

CARROT (*Daucus carota* subsp. *sativus*)
Alternaria leaf blight; *Alternaria dauci*
Cercospora leaf blight; *Cercospora carotae*

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Evaluation of fungicides to control carrot foliar blights - Hancock, 2004

A field experiment was conducted at the Hancock Agricultural Research Station to examine 10 fungicide treatments for the control of *Alternaria* and *Cercospora* foliar diseases of carrot. Seeds of the susceptible cultivar Fontana were planted 11 May at approximately 225,000 seeds/A, using a standard commercial planter. Natural inoculum of both pathogens was present from nearby commercial carrot fields and no inoculation was necessary. The experimental design was a randomized complete block with four replications. Each plot consisted of one, 6-ft-wide raised bed with three 22-ft-long rows planted 24 in. apart. Soil type was Plainfield loamy sand with pH 6.9. Oat seed was sown between carrot rows as a cover crop at bed shaping to provide wind protection. Fertilizer (0-0-60, 500 lb/A) was incorporated prior to tillage on 20 Apr and pop-up fertilizer (0-0-61, 250 lb/A) was broadcast during bed shaping on 26 Apr to aid in seedling development. Additional fertilizer was applied on 29 Jun as a sidedress consisting of NH₃SO₄, 100 lb/A + MAP (11-52-0), 50 lb/A + KMag, 150 lb/A, + Boron and micronutrients package, 10 lb/A. Foliar nitrogen was applied through overhead irrigation (28% UAN) (10 lb/A, 24 Jun; 15 lb/A, 4 Aug; 20 lb/A, 14 Sep; 30 lb/A, 11 and 25 Aug) to supplement root expansion. Aster leafhoppers were controlled with foliar applications of Baythroid (1.5 fl oz/A, 15 Jun) and Asana XL (6 fl oz/A, 8 Jul). Invasive broadleaves and grasses were suppressed with applications of Credit (glyphosate) (pre-emergence only) (32 fl oz/A, 20 May); Lorox DF (0.75 lb/A, 8 Jul; 1.0 lb/A, 29 Jun and 8 Aug); Sencor DF (0.15 lb/A, 29 Jun and 8 Jul; 0.25 lb/A, 6 Aug); and Fusilade DX (12 fl oz/A, 15 Jun). All fungicide treatments were applied according to protocol (Table 1) with a tractor-mounted boom sprayer using 8 Tee Jet D3-23 nozzles at 8-in. spacing and pressurized with an air compressor (40 psi). Fungicides were applied on 26 Jul, 3, 10, 17, 24 and 31 Aug, and 7 and 14 Sep at a rate equivalent to 35 gal water/A. The Horsfall-Barratt 0-11 scale was employed to rate disease severity at four locations in the center row of each plot, every 7-10 days from 27 Jul to 29 Sep. Two 5-ft-long sections of the center row in each plot were hand dug on 5 Oct. Subsequently, the roots were graded by hand into five size classes (based on diameter) and culls (misshapen or rotten). The size classes were grouped appropriately to conform to processing company standards for dicing carrots. Value was calculated for harvested yield from each treatment based on commercial processing contracts. Rainfall (in.) recorded for this field was: May, 1.7; Jun, 7.7; Jul, 0.5; Aug, 3.6; and Sep, 0. An additional 13.63 in. of irrigation was applied in 28 applications May-Sep.

Symptoms of foliar disease (1% severity) were observed throughout the trial on 23 Jul, triggering fungicide program initiation and weekly disease severity ratings. Disease pressure was light through most of the season, with moderately increasing pressure recognized from late August through harvest. The untreated control exceeded 40% disease severity by 22 Sep and had an AUDPC (relative area under the disease progress curve) of 0.147 for the season. Significant differences in disease severity were noted between treatments on 5 of 8 rating dates (17 and 24 Aug; 3, 22 and 29 Sep) and treatments showed visible differences in symptom severity and foliar health by seasons end. AUDPC for all fungicide programs was significantly lower than the untreated control. Statistical differences in symptom severity were observed between fungicide treated plots on 22 Sep and 29 Sep, with treatments alternating between Bravo and Quadris providing the best control. In addition, there were significant differences in AUDPC between fungicide treatments, with treatments containing Bravo or Bravo alternated with Quadris, Pristine or Endura provided better control than Switch and the untreated control. Heavy rains in the early part of season and significant root knot nematode pressure, resulted in substandard root quality. The adverse affects of these agents on carrot yield confounded interpretation of the effect of foliar disease on yield, root size distribution and crop value. The percentage of total yield in each size category and weight data (in t/A) for each size category was analyzed. Significant differences were observed ($P < 0.10$) between treatments in total yield. Highest yields were observed in plots treated with Quadris (week 4) and Bravo (week 1-3, 5-8) and Switch on weeks (1, 3, 5, 6, 8) and Bravo on the remaining weeks. Treatments employing the alternation of Bravo and various reduced-risk products (Quadris, Pristine, Endura) provided excellent disease control and yields comparable to the weekly Bravo plan. In addition, these programs drastically reduced the active ingredient and toxicity associated with a season-long disease management program. The treatment consisting of Gibgro alternated with Cabrio and Bravo performed similar to other weekly fungicide programs in disease control, yield and value with substantially lower active ingredient applied.

