POTATO (*Solanum tuberosum*) 'Russet Burbank'
Early Blight; *Alternaria solani*

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Evaluation of forecasting systems to determine fungicide application schedules for control of early blight of potato - Hancock, 2003

Use of forecasting systems based on weather and plant growth offer the potential to apply fungicides when they are most needed for control of potato foliar blights. A field trial was established 23 Apr at the Hancock Agricultural Research Station in central WI to compare disease control based on the recommendations of two forecasting systems with standard weekly programs. US#1 Russet Burbank tubers were mechanically cut into approximately 2 oz seedpieces 16 Apr and allowed to heal before planting. Plots consisted of four 24-ft-long rows spaced 36 in. apart with tubers 15 in. apart in the row. The trial was arranged in a randomized complete block design with four replications. To avoid soil compaction and damage to plants in rows used for foliar and yield evaluation, drive rows for pesticide application equipment were placed adjacent to plots. The soil type was Plainfield loamy sand, pH 7.1. Fertilizer applied was: 0-0-60, 300 lb/A, broadcast 3 Apr, before planting, 6-24-24, 550 lb/A, banded in the row at planting, and sidedress applications on 20 May (21-0-0, 350 lb/A), 29 May (Cal-Sul, 500 lb/A) and 3 Jun (34-0-0, 375 lb/A). Insects were controlled with Admire 2F incorporated in the fertilizer at planting (16 fl oz/500 lb) and foliar application of Spintor 2SC (4.0 fl oz/A) + Baythroid 2 (1.5 fl oz/A) 25 Jul. Lorox DF (1.0 lb/A, 6 May) was applied for weed control. To improve tuber shape and uniformity, MH-30 Xtra growth regulator was applied to the foliage 1 Aug at 1.3 gal/A. Fungicide treatments were applied to all four rows of each plot. The standard programs were applied at weekly intervals from 25 Jun to 20 Aug, according to treatment protocol, for a total of nine weeks. Standard weekly fungicide programs included weekly treatment with Bravo Zn (2.125 pt/a) and alternating treatments using Quadris Flowable (0.39 pt/a) and Bravo Zn (2.125 pt/a). Three forecasting treatments were compared with these standard weekly programs and the untreated check. Two of the forecasting treatments used WISDOM recommendations for fungicide treatment schedules, one based on environmental data collected in the plot area using Campbell Scientific CR-10 hardware and software and the second based on TisDat (Timely Satellite Data for Agricultural Management, http://www.soils.wisc.edu/nasacan.html) generated data. The third forecasting treatment used weather data collected in the field combined with weather forecasts and plant growth data entered on-line and processed by equipment and software supplied by DACOM PLANT-Plus. Recommendations for fungicide product, rate and schedule for this forecasting treatment were provided by DACOM PLANT-Plus online (http://www.dacom.nl/ppo/ppo.php). All treatments were applied with a plot sprayer consisting of a tractor-mounted boom pressurized with an air compressor using Tee Jet Hollow Disc Cone D3-23 nozzles at a rate equivalent to 35 gal water/A at 40 psi (15 nozzles at 8-in. spacing). Plots were not inoculated but relied on natural dispersal of inoculum for disease establishment and only early blight was observed in the trial. No late blight (caused by *Phytophthora infestans*) was observed in Wisconsin during the 2003 growing season. Disease severity was rated 16, 23 and 30 Jun, 7, 14, 21, and 28 Jul, 4, 11, 18 and 26 Aug and 2 Sep using the Horsfall-Barratt rating scale. Reglone (1.0 pt/A) plus Peptoil (1.0 qt/A) was applied on 3 and 10 Sep to kill vines prior to harvest. The two center rows of each plot (a total of 48 ft of row) were machine harvested and graded 23-26 Sep. Tubers were graded into US#1, undersize, and cull categories, and all potatoes in the US#1 category from each treatment plot were sorted using an optical size grader into six categories: < 4 oz, 4-6 oz, 6-10 oz, 10-13 oz, 13-16 oz and >16 oz and specific gravity was determined for a tuber sample from each plot. Rainfall recorded during the growing season (in.) was 23-30 Apr, 0.38; May, 4.62; Jun, 3.21; Jul, 2.13; Aug, 0.58; and 1-23 Sep, 2.44. An additional 27.5 in. of water was applied as overhead sprinkler irrigation in 40 applications (27 May – 11 Sep).

