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Name Walter Stevenson

Organization UW-Madison, Plant Pathology

Madison

E-Mail

WEB

Department Contact: DATCP - Marketing - ADD Grants
PO Box 8911 Madison, WI 53708-8911
Tel: (608)224-5136
http://datcp.state.wi.us

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Assessing The Potential For Reducing Disease Control Inputs On Carrot Using Disease Resistant Cultivars

Project Year End Report For 1994

Walter R. Stevenson and R. Vaughan James
Department of Plant Pathology, University of Wisconsin-Madison

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Asgrow Seed Company

R. S. Kincaid Farms, Palmyra, WI

Department of Plant Pathology
University of Wisconsin
1630 Linden Drive
Madison, WI 53705

(608) 262-6291

Project Summary

Title: Assessing The Potential For Reducing Disease Control Inputs On Carrot Using Disease Resistant Cultivars

The research project focuses on improving the competitive position of carrot growers in Wisconsin by assessing the potential for reducing fungicide input through the use of disease resistant carrot cultivars. Two years of field trials are planned to help account for variability in weather conditions from year to year. Trials were established on a commercial carrot producer's farm near Palmyra, WI during 1994. The trial consisted of two commercially available carrot cultivars and two advanced carrot breeding lines representing a range of susceptibility to Alternaria and Cercospora leaf blights, two common diseases currently controlled by intensive application of fungicide. Four fungicide spray schedules are used to treat these carrot cultivars and breeding lines, representing four levels of treatment intensity. Planting, fungicide application and routine crop maintenance are done by the cooperating grower. Disease assessment, sampling for yield and analysis of data are done by personnel from the UW Department of Plant Pathology.

Objectives

1. To assess the value of host resistance in controlling carrot leaf blights in larger scale plots in a grower's field using standard grower practices for all procedures except fungicide application.

2. To determine if host resistance and fungicide application are additive in controlling carrot leaf blights, permitting adequate disease management to be obtained with decreased fungicide application on carrot lines with host resistance.

3. To determine if a normal yielding crop can be produced with decreased fungicide application when carrot lines incorporating host resistance are used.

Results and Benefits From The 1994 Field Trial

Fungicide treatment of the highly susceptible Lucky B cultivar resulted in much better disease control than on the plots left untreated with fungicide. Three sprays resulted in an area under the disease progress curve (AUDPC) value significantly below that of the untreated control and five or eight sprays resulted in significantly less disease than three sprays. On the cultivars possessing greater host resistance, however, there was very little added benefit to fungicide treatment as measured by AUDPC and the final level of infection for the untreated control plots for these lines was only slightly higher than the level of disease on Lucky B with the weekly spray program. The same patterns were reflected in yield and crop value. For Lucky B, there was a significant yield benefit and increase in value derived from fungicide treatment, but this was not the case for any of the three lines with higher levels of host resistance. For Eclipse, XPH3740 and XPH3906, fungicide treatment did not increase yield. Eclipse and XPH3740 had moderate levels of resistance and the value of fungicide treatment varied from slightly detrimental economically to slightly beneficial. On XPH3906, with the highest level of resistance, all levels of fungicide treatment resulted in a loss of net crop value when compared to the untreated control. Results of this trial suggest there is great potential for obtaining good carrot yield with adequate disease control and substantially reduced input of fungicide when host resistance is incorporated into an integrated disease management program.

A report was published for use in winter educational meetings for muck crop growers sponsored by the University of Wisconsin - Extension. The field trial also served as a demonstration for visiting carrot growers and muck crop growers in the Midwest attending a field day on June 22.

Assessing The Potential For Reducing Disease Control Inputs On Carrot Using Disease Resistant Cultivars

Identification of Need

Carrots represent an important vegetable crop to the State of Wisconsin. The Wisconsin carrot crop is grown on approximately 4,000 acres for an average crop value of approximately $2,500 per acre. The crop is grown primarily on muck soil, although in the past four years, acreage on irrigated loamy sand in central and southern Wisconsin has increased. Most of the acreage is grown for processing, slicing and dicing carrots, although one producer in southeast Wisconsin grows a sizable acreage for fresh market consumption. Because most Wisconsin carrots are used for processing, the value per unit ($4.38 per cwt) is lower than other states such as California where the carrots are used more for fresh market. Wisconsin ranks fourth in total carrot production and in 1993, the carrot crop contributed $6,150,000 to the state's farm economy.

Weather conditions in Wisconsin typically favor infection of the carrot foliage by two fungal pathogens *Alternaria dauci* (Alternaria leaf blight) and *Cercospora carotae* (Cercospora leaf blight). Both diseases are commonly observed in most fields at some time during the growing season. The occurrence of dew and other sources of leaf wetness helps to determine the appearance of both of these fungal incited diseases and subsequent spread through the field. Both diseases attack the foliage and gradually debilitate the affected plants. Yields of affected plantings are reduced (estimated up to 25%) and premature defoliation affects plant vigor and root quality. Cercospora leaf blight is especially serious on fresh market carrots since it attacks and weakens the petioles. Healthy petioles are important in the harvest of fresh market carrots since the harvester grasps onto the foliage and pulls the carrots from the ground. Breakage of petioles at harvest due to extensive Cercospora infection interferes with harvest and badly infected carrots are left in the field because they cannot be harvested with existing machinery.

