

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

P. M. Rogers, R. V. James, W. R. Stevenson
and R. E. Rand
Department of Plant Pathology
University of Wisconsin-Madison
Madison, WI 53706

Evaluation of carrot cultivars and breeding selections to identify resistance to foliar blights - Lewiston, 2001

A trial was established at Gumz Muck Farms LLC, Lewiston Farm, in central WI, on May 17 to evaluate forty carrot cultivars and breeding selections for reaction to *Alternaria* and *Cercospora* leaf blights. Seeds were planted using a cone seeder with seeding rate adjusted according to carrot type - slicing or cut and peel type, approximately 24 seeds per foot; dicing type, approximately 10 seeds per foot. Each plot consisted of two 12-foot-long rows planted 1 foot apart in the center portion of a 6-foot-wide raised bed. A randomized complete block design with three replications was used. To minimize interplot interference and provide a uniform source of inoculum throughout the trial, a row of Heritage, susceptible to both pathogens, was planted on each side of each test plot. Test plots were separated within the bed by 3-foot-long open buffer spaces. Soil type was Houghton muck with pH 6.0. Fertilizer consisted of 22-15-15, 200 lb/A + 1.5 lb boron and 2 lb copper, broadcast in April, prior to planting and 0-0-46, 150 lb/A, as a sidedress application in June. Foliar applications of Asana XL were made for insect control (4.3 fl oz., May 14; 4.5 fl oz., June 8; 4.8 fl oz., June 28; 8 fl oz., July 18). Weeds were controlled with application of Lorox DF (1.0 lb/A, April 27, May 20 and June 8). No fungicide was applied to the test plots at any time during the growing season. Disease severity was rated on four 2-foot-long sections of each plot from August 1 to September 20 using the Horsfall-Barratt system. A five-foot-long section of each of two rows (total of 10 feet of row) was hand dug from each plot on September 27 and the yield was graded by hand into five size categories (based on diameter) and culls. The size categories were then grouped appropriately to conform to standards for slicing and dicing carrots. Yield values were calculated for each treatment based on typical processing contracts. Rainfall recorded at the site was (inches): April (3.5) May (4.49), June (8.99), July (0.75), August (3.92) and September (5.47).

The development of foliar diseases was slow through most of the growing season, but by September 20 symptoms were observed on 40% of the foliage on the most susceptible cultivars and breeding lines. Grower standard cultivars Fontana and Gold King represent high levels of susceptibility to foliar diseases. Both of these cultivars had a calculated AUDPC (area under the disease progress curve – a measure of season-long disease progress) greater than 0.15. In contrast, the cultivar Bolero, with high levels of disease resistance, had an AUDPC of only 0.056. The least significant difference for AUDPC was 0.081, and among the lines being evaluated, six, including Bolero, Carson, REX 248, KXPC-020, Canada and Cheyenne had AUDPC's significantly lower than Gold King and Fontana. There continues to be substantial progress being made by breeders in developing improved levels of disease resistance to these two pathogens. Twelve entries yielded over 20 T/A. Three entries yielded over 20 T/A and also had an AUDPC significantly less than the grower standard Gold King. These entries included Carson (dicer), Bolero (slicer/cut&peel) and Canada (dicer). The data suggest that these entries could be grown commercially without fungicide application. Gross values based on typical slicing and dicing contracts were calculated for each cultivar and breeding line in the trial. Several of the plot entries with high levels of disease resistance and yields over 20 T/A, were among the lines with the highest gross values of yield. Data on root quality and presence of aster yellows were collected by Steve Keil, Agrilink Foods Company. Higher levels of root forking were recorded in the muck trial (a field with extensive history of carrot cropping) when compared to the Hancock trial location (a field with very limited carrot cropping history). The incidence of aster yellows was low.

Table 1. Processing type and source of seed for cultivars and breeding lines used in this trial.