Environmental conditions were highly favorable for early blight development and by 11 Aug, foliar disease severity in untreated check plots was rated as 49%. All of the treatments provided a measure of early blight control with weekly and forecasting treatments using Quadris in at least one spray exhibiting the lowest disease severity in mid-August. All three of the forecasting-based treatments provided similar early blight control. Yields were similar in all fungicide treated plots and significantly better than the untreated check. A total of nine sprays were applied in the weekly programs, 10 in the treatment using TiSDat environmental data and eight in the treatments using CR-10 and Dacom Plant-Plus environmental data. The DACOM Plant-Plus system recommended two additional treatments early in the growing season, but because late blight was not present anywhere in the state at that time, these two sprays were not applied. All treatments evaluated in this trial had a positive effect on crop value. The treatment using WISDOM recommendations based on CR-10 data required the least amount of fungicide ai, had the lowest total toxicity units, the lowest cost of any of the fungicide treatments while maintaining high crop value. While the forecasting-based treatments provided effective early blight control, the comparison between the WISDOM CR-10 based program and the DACOM Plant-Plus system needs to be repeated in a year with late blight pressure.

Table 1. Effect of treatment on foliar disease severity (early blight, percent).

	Treatment	Rate/Acre product	Application schedule [1]	Total # appl	Total lb a. i.	Chem. cost/A $ [2]	Toxic-ity units[3]	Foliar disease severity - Early blight (%) [4]											
								16 Jun	23 Jun	30 Jun	7 Jul	14 Jul	21 Jul	28 Jul	4 Aug	11 Aug	18 Aug	26 Aug	2 Sep
1	Untreated			0	0	0	0	0.0	0.4	1.0	1.9	3.1	3.5	7.5	15.5	49.0	84.6	96.9	98.5
2	Bravo Zn 4.17F	2.125 pt	Weekly (Appl 1-9)	9	10.0	81	813	0.1	1.3	0.9	2.0	2.6	3.8	4.1	4.7	19.7	56.6	80.1	93.1
8	Quadris 2.08F	0.39 pt	Appl 1 3 5																
	Bravo Zn 4.17F	2.125 pt	Appl 2 4 6-9	9	7.0	89	556	0.0	0.6	0.6	2.0	2.8	3.2	3.7	4.1	8.6	30.1	59.8	86.7
Treatment chemicals applied according to:																			
103	**DACOM PlantPlus recommendation** [5]																		
	Quadris 2.08 F	0.39 pt	27 Jun																
	+ Bravo	1.25 pt																	
	WS	2.13 pt	7, 14 Jul																
	Bravo Zn	3.2 oz																	
	+ Curzate	2.13 pt	2, 30 Jul, 5, 13, 20 Aug																
	Bravo Zn			8	9.1	93	724	0.0	0.3	1.9	2.0	2.3	2.8	4.8	4.8	9.4	34.6	48.8	88.3
104	**WISDOM RATE and schedule based on TiSDat weather** [6]																		
	Bravo Zn	1.5 pt	18, 27 Jun, 2 Jul																
	Quadris 2.08 F	0.39 pt	9, 23 Jul, 6 Aug																
	Bravo Zn	1.8 pt	16 Jul																
	Bravo Zn	2.125 pt	30 Jul, 13, 20 Aug	10	6.9	80	554	0.0	0.1	0.7	1.8	2.2	2.9	3.1	3.5	7.5	28.5	53.1	89.5
105	**WISDOM RATE and schedule based on CR-10 weather** [6]																		
	Bravo Zn	1.5 pt	26 Jun, 3 Jul																
	Quadris 2.08 F	0.39 pt	10, 25 Jul																
	Bravo Zn	2.125 pt	17 Jul, 4, 14, 20 Aug	8	6.2	72	499	0.0	0.1	1.2	2.3	2.3	3.5	5.1	4.7	10.5	44.5	66.6	91.8
Pr > F [7]								0.45	<0.01	0.10	0.52	0.45	0.50	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
LSD								NS	0.5	0.9*	NS	NS	NS	2.0	5.5	18.8	17.0	18.4	6.3

1 Application dates for our standard spray program (Treatments 2,8): 1= 25 Jun; 2 = 2 Jul; 3 = 9 Jul; 4 = 16 Jul; 5 = 23 Jul; 6 = 30 Jul; 7 = 6 Aug; 8 = 13 Aug; 9 = 20 Aug .