Wisconsin growers traditionally treat carrot acreage with multiple applications of fungicide beginning when the first plantings have reached the 6 to 9" stage in mid-June and the first symptoms of disease are beginning to appear. Fungicide sprays continue at 7-14 day intervals depending on IPM scouting reports and weather conditions. Fields may be treated with fungicide 5-10 times during a "normal" growing season. Within a field planted to multiple carrot cultivars, no distinction is made in cultivar susceptibility to Alternaria and Cercospora leaf blights. The entire planting is generally sprayed according to the most susceptible cultivar. The fewest sprays are applied to the early planted and early harvested fields and the greatest number of sprays applied to the fields harvested late in the growing season. The cost of treatment with a standard fungicide program can be substantial depending on the frequency of application (Table 1).

Table 1. Cost of fungicide treatment for control of Alternaria and Cercospora leaf blights of carrot.

		Number of Fungicide Applications			
Brand Name	Rate	1	4	8	10
Bravo Ultrex	1.8 lb/A	$12.78	$51.12	$89.46	$115.02

Carrot cultivars available for planting in Wisconsin have traditionally been susceptible to both Alternaria and Cercospora leaf blights. Recently breeding efforts on the part of several seed companies have begun to develop carrot cultivars for fresh market and processing markets with a high level of resistance to both diseases. The planting of cultivars with blight resistance that require fewer fungicide sprays for disease control could dramatically reduce the amount of fungicide inputs and the disease control inputs applied by the grower. This in turn would lead to a lower unit cost of production and will help to improve the competitive position of Wisconsin's carrot industry.

Statement of Objectives

1. To assess the value of host resistance in controlling carrot leaf blights in larger scale plots in a grower's field using standard grower practices for all procedures except fungicide application.
2. To determine if host resistance and fungicide application are additive in controlling carrot leaf blights, permitting adequate disease management to be obtained with decreased fungicide application on carrot lines with host resistance.
3. To determine if a normal yielding crop can be produced with decreased fungicide application when carrot lines incorporating host resistance are used.

Methods Used in the 1994 Field Trial

The trial was established to assess the relative value of host resistance and fungicide treatment in controlling carrot leaf blights (Alternaria Blight; *Alternaria dauci* and Cercospora Blight; *Cercospora carotae*), in larger scale plots in a grower's field using standard grower practices for all procedures except fungicide application. The experiment was designed to determine if use of carrot lines incorporating host resistance would permit adequate disease management and normal yields to be obtained with decreased fungicide application. Seeds of two carrot cultivars and two breeding lines known to have varying levels of resistance to foliar blights were machine-planted in large plots at the R. S. Kincaid Farm, Palmyra, WI. The experiment was planned as a 4 x 4 factorial in a split-plot design with four replications. The four carrot lines made up the main plots and fungicide treatments were randomly assigned to the sub-plots. Each 4-row plot spanned two 3-foot wide raised beds with two 50-foot-long rows planted in each bed. To minimize interplot interference and provide uniform inoculum through out the trial, pairs of beds planted with the susceptible cultivar Lucky B separated plots in one dimension and 10-foot wide open alleys were located between the ends of adjacent plots. Soil type was a Houghton muck, pH 6.5. Plots were fertilized with 200 lb/A of 0-0-60 and 150 lb/A of 18-46-0 broadcast preplant. Insects were controlled with foliar applications of Sevin XLR Plus (2 qt/A -June 1, July 15, 29) and Asana (6 oz/A - August 5, 12, 19, 26, September 2). Weeds were controlled with application of Fusilade (12 oz/A - June 1, July 5) and Linex 4L (1 pt/A - June 16, 26, July 29). Fungicide treatments were applied from July 15 through September 2 using the grower's equipment delivering 56 gal/A at 40 psi. A 10-foot wide boom equipped with T-Jet 8003VS nozzles spanned two beds at a time. Bravo 90DG, 1.25 lb/A, was applied to each of the four types of carrots included in the trial according to four treatment schedules. These consisted of: 1) untreated control, 2) 8 fungicide treatments applied weekly beginning July 15, 3) five fungicide treatments applied every two weeks, beginning July 22 and 4) three fungicide treatments applied every 3 weeks beginning July 22. Disease severity was rated weekly from July 22 to September 15 using the Horsfall-Barratt system. Total rainfall and irrigation (May-August) was 17.1 inches.

Results from the 1994 Trial

Weather conditions during July, August and September were generally favorable for development of Alternaria leaf blight and Cercospora leaf blight. Foliage symptoms were rated weekly. The leaf blight diseases first appeared in mid-July and by late September, over 60% of the foliage in Lucky B plots receiving no fungicide was infected. On this cultivar, fungicide treatment resulted in much better disease control than on the untreated plots. Three sprays resulted in an AUDPC value significantly below that of the untreated control and five or eight sprays resulted in significantly less disease than three sprays. On the cultivars possessing greater host resistance, however, there was very little added benefit to fungicide treatment as measured by AUDPC and the final level of infection for the untreated control plots for these lines was only very slightly higher than the level of disease on Lucky B with the weekly spray program (Tables 2-3). The same patterns were reflected in yield and crop value. For Lucky B, there was a significant yield benefit and increase in value derived from fungicide treatment but this was not the case for any of the three lines with higher levels of host resistance. For Eclipse, XPH3740 and XPH3906 fungicide treatment did not increase yield. Eclipse and

XPH3740 had moderate levels of resistance and the value of fungicide treatment varied from slightly detrimental economically to slightly beneficial. On XPH3906, with the highest level of resistance, all levels of fungicide treatment resulted in a loss of net crop value when compared to the untreated control (Tables 4-6).