Cultivar or line	Source	Use Type ¹		
		Dice	Slice	Cut & Peel
B1833	Bejo		✓	
Bangor	Bejo		✓	
Bolero	Bejo		✓	✓
Calgary	Bejo	✓		
Canada	Bejo	✓		
Carson	Bejo	✓		
Cheyenne	Sunseeds		✓	
Danvers 126		✓		
Eagle	Sunseeds		✓	
Enterprise	Seminis		✓	
First Class	Seminis		✓	
Fontana	Bejo	✓		
Gold King		✓		
Goldman-1 [(W33 m W266)AY85-91Syn]m SNAY85Syn#3] 1002-01	I. Goldman ²			
Goldman-2 [(WY85Syn)AY91Syn] m W255] m WAY274] 1004-01	I. Goldman ²			
Goldman-3 [WAY274 m (WAY85-91Syn m W255)] 1006-01	I. Goldman ²			
Goldman-4 [WAY274 m (WAY85-91Syn m W255)] 1008-01	I. Goldman ²			
Goldman-5 [(W259 m W267C) m WAY274] 1010-01	I. Goldman ²			
Goldman-6 [(W259 m W267C) m WAY274] 1012-01	I. Goldman ²			
Infinity	Bejo		✓	
KXPC-020	Polonica		✓	
Lucky B	Chrised		✓	
Prospector	Seminis		✓	
PS 302295	Seminis	✓		
PX 80494	Seminis	✓		
Recoleta	Seminis	✓		
REX 248	Sakata		✓	
SugarSnax 54	Sunseeds			✓
Sunrise	Crookham		✓	
SXC 3293	Sunseeds			✓
USDA (5280x6366) x 6526 025-5	P. Simon ³			✓
USDA (6253x2144) x7241 027-6	P. Simon ³			✓
USDA 3475A 005-2	P. Simon ³			✓
USDA 5280B 728-1	P. Simon ³			✓
USDA 6526B Sun	P. Simon ³			✓
USDA 7241B 739-1	P. Simon ³			✓
USDA 7806B 742-1	P. Simon ³			✓
USDA W2-HC4 620-2	P. Simon ³			✓
XPH96W16	Crookham		✓	
Yellowstone	Bejo		✓	

1 "Dicer" types planted at approximately 10 seeds/foot; "slicer" and "cut & peel" types planted at approximately 24 seeds/foot.

2 Inbred line from UW Department of Horticulture carrot and onion breeding program

3 Line from USDA carrot breeding program, UW Department of Horticulture

Table 2. Severity of leaf blight on carrot cultivars and breeding selections.