2 Season-long cost of chemicals/Acre (rate, number of applications and retail cost are included in calculation). Application costs are not included. Typical retail prices used: Bravo WS - $48/gal; Bravo Zn 4.17F - $34/gal; Curzate - $27/lb; Quadris 2.08F - $240/gal.

3 Toxicity units are an overall measure of pesticide toxicity incorporating four component indices: acute mammalian toxicity, chronic mammalian toxicity, ecological impacts, and impacts on beneficial organisms and IPM systems. Benbrook, C.A., D.L. Sexson, J.A. Wyman, W.R. Stevenson, S. Lynch, J. Wallendal, S. Diercks, R. VanHaren, C.A. Granadino. 2002. Monitoring progress on reducing reliance on high-risk pesticides in WI potato production. J. of Potato Res. V. 79: pp.183-199.

4 Severity rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage and stems dead). Ratings were converted to percentages.

5 DACOM treatment: weather data, weather forecast, crop growth, presence of pathogens and previous applications were considered. Recommendations for fungicide applications were made on the DACOM PlantPlus web site. Fungicides which could be recommended included:

a. Contact fungicide: Bravo Zn 4.17F 2.125 pt or Bravo Zn 4.17F 2.125 pt alt with Quadris 2.08 F 0.39 pt
b. Local systemic (late blight): Curzate 60DF 0.2 lb + Bravo Zn 2.125 pt
c. Systemic fungicide (late blight): Curzate 60DF 0.2 lb + Previcur Flex 1.2 pt

6 TiSDat modeled weather and weather recorded in the field on a Campbell Scientific CR10 weather station were imported to the WISDOM crop management program. Fungicides for these two treatments were applied according to the schedule and rate recommended by WISDOM based on the two weather data sets.

7 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated (alpha=0.05). NS = not significant at $P = 0.10$ (* indicates differences between pairs of treatments were significant at $P = 0.10$, but not at $P = 0.05$).

Table 2. ***Effect of fungicide treatment on relative area under the disease progress curve, yield, proportion of US#1, undersize and cull potatoes, specific gravity, and size grades of US#1 potatoes*** *(Treatment numbers correspond to those listed in Table 1).*

Trt no.	Relative AUDPC [1] early blight	Yield							Specific gravity	No. of rotted tubers [3]	Size grades of US#1 potatoes - %						
		Total cwt/A	US#1		Undersize [2]		Culls				< 4 oz	4-6 oz	6-10 oz	10-13 oz	6-13 oz	13-16 oz	>16 oz
			cwt/A	%	cwt/A	%	cwt/A	%									
1	0.292	481.2	407.6	84.1	47.9	10.2	25.6	5.6	1.080	0.5	23.1	32.4	33.8	7.2	41.0	3.0	0.5
2	0.208	547.2	487.5	89.1	38.8	7.1	20.9	3.8	1.082	0.3	14.3	29.0	40.3	11.6	51.9	2.4	2.3
8	0.148	567.7	506.8	89.3	37.9	6.7	23.1	4.1	1.083	0.3	15.3	27.7	40.2	9.0	49.2	4.8	3.0
103	0.145	551.5	459.2	83.2	45.1	8.2	47.2	8.6	1.081	2.3	17.7	29.6	41.2	7.4	48.6	2.7	1.3
104	0.138	545.6	472.8	86.6	40.2	7.4	32.6	6.0	1.082	0.8	15.9	28.6	37.6	9.7	47.3	5.7	2.7
105	0.175	541.2	475.3	87.9	38.1	7.0	27.7	5.1	1.081	0.8	15.3	25.7	41.5	10.8	52.2	4.3	2.5
Pr>F [4]	< 0.01	0.04	0.07	0.12	0.05	0.03	0.06	0.13	0.18	0.19	0.02	0.06	0.13	0.09	0.04	0.24	0.18
LSD	0.041	50.4	62.4*	NS	7.3	2.1	17.4*	NS	NS	NS	4.9	4.1*	NS	3.5*	6.9	NS	NS

