

**CARROT** (*Daucus carota* subsp. *sativus*)  
**Alternaria Leaf Blight;** *Alternaria dauci*  
**Cercospora Leaf Blight;** *Cercospora carotae*

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### **Evaluation of reduced risk spray programs on tolerant and susceptible carrot varieties to control foliar diseases caused by *Alternaria* and *Cercospora* - Hancock 2002**

An integrated pest management field trial was established at the Hancock Agricultural Research Station in central Wisconsin, to evaluate the efficacy of reduced risk fungicide programs to control two carrot foliar diseases, using cultivars varying in susceptibility to *Alternaria* and *Cercospora*. Seeds of four dicer cultivars- Carson (tolerant), Recoleta (moderately susceptible), Gold King (moderately susceptible) and Fontana (highly susceptible)- were planted 8 May at approximately 250,000 seeds/A, using a standard commercial planter. Each plot consisted of one 72-in.-wide raised bed with three 22-ft-long rows planted 24 in. apart. The experimental design was a randomized complete block with four replications. Soil type was Plainfield loamy sand with pH 6.8. Soil test results showed fertility levels of P, K, Mg, S and Mn were adequate for carrot cropping and Potash 0-0-61 fertilizer was broadcast applied at 250 lb/A during bed shaping on 19 Apr. A cover crop of oats was sown between rows at bed shaping for early season wind protection. Additional nitrogen was applied through irrigation water (28% UAN, 30 lb/A) 15 Jul, 29 Jul and 20 Aug. Foliar applications of Asana XL (4 fl oz/A, 20 Jun; 6 fl oz/A, 15 Jul, 30 Jul, and 15 Aug) were made for insect control. Weeds were controlled with applications of Fusilade 2000 (8.0 fl oz/A, 20 Jun), Lorox DF (0.50 lb/A, 13 Jun; 1.0 lb/A, 25 Jun, 8 Jul, and 23 Jul), Sencor (0.10 lb/A on 13 Jun and 23 Jul) and Poast (1.5 lb/A, 2 Jul). Fungicide treatments were applied according to protocol with a tractor-mounted boom pressurized by an air compressor. Treatments were applied at a rate equivalent to 35 gal water/A at 40 psi, using Tee Jet D3-23 nozzles (8 nozzles at 8-in. spacing). Disease severity was rated on four 3-ft-long sections of the center row in each treatment plot, at approximately 7 day intervals from 9 Jul to 26 Sep using the Horsfall-Barratt (0-11) rating system. Two five-ft-long sections of the center test row were hand dug from each plot on 2 Oct and the yield was graded by hand into five size classes (based on diameter) and culls. The size classes were then grouped appropriately to conform to processing standards for dicing carrots. Yield values were calculated for each treatment based on typical processing contracts. Rainfall (inches) recorded for this field was: May-2.10, June-16.54, July-3.04, August-4.76, September-3.03 and October-0.71. An additional 14.81 inches of irrigation was applied May-October.

Plots were scouted routinely throughout the growing season and symptoms of *Alternaria* and *Cercospora* blight were first identified (1%) on 23 Jul throughout plots of the most susceptible variety Fontana. Detection of the disease symptoms initiated disease severity ratings and fungicide application programs, according to protocol. Disease severity in the Fontana untreated control plots exceeded 50% on 12 Sep and progressed to greater than 75% by the final rating on 26 Sep. Using the relative area under the disease progress curve (AUDPC) as a measure of season-long disease development, values for the untreated controls were: Gold King (0.18), Recoleta (0.21), Carson (0.26) and Fontana (0.32), with the least significant difference being 0.05. The alternation of the lowest labeled rate of Bravo and low rates of Quadris provided substantial disease control regardless of cultivar or spray protocol when compared to the untreated. Weekly spray programs provided significantly better disease control than the tri-weekly program on all four cultivars; however the weekly schedule did not differ significantly from the biweekly program on any of the cultivars tested. Three fewer fungicide applications could be made on any of the cultivars (weekly vs. bi-weekly programs) without significantly sacrificing disease control (as measured by AUDPC), thereby exhibiting the potential to stretch the interval between fungicide applications under the environmental conditions observed during the course of the 2002 growing season. Significant differences were observed between cultivar and fungicide treatment means when a factorial analysis was conducted. Total yield for all cultivars was significantly lower for the untreated plots when compared to the plots receiving the weekly application program, thus displaying the benefits of proper disease management. Significant differences were observed in yield size categories among and within cultivars, depending upon the spray program utilized.

