POTATO (*Solanum tuberosum*)
Early Blight; *Alternaria solani*

W. R. Stevenson and R. V. James
Department of Plant Pathology
University of Wisconsin-Madison
Madison, WI 53706

EVALUATION OF AERIAL APPLICATION OF QUADRIS TO CONTROL EARLY BLIGHT AND LATE BLIGHT OF POTATO, 1999: A field trial was established in a commercial potato field near Almond, WI to evaluate the efficacy of Quadris fungicide for control of early blight and late blight when incorporated in an aerial application program. Russet Burbank seedpieces were planted April 29 and all aspects of crop management were done according to standard commercial practice except that the aerial applicator applied four different fungicide treatments to different parts of the field. Fertilizer consisted of: 0-0-60, 300 lb/A, broadcast in the fall of 1998; 8-12-12-3S, 10 gal/A + 10-34-0, 35 gal/A + 14-0-0-17 Zn, 8 oz/A applied in the row at planting; and additional fertilizer as two sidedress applications after emergence. Sencor DF, 0.75 lb/A + Prowl 3.3EC, 1.5 pt/A was applied May 22 for weed control. The field was 0.5 mi wide and it was divided into 40-row-wide strips for aerial application of fungicide and insecticide. Strips were marked to receive a low rate of Quadris, a high rate of Quadris, or Bravo only and a forth strip from the remaining area of the field was designated as the grower standard for data collection. Treatments were made on a standard commercial schedule (treatments and application dates are summarized in Table 1). Strips receiving Quadris or Bravo treatments alternated with grower standard treated strips to provide buffer area between locations where data were collected. Within each treatment strip, 8 areas were flagged for data collection within the center 20 rows of the treatment strip. Four approximately 1-meter-square areas were rated weekly during the growing season for blight severity using the Horsfall-Barratt rating scale. Vines were killed with application of Des-I-Cate (1.5 pt/A) + Actamaster (17 lb/A) + Primrose (spreader-sticker, 8 fl. oz./A) on September 14 and 19. Samples were taken from the field, October 14, during commercial harvest to evaluate yield and quality of the tubers. Four rows at a time were windrowed by the grower and a 10-foot-long section (representing a total of 40 feet of row) from four different locations in each treatment strip. Yield samples were taken from four different areas in each 40-row-wide treatment strip - a sample from the 4 rows east of center, ~ 0.1 mi from the southern edge; from the 4 rows west of center ~ 0.1 mi from the northern edge; a sample from rows 9-12 east of center about 0.2 mi from the southern edge and a sample from rows 9-12 west of center about 0.2 mi from the northern edge. Tubers were stored at the Hancock Agricultural Research Station until grading on October 20. 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. Specific gravity was determined for a tuber sample from each plot. Rainfall (inches) measured during the growing season at the nearest recording weather station (Hancock) was 3.0 - May; 6.4 - June; 2.5 - July; 6.5 - August; 1.14 - September; 1.21 - October 1-14. An additional 10.3 inches of water was applied as overhead sprinkler irrigation during the growing season.

Environmental conditions during late July and August were not highly favorable for extensive early blight development. Symptoms of early blight were first observed in this trial on July 19 but no late blight was seen in this commercial field during the course of the trial. Early blight severity in the field section treated weekly with Bravo was slightly higher than sections treated with other fungicide programs through most of the rating period. Large differences in early blight control between treatments did not appear until the final rating on September 1 when early blight severity was 31% in the Bravo-treated section and less than 10% in all other sections treated with other fungicide programs that included Quadris SC. In comparisons between the 6.2 and 12.4 fl oz of Quadris SC alternated with Bravo, differences in early blight severity were not significant on any of the evaluation dates. Likewise the area under the disease progress curve (AUDPC) was highest for the Bravo treated field area and significantly lower when Quadris SC was either alternated with Bravo or included in some of the spray applications. Statistically similar total yields were observed for all treatments, but the yield of US#1 tubers in the plots treated with 12.4 fl oz Quadris SC every other week was slightly higher than in the remaining plots (P=0.10). After size grading, the proportion of tubers in each size grade was similar for each treatment. Small differences in specific gravity were observed between treatments, with the highest specific gravity recorded in plots treated with Quadris SC (12.4 fl oz) alternated with Bravo and in the plots treated with the grower standard program that included 3 applications of Quadris SC. An evaluation of the effect of season-long disease control programs on crop values provides an additional approach to comparing treatments. The gross value of yield for processing and fresh market was highest in plots treated with the 12.4 fl oz rate of Quadris alternated with Bravo fungicide (P=0.10). This program was the most expensive in terms of chemical cost. In comparison with the "grower standard" containing three sprays with Quadris, however, the program containing Quadris (12.4 fl oz) alternated with Bravo contributed to the highest net crop value.