Cultivar or Breeding Selection	Disease Severity (%) (Alternaria and Cercospora Blight - combined) ¹						Relative AUDPC ²
	8/1	8/8	8/14	8/30	9/10	9/20	
Slicer Standards							
Bolero	1.4	1.0	2.7	9.4	7.2	7.0	0.056
Prospector	1.8	1.0	2.9	11.3	16.0	29.4	0.102
Enterprise	1.4	1.4	3.3	12.9	14.8	33.3	0.109
Dicer Standards							
Danvers 126	1.2	1.4	2.9	19.5	19.3	31.5	0.134
Gold King	1.6	1.2	2.9	17.2	22.0	57.3	0.159
Test Lines							
B1833	1.6	1.2	2.1	9.8	11.7	26.0	0.084
Bangor	2.5	1.2	4.3	28.6	18.7	30.2	0.160
Calgary	1.4	1.6	1.6	5.9	9.0	35.4	0.076
Canada	2.0	1.0	2.1	7.0	10.9	21.1	0.070
Carson	0.8	1.0	1.4	4.1	4.5	9.6	0.034
Cheyenne	1.2	1.0	2.9	11.3	9.0	11.7	0.070
Eagle	2.3	1.6	2.7	16.9	18.4	59.6	0.154
First Class	2.0	1.2	2.7	16.9	13.3	18.7	0.101
Fontana	1.8	1.6	3.1	24.2	33.9	58.3	0.205
Goldman-1 ³	3.3	1.4	2.3	25.4	32.2	69.0	0.214
Goldman-2 ³	2.5	1.6	2.7	10.2	10.2	19.5	0.078
Goldman-3 ³	2.9	1.2	3.7	9.8	11.7	37.2	0.099
Goldman-4 ³	2.5	3.1	6.2	30.3	29.7	62.8	0.227
Goldman-5 ³	2.1	1.8	3.1	20.3	29.9	68.8	0.197
Goldman-6 ³	2.5	1.2	4.9	12.1	14.1	30.7	0.107
Infinity	2.3	1.6	5.7	16.0	14.1	31.5	0.120
KXPC-020	2.5	1.0	2.9	5.1	6.0	7.8	0.044
Lucky B	2.5	1.2	3.1	15.6	19.1	42.2	0.135
PS 302295	2.1	0.6	2.3	18.0	15.6	39.6	0.128
PX 80494	1.8	1.4	2.1	10.9	15.6	31.5	0.102
Recoleta	1.4	1.0	2.9	18.7	13.7	22.7	0.099
REX 248	2.1	1.6	2.1	8.6	9.4	16.4	0.068
SugarSnax	1.6	1.8	1.6	9.8	10.5	24.2	0.080
Sunrise	2.7	2.5	3.9	17.7	16.8	45.8	0.143
SXC 3293	1.2	1.4	2.1	9.4	13.3	28.6	0.090
USDA (5280x 6366) x6526 025-5	2.1	1.4	3.7	16.4	14.1	35.9	0.121
USDA (6253x 2144) x7241 027-6	3.1	2.3	4.9	23.2	14.5	22.3	0.131
USDA 5280B 728-1	2.1	1.0	3.9	9.0	9.0	19.8	0.074
USDA 6526B Sun	3.3	1.6	5.5	7.4	10.2	25.0	0.083
USDA 7241B 739-1	7.4	1.6	4.3	9.8	11.7	35.9	0.107
USDA 7806B 742-1	2.7	2.5	3.1	9.4	15.6	41.9	0.112
USDA W2-HC4 620-2	3.5	1.6	--	--	--	--	--
XPH96W16	1.6	1.4	1.8	10.9	10.9	15.6	0.075
Yellowstone	2.0	1.4	2.7	15.0	15.6	42.7	0.125
Pr > F ⁴	<0.01	0.01	0.11	0.02	0.04	<0.01	<0.01
LSD ⁴	1.5	1.0	NS	13.8	15.2	24.9	0.081

- 1 Severity of leaf blight symptoms was rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage dead). No attempt was made to evaluate symptoms of Alternaria and Cercospora blights separately. Ratings were converted to percentages.
- 2 Relative area under the disease progress curve. Data for each 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% 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.
- 3 Breeding line from UW Department of Horticulture carrot and onion breeding program, see Table 1 for complete breeding line numbers
- 4 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at $P = 0.10$.

Table 3. Yield, size distribution and gross value for carrot cultivars and breeding selections.