**Table 1. Treatment Summary**

**Cultivars, susceptibility and seed sources**

Carson (Tolerant) (Bejo)	Gold King (Moderately susceptible) (Seminis)
Recoleta (Moderately susceptible) (Seminis)	Fontana (Highly susceptible) (Bejo)

**The same four foliar fungicide treatment schedules were applied to each cultivar**

Treatment Chemicals	Rate/Acre		Schedule Summary	Total number of applications	Total active ingredient (ai) used during season (lb/A)
	(Form)	(a.i.)			
Untreated Control				0	0
Bravo Ultrex Quadris 2.08 SC	1.4 lb 9.2 fl oz	1.13 lb 0.15 lb	Weekly, Alternating	Appl. (1,3,5,7) Appl. (2,4,6)	7 4.97
Bravo Ultrex Quadris 2.08 SC	1.4 lb 9.2 fl oz	1.13 lb 0.15 lb	Every 2 weeks, alternating	Appl. (1, 5) Appl. (3, 7)	4 2.56
Bravo Ultrex Quadris 2.08 SC	1.4 lb 9.2 fl oz	1.13 lb 0.15 lb	Every 3 weeks, alternating	Appl. (1, 7) Appl. (4)	3 2.41

**Table 2. Effect of foliar fungicide treatment on Alternaria and Cercospora leaf blight on carrots.**

Cultivar and fungicide treatment		% Disease Severity (Alternaria and Cercospora Blight - combined) <sup>1</sup>								Relative AUDPC <sup>2</sup>
		7 Aug	14 Aug	21 Aug	28 Aug	5 Sep	12 Sep	20 Sep	27 Sep	
Carson	Untreated	1.3	2.2	13.6	12.7	25.8	42.6	54.3	54.7	0.26
	Weekly	1.0	0.7	5.1	3.5	6.4	7.0	14.4	10.2	0.06
	Every 2 weeks	0.6	0.9	4.5	4.1	8.2	16.9	17.6	21.1	0.09
	Every 3 weeks	0.9	0.9	6.7	4.5	12.0	16.7	29.3	29.3	0.12
Recoleta	Untreated	0.9	2.5	5.1	8.6	15.2	29.7	55.9	51.6	0.21
	Weekly	1.3	0.9	3.7	3.8	5.4	6.6	9.1	12.9	0.05
	Every 2 weeks	0.9	0.9	3.2	3.4	4.4	6.7	12.0	18.2	0.06
	Every 3 weeks	1.5	1.5	4.1	3.8	10.0	12.6	29.1	35.4	0.11
Gold King	Untreated	1.3	2.3	4.5	5.3	12.6	22.9	47.3	52.0	0.18
	Weekly	1.2	1.6	3.4	2.5	5.7	6.7	7.6	11.7	0.05
	Every 2 weeks	0.7	1.3	3.8	2.2	6.6	8.8	13.5	22.3	0.07
	Every 3 weeks	1.0	2.2	4.1	3.4	8.8	14.9	21.1	29.9	0.10
Fontana	Untreated	0.9	3.1	11.0	13.8	36.1	48.4	70.7	79.5	0.32
	Weekly	1.3	1.0	4.5	3.7	10.5	10.8	18.2	24.6	0.09
	Every 2 weeks	1.5	1.6	5.4	4.5	12.9	11.7	25.2	35.9	0.12
	Every 3 weeks	1.2	1.8	4.1	3.8	12.0	16.4	33.2	48.4	0.14
Pr > F <sup>3</sup>		0.84	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
LSD <sup>3</sup>		NS	0.9	5.4	3.7	8.0	11.9	10.9	9.6	0.05

**Analysis of the effect of cultivar and fungicide treatments**

Effect of cultivar										
Carson	1.0	1.2	7.5	6.2	13.1	20.8	28.9	28.8	0.13	
Recoleta	1.1	1.4	4.0	4.9	8.7	13.9	26.5	29.5	0.11	
GoldKing	1.1	1.9	4.0	3.3	8.4	13.3	22.4	29.0	0.10	
Fontana	1.2	1.9	6.3	6.4	17.9	21.9	36.8	47.1	0.17	
Pr > F <sup>3</sup>	0.74	0.06	0.03	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	
LSD <sup>3</sup>	NS	0.5*	2.7	1.9	4.0	5.9	5.5	4.8	0.02	
Effect of fungicide treatment										
Untreated	1.1	2.5	8.6	10.1	22.4	35.9	57.0	59.4	0.24	
Weekly	1.2	1.1	4.2	3.4	7.0	7.8	12.3	14.9	0.06	
Every 2 weeks	0.9	1.2	4.2	3.6	8.0	11.0	17.1	24.4	0.08	
Every 3 weeks	1.3	1.6	4.8	3.9	10.7	15.2	28.2	35.7	0.12	
Pr>F <sup>3</sup>	0.66	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
LSD <sup>3</sup>	NS	0.5	2.7	1.8	4.0	6.0	5.5	4.8	0.02	
Interaction - Cultivar x fungicide										
Pr>F <sup>3</sup>	0.69	0.57	0.45	0.12	0.02	0.14	0.65	0.32	0.04	

1 Severity of leaf blight symptoms was rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage dead). Symptoms of Alternaria and Cercospora blights were not separated. Ratings were converted to percent disease severity.