Discussion

In 1993 field trials cultivars such as Cumberland and Eclipse showed only about 2/3 of the disease development as the susceptible standard Lucky B, as measured by relative area under the disease progress curve (AUDPC - an assessment which combines severity and timing of disease development to give a measure of cumulative disease development through the growing season). Caro-Brite, Commanche and Cheyenne showed less than half the disease development of Lucky B as measured by the AUDPC. Similar results were observed in 1994 in field trials that included 47 carrot cultivars and breeding lines. Several breeding lines exhibited a high level of field resistance to these foliar diseases. Under a standard fungicide program using Bravo Ultrex at 1.8 lb/acre, the cost per spray per acre is $12.78 (based on a cost for Bravo Ultrex of $7.10/lb). For the 4300 acres planted in 1993 this would have meant a total savings of $54,954 for each fungicide spray which could be eliminated when disease resistant carrot cultivars are grown. Results from the 1994 phase of the research project demonstrated that on the highly susceptible Lucky B cultivar, fungicide treatment resulted in much better disease control than on the untreated plots. Three sprays resulted in an AUDPC value significantly below that of the untreated control and five or eight sprays resulted in significantly less disease than three sprays. On the cultivars possessing greater host resistance, however, there was very little added benefit to fungicide treatment as measured by AUDPC and the final level of infection for the untreated control plots for these lines was only slightly higher than the level of disease on Lucky B with the weekly spray program (Fig. 1-2). The same patterns were reflected in yield and crop value (Fig. 3-4). For Lucky B, there was a significant yield benefit and increase in value derived from fungicide treatment, but this was not the case for any of the three lines with higher levels of host resistance. For Eclipse, XPH3740 and XPH3906, fungicide treatment did not increase yield. Eclipse and XPH3740 had moderate levels of resistance and the value of fungicide treatment varied from slightly detrimental economically to slightly beneficial. On XPH3906, with the highest level of resistance, all levels of fungicide treatment resulted in a loss of net crop value when compared to the untreated control. Results of this trial suggest there is great potential for obtaining good carrot yield with adequate disease control and substantially reduced input of fungicide when host resistance is incorporated into an integrated disease management program.

We plan to conduct the trial again in 1995 at the R.S. Kincaid Farm near Palmyra, WI as part of a cooperative research plot area developed with interest and support from the Wisconsin Muck Growers Association, the Wisconsin Potato and Vegetable Growers Association and the Wisconsin Carrot Growers Association. The same or similar carrot lines and fungicide application schedules will be included in this year's trial.

Table 2. Effect of treatment on foliar blight development and area under the disease progress curve.

Cultivar or Breeding Line	Treatment schedule	Mean foliar blight								AUDPC [1]
		7/22	7/29	8/5	8/12	8/19	8/26	9/2	9/15	
Lucky B	Untreated Control	3.5	7.3	9.7	15.4	36.4	43.9	66.7	63.8	0.34
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	4.2	6.3	7.3	9.0	13.2	24.1	21.1	19.0	0.14
	Bravo 90DG, 1.25 lb/A, two week intervals (5 sprays) [3]	3.9	6.2	7.4	12.7	17.1	21.2	24.8	25.3	0.16
	Bravo 90DG, 1.25 lb/A, three week intervals (3 sprays) [4]	4.6	8.8	8.1	17.1	28.0	29.9	42.3	45.2	0.25
Eclipse	Untreated Control	2.9	5.0	4.7	8.0	11.0	14.1	22.5	26.5	0.13
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	2.8	4.7	4.5	7.1	9.0	10.7	13.9	16.1	0.09
	Bravo 90DG, 1.25 lb/A, two week intervals (5 sprays) [3]	2.5	4.6	5.0	7.3	9.8	9.8	13.0	15.1	0.09
	Bravo 90DG, 1.25 lb/A, three week intervals (3 sprays) [4]	2.9	4.4	5.6	7.8	11.6	15.8	19.7	25.3	0.13
XPH3740	Untreated Control	2.7	4.4	4.5	7.8	10.0	14.2	21.0	27.4	0.12
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	4.0	5.7	6.3	10.0	10.5	12.6	16.9	16.1	0.11
	Bravo 90DG, 1.25 lb/A, two week intervals (5 sprays) [3]	3.1	4.7	5.3	8.5	9.3	12.2	16.4	20.5	0.11
	Bravo 90DG, 1.25 lb/A, three week intervals (3 sprays) [4]	3.9	6.5	6.3	9.5	12.1	16.3	18.7	24.1	0.13
XPH3906	Untreated Control	2.8	4.3	4.2	7.6	10.7	11.5	15.3	25.8	0.11
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	2.7	3.7	4.2	6.3	7.6	9.6	12.9	13.1	0.08
	Bravo 90DG, 1.25 lb/A, two week intervals (5 sprays) [3]	2.4	3.5	4.3	6.1	7.3	10.7	11.2	14.3	0.08
	Bravo 90DG, 1.25 lb/A, three week intervals (3 sprays) [4]	2.7	4.4	3.7	6.8	8.8	12.5	13.8	17.5	0.09
LSD ($P = 0.05$) [5]		0.4	0.9	1.8	3.0	3.6	7.7	6.8	7.9	0.03

[1] Relative area under the disease progress curve. Data for each observation date are plotted on a graph and the relative area under the line is calculated for each separate treatment providing a measure of the relative severity of disease throughout the season. Either decreased disease severity or later disease development will contribute to lower relative areas under the disease progress curve.

[2] Applied: 7/15, 7/22, 7/29, 8/5, 8/12, 8/19, 8/26, 9/2

[3] Applied: 7/22, 8/5, 8/19, 8/26, 9/2

[4] Applied: 7/29, 8/19, 9/2

[5] Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ level.