Table 1. Foliar fungicide treatments.

Trt no.	Treatment chemicals	Rate/Acre		Schedule summary	Total active ingredient (ai) used during season (lb/A)
		Formulation	a.i.		
1	Untreated Control				0
2	Bravo Ultrex 82.5 WDG	1.4 lb	1.16 lb	weekly	9.28
3	Bravo Ultrex 82.5 WDG Quadris 2.08 SC	1.4 lb 9.2 fl oz (0.575 pt)	1.16 lb 0.15 lb	Appl 1-3, 5-8 Appl 4	8.27
4	Bravo Ultrex 82.5 WDG + Quadris 2.08 SC	1.4 lb 9.2 fl oz (0.575 pt)	1.16 lb 0.15 lb	Appl 1, 3, 5	3.93
5	Bravo Ultrex 82.5 WDG Quadris 2.08 SC	1.4 lb 9.2 fl oz (0.575 pt)	1.16 lb 0.15 lb	Appl 1, 3, 5, 6, 8 Appl 2, 4, 7	6.25
6	Bravo Ultrex 82.5 WDG Pristine (BAS 516) 38 WG	1.0 lb 0.66 lb	0.83 lb 0.25 lb	Appl 1, 3, 5, 6, 8 Appl 2, 4, 7	4.90
7	Bravo Ultrex 82.5 WDG Endura (BAS 510) 70 WG	1.0 lb 0.29 lb	0.83 lb 0.2 lb	Appl 1, 3, 5, 6, 8 Appl 2, 4, 7	4.75
8	Switch 62.5 WG Bravo Ultrex 82.5 WDG	0.69 lb 1.4 lb	0.42 lb 1.16 lb	Appl 1, 3, 5, 6, 8 Appl 2, 4, 7	5.58
9	Switch 62.5 WG	0.69 lb	0.42 lb	Appl 1-8	3.36
10	GibGro-Gibberellic Acid Bravo Ultrex 82.5 WDG Cabrio 20 WG (BAS 500)	0.075 g/L 1.0 lb 8.0 oz (0.5 lb)	30 mg/L 0.83 lb 0.10 lb	Appl 1 Appl 3, 7 Appl 5	1.77

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

Trt no.	Foliar Disease Severity (%) ¹								Relative AUDPC ²
	27 Jul	10 Aug	17 Aug	24 Aug	3 Sep	10 Sep	22 Sep	29 Sep	
1	1.0	2.2	4.7	8.9	12.9	14.6	41.4	52.0	0.147
2	1.5	1.9	2.0	3.1	5.9	5.9	7.9	11.4	0.046
3	0.9	1.6	2.3	2.9	3.9	5.6	8.2	6.7	0.040
4	1.2	2.0	2.2	3.1	7.0	10.2	15.8	19.0	0.066
5	0.4	2.0	1.9	2.6	5.0	5.9	6.0	7.9	0.037
6	1.2	1.9	1.8	2.3	5.3	5.1	7.3	8.2	0.040
7	1.8	1.9	2.6	3.4	7.3	12.0	10.4	12.6	0.056
8	1.0	2.0	1.8	3.2	4.1	6.1	11.4	9.7	0.048
9	1.0	2.5	2.6	3.1	5.4	6.9	24.6	33.8	0.084
10	1.5	1.9	2.5	2.9	5.9	6.7	12.3	19.8	0.058
$P > F^3$	0.39	0.96	<0.01	<0.01	0.02	0.29	<0.01	<0.01	<0.01
LSD ³	NS	NS	1.0	2.1	4.5	NS	3.7	16.3	0.032

- 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 %.
- 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 by treatment, providing a measure of the relative disease severity over the season. A 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 AUDPC.
- 3 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated ($\alpha=0.05$). NS =not significant at $P = 0.05$.

Table 3. Effect of foliar fungicide treatment on carrot yield and value based upon percentage of carrots graded into each size category.