2 Relative area under the disease progress curve. % disease severity for each date was plotted on a graph and the area under the curve was calculated for each treatment providing a measure of the relative severity of disease over the season. A disease severity rating of 100% 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.

3 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at P = 0.10. \* indicates differences are significant at P = 0.10 but not at P = 0.05.

**Table 3. Yield, size distribution for carrot cultivars with different fungicide spray schedules.**

Cultivar and fungicide treatment	Total yield (Ton/A) <sup>1</sup>	Percentage of yield for carrot diameter (inches)					% culls	# of roots with Aster yellows symptoms
		< 3/4	3/4 - 1 1/4	1 1/4 - 1 5/8	1 5/8 - 2	> 2		
<b>Carson</b>								
Untreated	21.8	0.1	4.9	23.2	25.6	45.6	0.5	5.3
Weekly	26.3	0.0	1.7	12.2	20.3	63.0	2.8	10.0
Every 2 weeks	22.7	0.1	2.4	18.1	27.2	48.9	3.4	5.5
Every 3 weeks	24.8	0.1	3.4	26.3	32.4	36.4	1.4	7.8
<b>Recoleta</b>								
Untreated	21.8	0.8	17.1	45.0	19.5	12.3	5.3	4.5
Weekly	28.4	0.4	12.6	41.4	24.8	19.2	1.6	3.8
Every 2 weeks	25.8	0.3	13.6	37.2	29.5	16.5	3.0	5.5
Every 3 weeks	23.8	1.4	18.1	42.9	28.4	6.8	2.4	2.8
<b>Gold King</b>								
Untreated	19.6	0.1	2.8	18.4	25.1	49.7	3.9	1.0
Weekly	26.5	0.3	1.6	11.8	20.9	59.2	6.3	2.5
Every 2 weeks	23.1	0.2	3.2	15.1	27.2	53.0	1.3	3.0
Every 3 weeks	21.3	0.3	1.8	15.0	27.7	54.1	1.2	2.0
<b>Fontana</b>								
Untreated	24.4	0.2	9.0	44.4	34.5	10.3	1.6	9.8
Weekly	31.4	0.3	4.9	28.6	36.3	29.1	0.9	9.5
Every 2 weeks	28.3	0.1	4.4	40.1	29.7	24.2	1.4	10.3
Every 3 weeks	31.1	0.0	2.0	24.7	32.7	36.2	4.4	8.5
Pr > F <sup>2</sup>	<0.01	0.20	<0.01	<0.01	0.07	<0.01	0.04	<0.01
LSD <sup>2</sup>	4.1	0.9	5.1	11.1	10.5*	17.8	3.4	4.7
<b>Analysis of the effect of cultivar and fungicide treatments</b>								
<b>Effect of cultivar</b>								
Carson	23.9	0.1	3.1	20.0	26.4	48.5	2.0	7.1
Recoleta	25.0	0.7	15.3	41.7	25.5	13.7	3.1	4.1
GoldKing	22.7	0.2	2.4	15.1	25.2	54.0	3.2	2.1
Fontana	28.8	0.2	5.1	34.5	33.3	25.0	2.1	9.5
Pr > F <sup>2</sup>	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.52	<0.01
LSD <sup>2</sup>	2.8	0.4	2.7	6.3	5.3	9.5	NS	2.1
<b>Effect of fungicide treatment</b>								
Untreated	21.9	0.3	8.5	32.8	26.2	29.5	2.8	5.1
Weekly	28.2	0.2	5.2	23.5	25.6	42.6	2.9	6.4
Every 2 weeks	25.0	0.2	5.9	27.6	28.4	35.6	2.3	6.1
Every 3 weeks	25.3	0.5	6.3	27.2	30.3	33.4	2.4	5.3
Pr>F <sup>2</sup>	<0.01	0.56	0.07	0.02	0.27	0.04	0.84	0.62
LSD <sup>2</sup>	2.0	NS	2.6	5.6	NS	8.9	NS	NS
<b>Interaction - Cultivar x fungicide</b>								
Pr>F <sup>2</sup>	0.56	0.60	0.41	0.08	0.40	0.21	<0.01	0.67