Table 3. Effect of cultivar or fungicide application on foliar blight development.

Factor	Mean foliar blight [1]			
	7/22	7/29	8/5	8/12
Cultivar				
Lucky B	4.0	7.1	8.1	13.5
Eclipse	2.8	4.7	4.9	7.6
XPH3740	3.4	5.3	5.6	9.0
XPH3906	2.7	4.0	4.1	6.7
LSD ($P = 0.05$)	0.4	0.9	0.9	1.5
Fungicide				
Untreated Control	3.0	5.2	5.8	9.7
Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	3.4	5.1	5.6	8.1
Bravo 90DG, 1.25 lb/A, two week intervals (5 sprays) [3]	3.0	4.8	5.5	8.6
Bravo 90DG, 1.25 lb/A, three week intervals (3 sprays) [4]	3.5	6.0	5.9	10.3
LSD ($P = 0.05$) [2]	0.4	0.9	NS	1.5

[1] There was a significant interaction between cultivar and fungicide for all rating dates after August 12 so it is inappropriate to consider cultivar or fungicide means for those data.

[2] Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ level.

Table 4. Effect of treatment on carrot yield and size distribution.

Cultivar or Breeding Line	Treatment schedule	Total Yield (Tons/A) [1]	Carrot Diameter (inches)								Culls	
			< 3/4		3/4 - 1 5/8		1 5/8 - 2		> 2 inch			
			Yield (Ton/A)	%	Yield (Ton/A)	%	Yield (Ton/A)	%	Yield (Ton/A)	%	Yield (Ton/A)	%
Lucky B	Untreated Control	49.1	0.8	1.6	40.4	82.3	3.9	7.8	0.4	0.9	3.6	7.4
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	63.6	0.6	0.9	49.6	77.7	8.4	13.4	1.2	1.9	3.8	6.0
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [3]	51.9	0.5	1.0	40.4	77.9	7.3	14.0	0.6	1.2	3.0	5.8
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [4]	49.0	0.6	1.0	37.3	75.2	8.0	17.1	1.5	3.1	1.7	3.6
Eclipse	Untreated Control	52.9	0.2	0.4	22.7	42.7	13.1	24.3	8.1	14.7	8.8	17.9
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	53.3	0.3	0.6	25.1	47.2	14.7	27.6	6.0	11.1	7.2	13.4
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [3]	54.2	0.1	0.3	21.0	38.6	16.3	30.1	7.6	14.0	9.0	17.0
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [4]	53.1	0.1	0.2	24.0	45.1	15.3	29.1	6.1	11.4	7.6	14.2
XPH3740	Untreated Control	53.2	0.3	0.5	22.9	42.8	12.2	23.1	4.6	8.4	13.2	25.2
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	54.6	0.2	0.4	24.7	45.5	12.1	22.2	4.3	7.7	13.2	24.2
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [3]	54.5	0.1	0.2	22.1	40.7	12.9	23.7	5.6	10.3	13.7	25.1
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [4]	57.6	0.3	0.5	26.2	45.5	15.3	26.6	3.7	6.4	12.2	21.0
XPH3906	Untreated Control	57.1	0.4	0.8	35.7	62.8	13.8	24.1	2.7	4.8	4.4	7.6
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	57.3	0.4	0.7	36.1	63.0	11.4	19.9	1.5	2.6	7.9	13.8
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [3]	57.7	0.4	0.7	37.2	64.7	11.5	19.7	3.0	5.2	5.6	9.7
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [4]	57.3	0.4	0.8	36.5	63.9	10.1	17.4	2.2	3.8	8.1	14.1
LSD ($P = 0.05$) [5]		6.7	0.3	0.5	7.1	10.2	4.2	8.0	3.4	5.8	5.5	10.7

[1] A 10-foot section of row was hand dug in each plot and yield was converted to tons/A. Yields may appear biased -- hand digging tends to result in a higher apparent yield as fewer carrots are lost than when mechanically dug.

[2] Applied: 7/15, 7/22, 7/29, 8/5, 8/12, 8/19, 8/26, 9/2

[3] Applied: 7/22, 8/5, 8/19, 8/26, 9/2

[4] Applied: 7/29, 8/19, 9/2

[5] Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ level.

Table 5. Effect of cultivar or fungicide application on carrot yield and size distribution.

Factor	Total Yield (Ton/A)	Carrot Diameter (inches)								Culls	
		< 3/4		3/4 - 1 5/8		1 5/8 - 2		> 2 inch			
		Yield (Ton/A)	%	Yield (Ton/A)	%	Yield (Ton/A)	%	Yield (Ton/A)	%	Yield (Ton/A)	%
Cultivar											
Lucky B [1]	--	0.6	1.1	41.9	78.3	6.9	13.1	0.9	1.8	3.0	5.7
Eclipse	--	0.2	0.4	23.2	43.4	14.9	27.8	7.0	12.8	8.1	15.6
XPH3740	--	0.2	0.4	24.0	43.6	13.2	23.9	4.5	8.2	13.1	23.9
XPH3906	--	0.4	0.7	36.4	63.6	11.7	20.3	2.4	4.1	6.5	11.3
LSD ($P = 0.05$) [2]	--	0.1	0.3	3.5	5.1	2.1	4.0	1.7	2.9	2.7	5.4
Fungicide											
Untreated Control	--	0.4	0.8	30.4	57.7	10.7	19.8	3.9	7.2	7.5	14.5
Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [2]	--	0.4	0.7	33.9	58.3	11.7	20.8	3.3	5.8	8.0	14.4
Bravo 90DG, 1.25 lb/A, two week intervals (5 sprays) [3]	--	0.3	0.5	30.2	55.5	12.0	21.9	4.2	7.7	7.8	14.4
Bravo 90DG, 1.25 lb/A, three week intervals (3 sprays) [4]	--	0.3	0.6	31.0	57.4	12.2	22.5	3.4	6.2	7.4	13.2
LSD ($P = 0.05$) [5]	--	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] There was significant interaction between cultivar and fungicide treatment for total yield so it is inappropriate to pool data for cultivars or fungicide. Individual treatment means are listed in previous table.

