necrotic and rating interval after application[1]				
Treatment and application rate (product/A)	3 day	9 day	14 day	percent regrowth	ADPC[2]
1. Nontreated control	4.8 c[3]	12.0 b	50.0 b	2.0 b	48.4 c
2. TD2335 2SC (4 pt/a) + Ammonium Sulfate (5 lb/A)	36.0 b	64.0 a	97.0 a	0.0 a	100.9 ab
3. TD2335 2SC (6 pt/a) + Ammonium Sulfate (5 lb/A)	59.5 a	72.5 a	97.0 a	2.0 a	111.0 a
4. TD2335 2SC (4 pt/a) + Dyne-Amic (0.56 percent V:V)	27.0 b	40.5 a	91.5 a	10.5 a	85.6 b
5. TD2335 2SC (6 pt/a) + Dyne-Amic (0.56 percent V:V)	31.0 b	64.0 a	96.0 a	2.0 a	98.6 ab
6. Diquat 2EC (1 pt/A) + X-77 (0.125 percent V:V)	20.0 b	50.0 a	91.5 a	3.0 a	86.1 b
7. Cyclone 2.5SC (1 pt/A) + X-77 (0.125 percent V:V)	36.0 b	69.0 a	94.0 a	2.0 a	99.9 ab

[1] Percentage data were convered from Horsfall-Barratt ratings.
[2] Area under the desiccation progress curve.
[3] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, P=0.05).

Table 2. The effects of foliar vine desiccation treatments on potato (cv. Atlantic) tuber characteristics (G.D. Franc, et al., University of Wyoming, 1996).

	Tuber bruising incidence (average no. per tuber)[1]				Tuber-skin characteristics[1]			
Treatment and application rate (product/A)	Slight	Medium	Severe	Total	Skin-Set (shear)	% SA skinned	Rhizoctonia black scurf[2]	Proliferated lenticels[2]
1. Nontreated control	0.18	0.15 a[3]	0.05	0.38	51.9	0.88	0.90	1.0
2. TD2335 2SC (4 pt/a) + Ammonium Sulfate (5 lb/A)	0.23	0.03 bc	0.00	0.25	55.3	0.60	0.33	1.3
3. TD2335 2SC (6 pt/a) + Ammonium Sulfate (5 lb/A)	0.18	0.03 bc	0.03	0.23	50.1	0.82	0.43	1.5
4. TD2335 2SC (4 pt/a) + Dyne-Amic (0.56 percent V:V)	0.25	0.00 c	0.08	0.33	48.4	1.00	0.63	1.0
5. TD2335 2SC (6 pt/a) + Dyne-Amic (0.56 percent V:V)	0.23	0.10 ab	0.03	0.35	53.5	0.58	0.65	1.8
6. Diquat 2EC (1 pt/A) + X-77 (0.125 percent V:V)	0.23	0.05 bc	0.05	0.33	52.9	1.23	0.63	1.3
7. Cyclone 2.5SC (1 pt/A) + X-77 (0.125 percent V:V)	0.13	0.03 bc	0.08	0.23	51.0	0.83	0.68	1.5
ANOVA results	**n.s.[4]**	**P<0.05**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

[1] All data are based on a subsample of 10 tubers per treatment plot, except for the skin-set (shear) test data. Skin-set results were based on three torque readings per tuber; five tubers were tested per treatment plot.
[2] Ratings were: 1=slight, 2=moderate, and 3=severe occurrence.
[3] Means followed by the same letter in the column do not differ significantly (Fisher's Protected LSD, P=0.05).
[4] Means in the column do not differ significantly (Fisher's Protected LSD, P=0.05).

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