Cultivar or Breeding Selection	Total Yield (Ton/A) ¹	Percentage of yield for carrot diameter (inches)					% culls	Yield Graded as Slicers ²					Yield Graded as Dicers ²				
		< ¾	¾ - 1 ¼	1 ¼ - 1 ⅝	1 ⅝ - 2	> 2		Percentage of Yield			Price/ Ton (\$)	Gross Value of Yield (\$)	Percentage of Yield			Price/ Ton (\$)	Gross Value of Yield (\$)
								¾ - 1 ⅝"	> 1 ⅝"	Dis-cards			1 ¼ - 2"	> 2"	Dis-cards		
Slicer Standards																	
Bolero	22.3	12.9	63.9	13.2	1.0	0	9.0	77.1	1.0	21.9	54.1	924.8	14.2	0	85.8	17.1	57.2
Prospector	17.3	29.3	48.2	7.9	0	0	14.7	56.0	0	44.0	54.1	538.9	7.9	0	92.1	17.1	27.0
Enterprise	14.7	28.5	29.5	7.2	0	0	34.9	36.7	0	63.3	54.1	300.8	7.2	0	92.8	17.1	19.1
Dicer Standards																	
Danvers 126	22.1	0.7	8.8	25.9	20.6	23.6	20.3	34.7	44.2	21.1	43.6	750.3	46.5	23.6	30.0	17.1	267.4
Gold King	28.2	4.3	8.8	27.2	24.4	20.4	14.9	36.0	44.9	19.2	44.5	1018.7	51.7	20.4	28.0	17.1	349.1
Test Lines																	
B1833	20.1	4.2	27.0	31.8	2.9	0.9	33.2	58.7	3.9	37.4	54.1	680.2	34.7	0.9	64.4	17.1	125.6
Bangor	23.9	11.8	50.0	26.2	2.1	1.9	8.0	76.2	4.0	19.8	54.1	1058.2	28.3	1.9	69.8	17.1	131.4
Calgary	19.7	1.9	6.4	17.1	19.8	24.9	30.0	23.6	44.7	31.7	43.6	582.5	36.9	24.9	38.2	17.1	210.6
Canada	23.9	1.5	10.1	25.4	24.0	7.9	31.1	35.5	31.9	32.6	47.3	803.1	49.4	7.9	42.7	17.1	253.7
Carson	29.8	1.2	7.1	25.2	26.3	17.3	23.0	32.2	43.6	24.2	44.6	968.5	51.5	17.3	31.3	17.1	345.3
Cheyenne	16.5	26.5	39.0	15.8	1.3	0	17.4	54.8	1.3	43.9	54.1	518.0	17.1	0	82.9	17.1	47.7
Eagle	27.0	5.7	39.2	31.9	4.6	2.6	16.0	71.1	7.2	21.7	54.1	1141.9	36.5	2.6	61.0	17.1	181.2
First Class	15.4	22.5	33.6	13.3	0.9	0	29.6	47.0	0.9	52.1	54.1	409.4	14.3	0	85.7	17.1	41.0
Fontana	19.8	4.9	11.0	23.2	11.6	4.2	45.0	34.3	15.8	50.0	50.8	577.1	34.8	4.2	61.0	17.1	170.4
Goldman-1 ³	10.5	7.9	34.4	31.9	1.0	0	24.8	66.3	1.0	32.7	54.1	357.1	32.9	0	67.1	17.1	60.5
Goldman-2 ³	11.9	18.1	19.5	36.9	8.4	6.8	10.3	56.4	15.1	28.4	51.8	473.0	45.3	6.8	48.0	17.1	117.3
Goldman-3 ³	7.0	18.5	60.5	12.4	0	0	8.6	73.0	0	27.1	54.1	278.6	12.4	0	87.6	17.1	14.9
Goldman-4 ³	13.0	11.9	61.5	15.7	0	0	10.9	77.2	0	22.8	54.1	557.2	15.7	0	84.3	17.1	42.3
Goldman-5 ³	9.0	32.9	61.0	4.2	0	0	1.9	65.3	0	34.7	54.1	338.8	4.2	0	95.8	17.1	7.9
Goldman-6 ³	9.9	31.1	56.5	7.5	0	0	4.9	64.0	0	36.0	54.1	381.3	7.5	0	92.5	17.1	18.5
Infinity	18.5	34.2	35.6	3.8	0	0	26.5	39.3	0	60.7	54.1	388.5	3.8	0	96.3	17.1	11.6
KXPC-020	15.0	7.0	28.3	28.3	6.9	2.6	26.9	56.6	9.5	33.9	53.3	511.3	35.2	2.6	62.2	17.1	92.4
Lucky B	21.7	7.7	29.2	26.0	3.0	2.8	31.1	55.2	5.8	39.0	53.3	708.9	29.0	2.8	68.2	17.1	124.4
PS 302295	23.9	1.7	15.6	20.2	19.3	12.6	30.7	35.7	31.9	32.4	47.6	748.7	39.5	12.6	48.0	17.1	216.1
PX 80494	16.9	2.0	12.9	34.1	25.0	6.7	19.3	47.1	31.6	21.3	47.3	610.3	59.1	6.7	34.3	17.1	184.5
Recoleta	18.2	4.4	22.0	19.7	3.1	1.3	49.5	41.8	4.4	53.9	53.3	422.4	22.8	1.3	75.9	17.1	67.6
REX 248	13.3	18.3	26.6	5.0	0	0	50.1	31.6	0	68.4	54.1	230.2	5.0	0	95.0	17.1	11.6
SugarSnax ⁵⁴	26.7	25.4	50.8	10.2	1.1	0	12.5	61.0	1.1	37.9	54.1	897.3	11.3	0	88.7	17.1	51.0
Sunrise	16.4	21.4	43.6	22.2	1.5	0	11.5	65.7	1.5	32.9	54.1	600.4	23.6	0	76.4	17.1	67.2
SXC 3293	22.4	28.2	32.1	10.8	0	0	28.9	42.9	0	57.1	54.1	516.7	10.8	0	89.2	17.1	42.7
USDA (5280x 6366)x6526 025-5	13.3	9.1	26.6	16.0	12.9	2.5	32.9	42.6	15.4	42.1	51.8	408.7	28.9	2.5	68.6	17.1	73.8
USDA (6253x 2144)x7241 027-6	9.5	49.7	22.6	1.4	0	0	26.4	24.0	0	76.0	54.1	130.8	1.4	0	98.6	17.1	2.9
USDA 5280B 728-1	8.1	13.9	38.8	19.7	0	0	27.6	58.5	0	41.5	54.1	238.9	19.7	0	80.3	17.1	30.0
USDA 6526B Sun	3.7	49.0	28.4	0	0	0	22.7	28.4	0	71.6	54.1	71.9	0	0	100.0	17.1	0
USDA 7806B 742-1	5.0	34.0	37.5	7.4	0	0	21.1	44.9	0	55.1	54.1	98.1	7.4	0	92.6	17.1	1.7
XPH96W16	19.3	14.4	42.0	22.9	0.8	0	19.9	64.9	0.8	34.3	54.1	660.6	23.7	0	76.3	17.1	77.1