[2] Applied: 7/15, 7/22, 7/29, 8/5, 8/12, 8/19, 8/26, 9/2

[3] Applied: 7/22, 8/5, 8/19, 8/26, 9/2

[4] Applied: 7/29, 8/19, 9/2

[5] Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at the $P = 0.05$ level.

Table 6. Effect of treatment on value per acre of carrots for processing.

Cultivar or Breeding Line	Treatment schedule	Cost of Chemicals per Acre [1]	Gross Value of Yield [2]			Net Value of Yield [3]			Effect of Treatment on Value [4]		
			Dicers			Dicers			Dicers		
			> 3/4 inch	> 1 1/4 inch	Slicers	> 3/4 inch	> 1 1/4 inch	Slicers	> 3/4 inch	> 1 1/4 inch	Slicers
Lucky B	Untreated Control	0.00	1956.90	945.73	2328.67	1956.90	945.73	2328.67	0.00	0.00	0.00
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [5]	75.50	2593.59	1352.88	3060.69	2518.09	1277.38	2985.19	561.19	331.65	656.52
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [6]	47.19	2117.26	1106.55	2496.91	2070.08	1059.36	2449.72	113.18	113.63	121.05
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [7]	28.31	2047.40	1113.35	2387.08	2019.09	1085.04	2358.77	62.19	139.31	30.10
Eclipse	Untreated Control	0.00	1924.35	1355.48	1986.85	1924.35	1355.48	1986.85	0.00	0.00	0.00
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [5]	75.50	2006.12	1378.28	2161.46	1930.62	1302.78	2085.96	6.27	-52.70	99.11
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [6]	47.19	1971.99	1445.76	2026.43	1924.80	1398.57	1979.24	0.45	43.09	-7.61
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [7]	28.31	1987.86	1386.33	2113.31	1959.55	1358.02	2085.00	35.20	2.54	98.15
XPH3740	Untreated Control	0.00	1739.38	1166.43	1940.26	1739.38	1166.43	1940.26	0.00	0.00	0.00
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [5]	75.50	1799.71	1182.76	2023.09	1724.21	1107.26	1947.59	-15.17	-59.17	7.33
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [6]	47.19	1781.46	1228.01	1973.63	1734.27	1180.82	1926.45	-5.11	14.39	-13.81
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [7]	28.31	1977.54	1322.94	2162.66	1949.23	1294.62	2134.34	209.85	128.19	194.08
XPH3906	Untreated Control	0.00	2285.57	1391.44	2603.83	2285.57	1391.44	2603.83	0.00	0.00	0.00
	Bravo 90DG, 1.25 lb/A, weekly (8 sprays) [5]	75.50	2146.64	1242.98	2461.97	2071.14	1167.48	2386.47	-214.43	-223.96	-217.36
	Bravo 90DG, 1.25 lb/A, 2-week intervals (5 sprays) [6]	47.19	2263.34	1332.46	2593.95	2216.15	1285.27	2546.77	-69.42	-106.17	-57.06
	Bravo 90DG, 1.25 lb/A, 3-week intervals (3 sprays) [7]	28.31	2134.73	1221.55	2497.43	2106.42	1193.23	2469.11	-179.15	-198.21	-134.72

[1] Season-long cost of chemicals/Acre (rate, number of applications and retail cost are included in calculation). Retail price used for Bravo 90 DG was $7.55/lb. No price information was available for the experimental products:

[2] Values are calculated based on typical 1994 processing contracts for uncrowned carrots. Minimum size for dicing contract is 1 1/4 inch. This was not a cut-off point in our size grading so two estimates are given. The first column includes all carrots > 3/4 inch in diameter. The second column excludes a portion of the yield in the size range 3/4 - 1 5/8 inch diameter. If carrot diameter was evenly distributed between 3/4 and 1 5/8 inch then 3/7 of the carrots could be expected to be > 1 1/4 inch so 3/7 of the yield in this size class was included in this calculation. Dicing price per ton is: >90% of crop over 2" diameter - $51.70; 81-90% > 2" - $51.30; 71-80% > 2" - $50.10; 61-70% > 2" - $48.00; 51-60% > 2" - $45.90; < 51% > 2" - $43.80. Minimum size accepted for slicing contract is 3/4 inch diameter. Slicing price per ton is: < 10% over 1 5/8" diameter - $52.50; 10-19% > 1 5/8" - $51.90; 20-29% > 1 5/8" - $50.65; 30-39% > 1 5/8" - $47.90; 40-49% > 1 5/8" - $45.20; >49% > 1 5/8" - $42.60. Values were calculated for both uses regardless of category carrot line was place in.

[3] Gross value minus cost of chemicals applied.