Trt no.	Total yield (t/A) ¹	Cost of chemicals (\$/A)	Percentage of yield in size classes by carrot diameter (in.)						Culls	Yield graded as dicers ²				Effect of treatment on value (\$/A) ⁴	
			< 3/4	3/4 - 1 1/4	1 1/4 - 1 5/8	1 5/8 - 2	> 2	Percentage of yield			Price/ t (\$)	Value of yield (\$)			
								1 1/4 - 2 in.		> 2 in.		Discards	Gross		Net ³
1	34.4	0	0.2	1.4	4.5	19.1	40.6	34.3	23.6	40.6	35.8	34.3	774.10	774.1	0
2	39.6	78.4	0.3	1.2	3.7	15.9	45.0	33.9	19.6	45.0	35.4	34.3	928.26	849.9	75.8
3	43.5	87.0	0.2	1.5	7.5	35.2	46.7	8.9	42.7	46.7	10.6	34.3	1343.14	1256.1	482.0
4	35.7	84.6	0.2	1.3	3.8	9.0	42.4	43.4	12.8	42.4	44.9	35.4	710.81	626.2	-147.9
5	39.3	104.2	0.1	2.0	4.9	15.0	52.3	25.7	19.8	52.3	27.9	35.4	1033.97	929.8	155.7
6	38.8	90.6	0.1	0.7	3.4	17.1	45.1	33.6	20.5	45.1	34.4	35.4	917.00	826.4	52.3
7	37.3	71.6	0.2	2.4	5.0	19.3	47.8	25.3	24.3	47.8	27.9	35.4	950.94	879.3	105.2
8	45.0	174.1	0.2	1.3	5.8	24.4	44.1	24.2	30.2	44.1	25.7	34.3	1194.36	1020.2	246.1
9	39.2	231.6	0.2	1.1	6.5	29.2	34.6	28.4	35.8	34.6	29.7	34.3	987.94	756.4	-17.7
10	40.5	19.3	0.2	1.5	3.0	21.4	52.8	21.0	24.4	52.8	22.8	35.4	1125.17	1105.9	331.8
P>F ⁵	0.07	--	0.91	0.34	0.71	0.15	0.82	0.75	0.20	0.82	0.77	-	0.55	0.59	0.58
LSD ⁵	*6.5	--	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	NS	NS	NS

- Two 5-ft-long sections of row were 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.
- Values are calculated based on a typical 2003 processing contract for 60% crowned 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 in. diameter - \$44.60; 80.1-90% > 2 in. - \$41.80; 70.1-80% > 2 in. - \$38.15; 60.1-70% > 2 in. - \$36.60; 50.1-60% > 2 in. - \$35.40; <50% > 2 in. - \$34.20. Price was calculated for each plot. Values shown 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 (alpha=0.05). NS = not significant at P = 0.05.

Table 4. Effect of foliar fungicide treatment on carrot yield and value based upon total harvested weight for each treatment in t/A.

Trt no.	Total yield (t/A) ¹	Cost of chemicals (\$/A)	Yield in size classes by diameter (in.) (t/A)						culls	Yield graded as dicers ²				Effect of treatment on value (\$/A) ⁴	
			< 3/4	3/4 - 1 1/4	1 1/4 - 1 5/8	1 5/8 - 2	> 2	Percentage of yield			Price/ t (\$)	Value of yield (\$)			
								1 1/4 - 2 in.		> 2 in.		Discards	Gross		Net ³
1	34.4	0	0.1	0.5	1.5	6.5	14.1	11.7	23.6	40.6	35.8	34.3	774.10	774.1	0
2	39.6	78.4	0.1	0.5	1.5	6.6	18.3	12.6	19.6	45.0	35.4	34.3	928.26	849.9	75.8
3	43.5	87.0	0.1	0.7	3.3	15.3	20.3	3.9	42.7	46.7	10.6	34.3	1343.14	1256.1	482.0
4	35.7	84.6	0.1	0.5	1.3	3.2	15.6	15.2	12.8	42.4	44.9	35.4	710.81	626.2	-147.9
5	39.3	104.2	0.0	0.8	1.9	5.8	20.9	9.9	19.8	52.3	27.9	35.4	1033.97	929.8	155.7
6	38.8	90.6	0.0	0.3	1.3	6.4	18.1	12.7	20.5	45.1	34.4	35.4	917.00	826.4	52.3
7	37.3	71.6	0.1	0.9	1.8	7.4	17.7	9.5	24.3	47.8	27.9	35.4	950.94	879.3	105.2
8	45.0	174.1	0.1	0.6	2.7	11.3	20.2	10.3	30.2	44.1	25.7	34.3	1194.36	1020.2	246.1
9	39.2	231.6	0.1	0.4	2.8	12.0	14.0	9.9	35.8	34.6	29.7	34.3	987.94	756.4	-17.7
10	40.5	19.3	0.1	0.6	1.3	8.9	21.7	8.0	24.4	52.8	22.8	35.4	1125.17	1105.9	331.8
P>F ⁵	0.07	--	0.78	0.34	0.48	0.07	0.78	0.83	0.20	0.82	0.77	--	0.55	0.59	0.58
LSD ⁵	*6.5	--	NS	NS	NS	*7.2	NS	NS	NS	NS	NS	--	NS	NS	NS

* see foot notes above