- 1 A 10-foot section of row was hand dug in each plot and yield was converted to tons/A. Hand digging is likely to result in a higher apparent yield as fewer carrots are lost than when mechanically dug. Carrots were graded into five size classes and culls (misshapen or rotted). The size classes were then grouped appropriately to conform to standards for dicing carrots. Yield samples were intended only to permit evaluation of quality and relative size distribution of carrots.
- 2 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at P = 0.10. \* indicate differences are significant at P = 0.10 but not at P = 0.05.

**Table 4. Size distribution, gross value and control cost benefit for carrot cultivars with different fungicide spray schedules.**

Cultivar and fungicide treatment	Total yield (Ton/A)	Cost of Chemicals/Acre <sup>1</sup>	Yield graded as dicers <sup>2</sup>						Effect of treatment on value (\$/A) <sup>4</sup>
			Percentage of yield			Price/ton (\$)	Value of yield (\$)		
			1 ¼ - 2"	> 2"	Dis-cards		Gross	Net <sup>3</sup>	
<b>Carson</b>									
Untreated	21.8	0	48.8	45.6	5.5	17.9	372.9	372.9	0
Weekly	26.3	89.4	32.5	63.0	4.5	18.2	457.5	368.2	-4.7
Every 2 weeks	22.7	54.1	45.3	48.9	5.9	17.4	372.8	318.8	-54.1
Every 3 weeks	24.8	35.3	58.7	36.4	4.9	17.1	403.6	368.3	-4.6
<b>Recoleta</b>									
Untreated	21.8	0	64.6	12.3	23.1	17.1	287.5	287.5	0
Weekly	28.4	89.4	66.3	19.2	14.6	17.1	417.3	328.0	40.5
Every 2 weeks	25.8	54.1	66.7	16.5	16.9	17.1	368.7	314.7	27.1
Every 3 weeks	23.8	35.3	71.3	6.8	21.9	17.1	318.3	283.0	-4.5
<b>Gold King</b>									
Untreated	19.6	0	43.5	49.7	6.8	17.4	318.7	318.7	0
Weekly	26.5	89.4	32.7	59.2	8.1	18.0	439.2	349.9	31.1
Every 2 weeks	23.1	54.1	42.3	53.0	4.7	17.6	388.8	334.8	16.0
Every 3 weeks	21.3	35.3	42.7	54.1	3.3	17.9	368.9	333.6	14.8
<b>Fontana</b>									
Untreated	24.4	0	78.9	10.3	10.8	17.1	373.3	373.3	0
Weekly	31.4	89.4	64.9	29.1	6.0	17.4	514.6	425.2	51.9
Every 2 weeks	28.3	54.1	69.8	24.2	5.9	17.1	454.7	400.7	27.4
Every 3 weeks	31.1	35.3	57.4	36.2	6.4	17.3	502.9	467.6	94.3
Pr > F <sup>5</sup>	<0.01	-	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.28
LSD <sup>5</sup>	4.1	-	16.3	17.8	5.6	0.7	78.8	78.8	NS
<b>Analysis of the effect of cultivar and fungicide treatments</b>									
<b>Effect of cultivar</b>									
Carson	23.9	59.6	46.3	48.5	5.2	17.7	401.7	357.0	-15.8
Recoleta	25.0	59.6	67.2	13.7	19.1	17.7	348.0	303.3	43.4
Gold King	22.7	59.6	40.3	54.0	5.7	17.1	378.9	334.2	15.5
Fontana	28.8	59.6	67.8	25.0	7.3	17.2	461.4	416.7	15.8
Pr > F <sup>5</sup>	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
LSD <sup>5</sup>	2.8	-	8.2	8.9	2.8	0.4	39.4	39.4	41.3
<b>Effect of fungicide treatment</b>									
Untreated	21.9	0	59.0	29.5	11.6	17.4	338.1	338.1	0
Weekly	28.2	89.4	49.1	42.6	8.3	17.7	457.2	367.8	29.7
Every 2 weeks	25.0	54.1	56.0	35.6	8.3	17.3	396.2	342.2	4.1
Every 3 weeks	25.3	35.3	57.5	33.4	9.1	17.4	398.4	363.1	25.0
Pr > F <sup>5</sup>	<0.01	-	0.09	0.04	0.07	0.12	<0.01	0.34	0.38
LSD <sup>5</sup>	2.0	-	8.2	8.8	2.8	NS	39.4	NS	NS
<b>Interaction - Cultivar x fungicide</b>									
Pr > F <sup>5</sup>	0.56	-	0.15	0.21	0.17	0.30	0.56	0.56	0.63