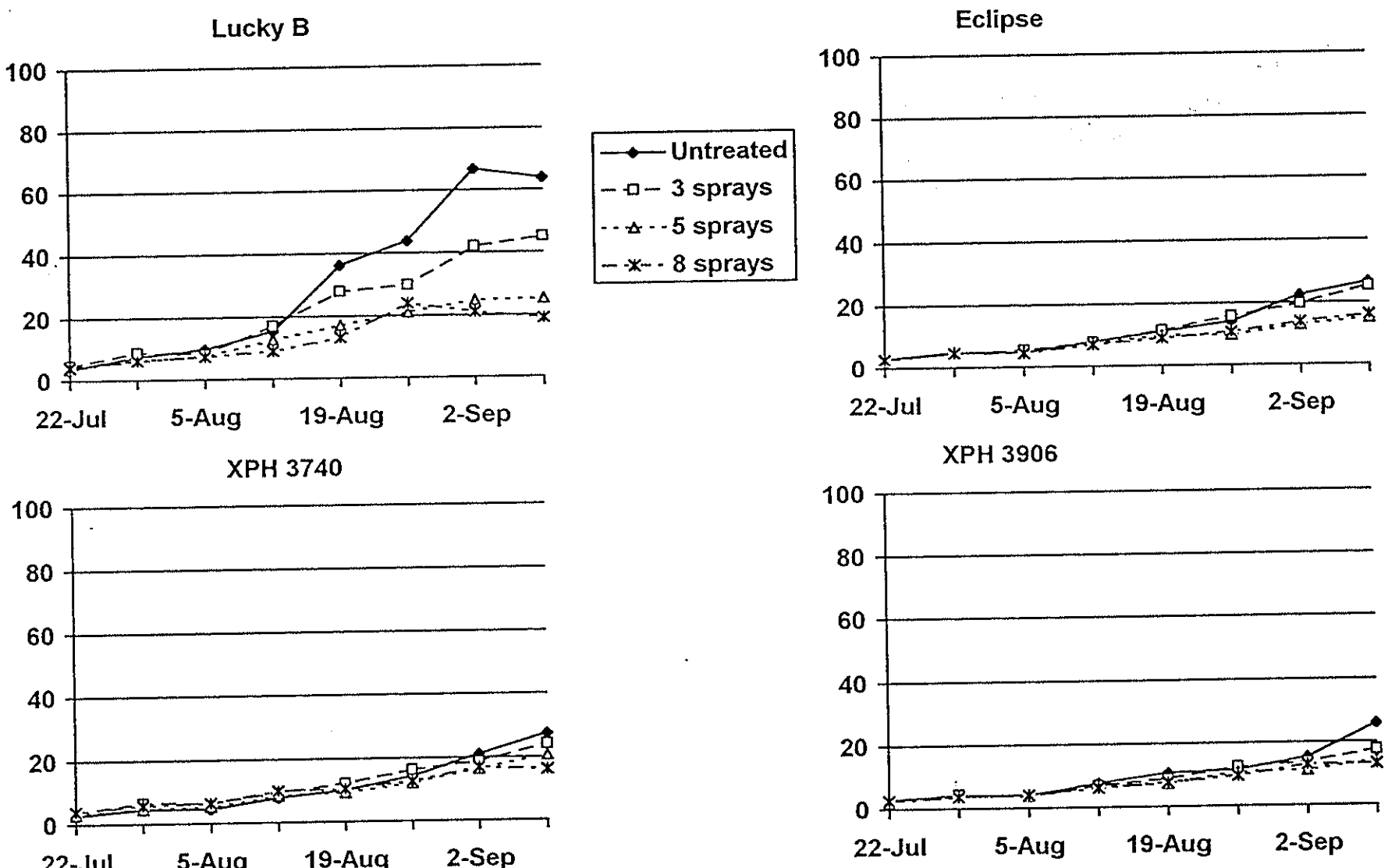
[4] Net value of the treatment minus net value for the untreated control (calculated within each cultivar or breeding line group).

[5] Applied: 7/15, 7/22, 7/29, 8/5, 8/12, 8/19, 8/26, 9/2

[6] Applied: 7/22, 8/5, 8/19, 8/26, 9/2

[7] Applied: 7/29, 8/19, 9/2

Fig 1. Disease development over time (% foliar infection) for four carrot cultivars using four fungicide application schedules.



LSD ($P = 0.05$) : 22-Jul - 0.4, 29-Jul - 0.9, 5-Aug - 1.8, 12-Aug - 3/0, 19-Aug - 3.6, 26-Aug - 7.7, 2-Sept - 6.8, 15-Sept - 7.9 (applies to all graphs on this page)

Fig 2. ***Relative area under the disease progress curve for four carrot cultivars using four fungicide application schedules.***