Table 1. Fungicide and insecticide application summary. All aerial applications were made at 4-5 gal/A.

Date	Fungicide				Insecticide
	#1 Quadris "low"	#2 Quadris "high"	#3 Bravo	#4 "Grower standard"	
6/12	Quadris 6.2 fl oz	Quadris 12.4 fl oz	Bravo WS 1.5 pt	Penncozeb 75DF 2 lb + Plyac 2.0 fl oz	Asana XL 9.6 fl oz + Incite (PBO) 8 fl oz
6/18	Bravo WS 1 pt	Bravo WS 1 pt	Bravo WS 1.5 pt	Bravo WS 1.1 pt	
6/24	Quadris 6.2 fl oz + Plyac 2.0 fl oz	Quadris 12.4 fl oz+ Plyac 2.0 fl oz	Bravo Zn 2.125 pt	Quadris 6.2 fl oz + Plyac 2.0 fl oz	
7/1	Bravo Zn 1.5 pt	Bravo Zn 1.5 pt	Bravo Zn 2.125 pt	Ridomil Gold Bravo 2 lb	Asana XL 9.6 fl oz + Incite (PBO) 6 fl oz
7/10	Quadris 6.2 fl oz + Plyac 2.0 fl oz	Quadris 12.4 fl oz+ Plyac 2.0 fl oz	Bravo WS 1.5 pt	Bravo WS 1.1 pt	
7/15	Bravo WS 1 pt	Bravo WS 1 pt	Bravo WS 1.5 pt	Bravo WS 1.1 pt	
7/22	Quadris 6.2 fl oz	Quadris 12.4 fl oz	Bravo Zn 2.125 pt	Bravo WS 1.1 pt + Penncozeb 75DF 1 lb	
8/2	Bravo WS 1 pt	Bravo WS 1 pt	Bravo WS 1.5 pt	Quadris 6.2 fl oz	Dimethoate 400 1 pt
8/6	Quadris 6.2 fl oz	Quadris 12.4 fl oz	Bravo Zn 2.125 pt	Bravo WS 1.5 pt + Curzate 60DF 3.2 oz	Thiodan 3 EC 2 pt + Imidan 70 WSB 1 lb
8/11	Bravo Zn 2.125 pt	Bravo Zn 2.125 pt	Bravo Zn 2.125 pt	Quadris 6.2 fl oz	
8/18	Quadris 12.4 fl oz	Quadris 12.4 fl oz	Bravo Zn 2.125 pt	Bravo WS 1.5 pt + Curzate 60DF 3.2 oz	Provado 1.6F 3.75 fl oz + Dimethoate 400 1 pt
8/25	Bravo WS 1.5 pt	Bravo WS 1.5 pt	Bravo WS 1.5 pt	Bravo WS 1.5 pt + Super Tin 80WP 3 oz	
9/2	Quadris 12.4 fl oz	Quadris 12.4 fl oz	Bravo WS 1.5 pt	Bravo WS 1.5 pt + Super Tin 80WP 3 oz	
9/11			Bravo WS 1.5 pt		

Table 2 Effect of treatment on early blight severity (percent foliage infection).

Treatment	Percent Foliage Infection - Early Blight [1]									
	6/29	7/7	7/12	7/19	7/30	8/5	8/11	8/18	8/25	9/1
1 Quadris "low"	0	0	0	0.0	0.3	0.3	0.4	1.2	1.6	7.3
2 Quadris "high"	0	0	0	0.6	0.1	0.1	0.3	0.4	0.7	4.5
3 Bravo	0	0	0	1.3	1.3	2.0	2.7	3.0	5.0	31.2
4 "Grower standard"	0	0	0	0.3	0.4	0.6	1.5	1.4	1.2	6.1
Pr > F [2]	---	---	---	0.07	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
LSD *(P = 0.05)* [2]	---	---	---	1.0	0.8	0.5	1.0	1.1	1.9	11.3

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

2 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ (or $P = 0.10$) level. * = Differences between pairs of treatments were significant at $P = 0.10$ (but not at $P = 0.05$).

Table 3 Effect of fungicide treatment on relative area under the disease progress curve, yield, proportion of US#1, undersize and cull potatoes, and specific gravity.