- 2002 Season-long cost of chemicals/Acre (rate, number of applications and retail cost are included in calculation). Retail prices used: Bravo Ultrex = \$5.95/lb; Quadris 2.08 SC = 2.03/oz. Application costs are not included.
- Values are calculated based on a typical 2001 processing contract for uncrowned carrots. Minimum size accepted for dicing contract is 1-1/4 inch diameter; discard class includes culls and carrots below the minimum diameter.
  - Dicing base price per ton is: >90.1% over 2" diameter - \$22.33; 80.1-90% > 2" - \$20.90; 70.1-80% > 2" - \$19.01; 60.1-70% > 2" - \$18.30; 50.1-60% > 2" - \$17.70; <50% > 2" - \$17.13. Price was calculated for each replicate plot. Values are means of four replicates.
- Gross value minus cost of chemicals applied.
- Net value for the treatment minus net value of the untreated control.
- Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at P = 0.10. \* indicate differences are significant at P = 0.10 but not at P = 0.05.

**Table 5. Data ranked (within each cultivar) by AUDPC (increasing).**

Cultivar and Fungicide Treatment	% Disease severity 20 Sep <sup>1</sup>	Relative AUDPC <sup>2</sup>	Total yield t/A <sup>3</sup>	Value of yield grade as dicers <sup>4</sup>	Cost of spray program <sup>5</sup>
<b>Carson</b>					
Weekly	14.4	0.06	26.3	457.5	89.4
Every 2 weeks	17.6	0.09	22.7	372.8	54.1
Every 3 weeks	29.3	0.12	24.8	403.6	35.3
Untreated	54.3	0.26	21.8	372.9	0
<b>Recoleta</b>					
Weekly	9.1	0.05	28.4	417.3	89.4
Every 2 weeks	12.0	0.06	25.8	368.7	54.1
Every 3 weeks	29.1	0.11	23.8	318.3	35.3
Untreated	55.9	0.21	21.8	287.5	0
<b>Gold King</b>					
Weekly	7.6	0.05	26.5	439.2	89.4
Every 2 weeks	13.5	0.07	23.1	388.8	54.1
Every 3 weeks	21.1	0.10	21.3	368.9	35.3
Untreated	47.3	0.18	19.6	318.7	0
<b>Fontana</b>					
Weekly	18.2	0.09	31.4	514.6	89.4
Every 2 weeks	25.2	0.12	28.3	454.7	54.1
Every 3 weeks	33.2	0.14	31.1	502.9	35.3
Untreated	70.7	0.32	24.4	373.3	0
Pr>F <sup>6</sup>	<0.01	<0.01	<0.01	<0.01	-
LSD <sup>6</sup>	10.9	0.05	4.1	78.8	-

- Severity of leaf blight symptoms was rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage dead). Symptoms of *Alternaria* and *Cercospora* blights were not separated. Ratings were converted to percent disease severity.
- Relative area under the disease progress curve. % disease severity for each date was plotted on a graph and the area under the curve was calculated for each treatment providing a measure of the relative severity of disease over the season. A disease severity rating of 100% 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.
- A 10-foot section of row was hand dug in each plot and yield was converted to tons/A. Hand digging is likely to result in a higher apparent yield as fewer carrots are lost than when mechanically dug. Carrots were graded into five size classes and culls (misshapen or rotted). The size classes were then grouped appropriately to conform to standards for dicing carrots. Yield samples were intended only to permit evaluation of quality and relative size distribution of carrots.
- Values are calculated based on a typical 2001 processing contract for uncrowned carrots. Minimum size accepted for dicing contract is 1-1/4 inch diameter; discard class includes culls and carrots below the minimum diameter.
  - Dicing base price per ton is: >90.1% over 2" diameter - \$22.33; 80.1-90% > 2" - \$20.90; 70.1-80% > 2" - \$19.01; 60.1-70% > 2" - \$18.30; 50.1-60% > 2" - \$17.70; <50% > 2" - \$17.13. Price was calculated for each replicate plot. Values are means of four replicates.
- 2002 Season-long cost of chemicals/Acre (rate, number of applications and retail cost are included in calculation). Retail prices used: Bravo Ultrex = \$5.95/lb; Quadris 2.08 SC = 2.03/oz. Application costs are not included.
- Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at  $P = 0.10$ . \* indicates differences are significant at  $P = 0.10$  but not at  $P = 0.05$ .