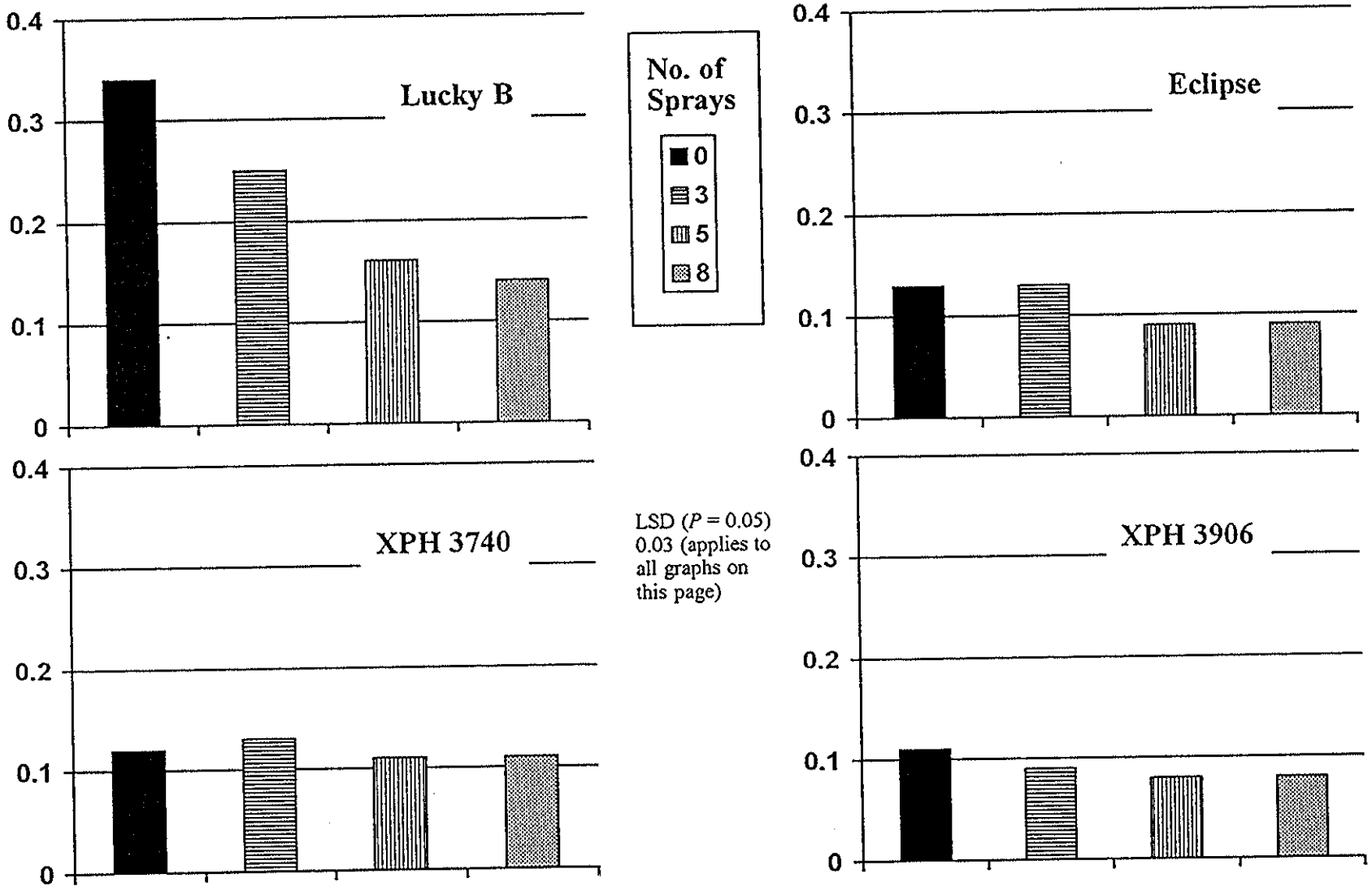
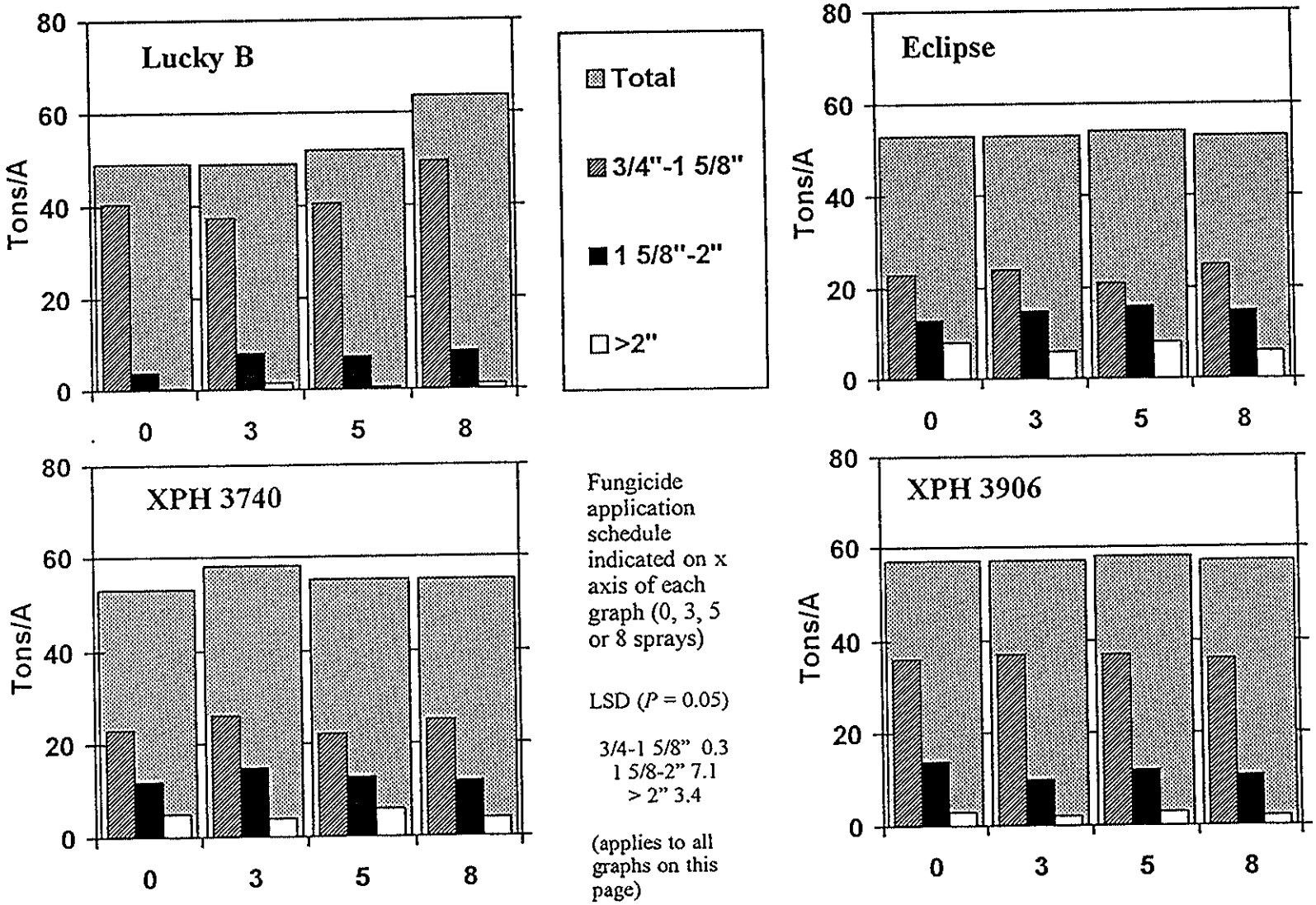
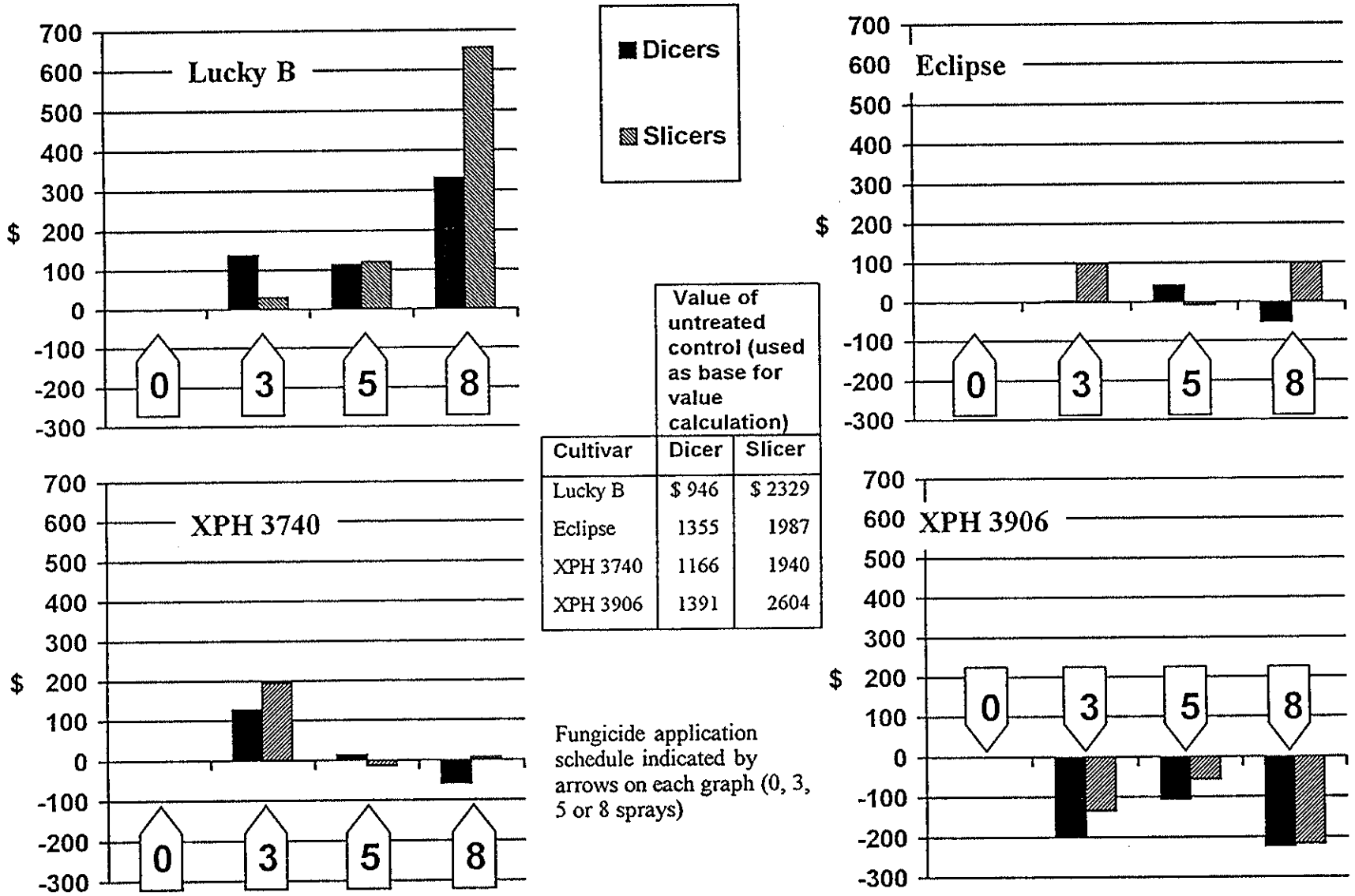


Fig 3. ***Yield (total and distribution into 4 size classes)* for four carrot cultivars using four fungicide application schedules.***



* a very small proportion of the yield was < 3/4' in diameter; this class is not included in the graph

Fig 4 ***Relative value of fungicide treatment compared to untreated control for four carrot cultivars.***



Cultivar	Value of untreated control (used as base for value calculation) Dicer	Slicer
Lucky B	$ 946	$ 2329
Eclipse	1355	1987
XPH 3740	1166	1940
XPH 3906	1391	2604

Fungicide application schedule indicated by arrows on each graph (0, 3, 5 or 8 sprays)