1. Relative area under the disease progress curve. Data for each observation date were plotted on a graph and the area under the line was calculated for each treatment providing a measure of the relative severity of disease throughout the season. A disease rating of 100% severity for the entire season would produce a value of 1.0. All relative AUDPC values are expressed as a proportion of this value. Either decreased disease severity or later disease development will contribute to lower relative AUDPC. Only early blight was observed in this trial and AUDPC values were calculated from 16 Jun - 2 Sep.
2. Undersize indicates potatoes < 1 7/8" in diameter.
3. The average number of tubers per treatment with any kind of rot observed during grading.
4. Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated (alpha=0.05). NS = not significant at $P = 0.10$ (* indicates differences between pairs of treatments were significant at $P = 0.10$, but not at $P = 0.05$).

Table 3. Effect of experimental treatment on value per acre of Russet Burbank tubers. *(Treatment numbers correspond to those listed in Table 1)*

Trt No.	Cost of Chemicals/Acre ($) [1]	Gross Value of Yield ($/A)		Net Value of Yield ($/A) [4]		Effect of Treatment on Value ($/A) [5]	
		Fresh Market [2]	Processing [3]	Fresh Market [2]	Processing [3]	Fresh Market [2]	Processing [3]
1	0	2883	2259	2883	2259	0	0
2	81	3923	2771	3842	2690	959	431
8	89	4112	2897	4022	2808	1139	550
103	93	3499	2605	3406	2511	523	253
104	89	3858	2701	3769	2612	886	353
105	72	3880	2704	3807	2632	924	374
Pr > F [6]	---	< 0.01	0.02	< 0.01	0.06	< 0.01	0.06
LSD [6]	---	507	339	507	339*	507	339*

1 Season-long cost of chemicals/A (rate, number of applications and retail cost are included in calculation). Application costs are not included. Typical retail prices used:
Bravo WS 6F - $ 48.00/gal Bravo Zn 4.17F - $ 32.00/gal Curzate 60DF - $ 27.00/lb Quadris 2.08 F - $ 240/gal

2 Typical 2003 fresh market pricing: 4-6 oz $6.00/cwt, 6-10 oz $9.00/cwt, 10-13 oz $13.50/cwt, >13 oz $16.50/cwt, < 4 oz and culls $1.25/cwt.

3 Typical 2003 processing contract pricing:
- Base price is $5.45/cwt for 69% US#1 (4 oz minimum) with specific gravity of 1.078.
- There is an increase or decrease of $.01 per hundred weight for each 1% above or below 69% US No1 2 inch or 4 oz minimum to a maximum of 85% or a minimum of 53%. (There is no additional incentive for % US No. 1 > 85% and there is no additional penalty for % US No. 1 < 53%).
- A premium is paid for > 17% 10 oz or greater. For each 1% above 17% (to a maximum of 36%) > 10 oz the price increases $0.01/cwt. The price decreases $0.01/cwt for each 1% below 17%.
- There is also an increase/decrease of ($.001) per hundred weight for each 1% above/below 35% >7 oz (to a maximum of 52% >7 oz). There is no further penalty if % > 7 oz is less than 18%.
- There is an adjustment in price per hundred weight depending on specific gravity: 1.067 or less, -$.20; 1.069 -$.18; 1.070 -$.16; 1.071 -$.14; 1.072 -$.12; 1.073 -$.10; 1.074 -$.08; 1.075 -$.06; 1.076 -$.04; 1.077 -$.02; 1.078 .00; 1.079 +$.02; 1.080 +$.04; 1.081 +$.06; 1.082 +$.08; 1.083 +$.10; 1.084 +$.12; 1.085 +$.14; 1.086 +$.16; 1.087 +$.18; 1.088 or greater +$.20.
- There is a payment of $2.00/cwt for processing culls (up to a maximum of 15% of the total by weight).
- Additional contract adjustments are made for percent bruise free and percent soft rot. We do not have data to calculate these adjustments.

4 Net value of yield = gross value minus cost of chemicals applied. If price was unavailable for **ANY** component of the treatment, net value was not calculated.

5 Effect of treatment on value = Net value for the treatment minus net value of the untreated control.

6 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated (alpha=0.05). NS = not significant at $P = 0.10$ (* indicates differences between pairs of treatments were significant at $P = 0.10$, but not at $P = 0.05$).