Treatment	Relative AUDPC [1]	Total Yield cwt/A	US#1		Undersize [2]		Culls		Specific Gravity
			cwt/A	%	cwt/A	%	cwt/A	%	
1 Quadris "low"	0.008	482.5	420.4	87.1	51.6	10.7	10.4	2.2	1.083
2 Quadris "high"	0.005	535.5	483.7	90.3	45.9	8.6	5.9	1.1	1.088
3 Bravo	0.034	496.6	434.1	87.3	53.0	10.8	9.5	1.9	1.085
4 "Grower standard"	0.009	507.3	439.7	86.7	58.7	11.6	8.8	1.8	1.089
Pr > F [3]	< 0.01	0.14	0.07	0.06	0.44	0.31	0.32	0.27	0.02
LSD *(P = 0.05)* [3]	0.010	NS	47.3*	2.7*	NS	NS	NS	NS	0.004

1 Relative area under the disease progress curve. Data for each observation date (from 6/22-8/16) 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% foliage infection for the entire season would produce a value of 1.0. All relative AUDPC values are expressed as the proportion of this value. Either decreased disease severity or later disease development will contribute to lower relative areas under the disease progress curve.

2 Undersize indicates potatoes < 1 7/8" in diameter.

3 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ (or $P = 0.10$) level. * = Differences between pairs of treatments were significant at $P = 0.10$ (but not at $P = 0.05$).

Table 4 Effect of fungicide treatment on size grades of US#1 potatoes.

	Treatment	US#1 cwt/A	Size Grades of US#1 Potatoes						
			% < 4 oz.	% 4-6 oz.	% 6-10 oz.	% 10-13 oz.	% 6-13 oz.	% 13-16 oz.	% > 16 oz.
1	Quadris "low"	420.4	5.9	20.0	48.2	14.2	62.4	7.5	4.3
2	Quadris "high"	483.7	5.5	17.8	44.4	18.3	62.7	8.3	5.7
3	Bravo	434.1	6.5	19.9	47.4	16.0	63.4	7.5	2.7
4	"Grower standard"	439.7	6.9	22.9	49.1	14.2	63.3	5.1	1.8
	Pr > F [1]	0.07	0.60	0.28	0.18	0.31	0.95	0.24	0.13
	LSD *(P = 0.05)* [1]	47.3*	NS	NS	NS	NS	NS	NS	NS

1 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ (or $P = 0.10$) level. * = Differences between pairs of treatments were significant at $P = 0.10$ (but not at $P = 0.05$).

Table 5. Effect of experimental treatment on value per acre of Russet Burbank tubers.

	Treatment	Cost of Chemicals/ Acre [1]	Gross Value of Yield		Net Value of Yield [4]		Effect of Treatment on Value [5]	
			Fresh Market[2]	Processing [3]	Fresh Market[2]	Processing [3]	Fresh Market[2]	Processing [3]
1	Quadris "low"	157.70	3561.12	2150.80	3403.42	1993.10	-87.12	-52.44
2	Quadris "high"	222.29	4131.80	2560.82	3909.51	2338.52	418.98	292.99
3	Bravo	121.69	3661.67	2236.46	3539.98	2114.77	49.45	69.24
4	"Grower standard"	158.35	3648.88	2203.88	3490.53	2045.54	0.00	0.00
Pr > F [6]		---	0.08	0.07	0.14	0.14	0.16	0.16
LSD		---	462.04*	328.71*	NS	NS	NS	NS

1 1999 Season-long cost of chemicals/Acre (rate, number of applications and retail cost are included in calculation; cost of aerial application is not included as it was constant for all treatments). Retail prices used include:
Bravo WS 6F - $45/gal; Bravo Zn 4.17F - $34/gal ; Curzate 60DF - $27.75/lb; Penncozeb 75DF - $2.15/lb; Plyac - $22.80/gal; Quadris SC - $265/gal; Ridomil Gold Bravo - $16.15/lb; Super Tin 80WP - $28/lb

2 Typical 1999 fresh market pricing: 4-6 oz. $8.50/cwt, 6-10 oz. $10.50/cwt, 10-13 oz. $11.50, >13 oz. $12.00, < 4 oz. and culls $1.75/cwt.

3 Typical 1999 processing contract pricing: Base price is $4.70/cwt for 69% US#1 (4 oz minimum) with specific gravity of 1.077. A premium is paid for > 19% 10oz or greater. For each 1% > 19% (max.= 32%) > 10oz the price increases $0.03/cwt. The price decreases $0.03/cwt for each 1% below 19% to 10%. A decrease of $0.05 for each 1% of potatoes below 10% 10 oz. For each .001 difference in specific gravity > or < 1.080 (max.= 1.085), the price increases or decreases $0.02/cwt. If the specific gravity is < 1.072 there is a $.25 decrease in price for each .001. Minimum specific gravity accepted is 1.070. Value of culls for processing is $1.50/cwt.

4 Gross value minus cost of chemicals applied.

5 Net value for the treatment minus net value of the grower standard (treatment 4).

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