Cultivar or Breeding Selection	Total Yield (Ton/A) ¹	Percentage of yield for carrot diameter (inches)					% culls	Yield Graded as Slicers ²					Yield Graded as Dicers ²				
		< 3/4	3/4 - 1 1/4	1 1/4 - 1 5/8	1 5/8 - 2	> 2		Percentage of Yield			Price/Ton (\$)	Gross Value of Yield (\$)	Percentage of Yield			Price/Ton (\$)	Gross Value of Yield (\$)
								3/4 - 1 5/8"	> 1 5/8"	Dis-cards			1 1/4 - 2"	> 2"	Dis-cards		
Yellowstone	16.1	3.3	18.5	36.4	13.4	8.0	20.4	54.9	21.4	23.6	50.1	626.1	49.8	8.0	42.1	17.1	160.6
Pr > F ⁴	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01
LSD ⁴	7.1	16.4	18.1	14.1	7.8	7.2	21.8	24.7	10.2	26.1	2.6	333.2	17.5	7.2	17.7	--	87.9

- 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 or culls (misshapen or rotted). The size classes were then grouped appropriately to conform to standards for slicing carrots. Yield samples were intended only to permit evaluation of quality and relative size distribution of carrots.
- 2 Values are calculated based on typical 2001 processing contracts for uncrowned carrots.
- Dicing carrot contract: Minimum size accepted is 1 1/4 inch; discard class includes culls and carrots below the minimum diameter. Dicing base price per ton is: >90% of crop over 2" diameter - \$22.33; 81-90% > 2" - \$20.90; 71-80% > 2" - \$19.01; 61-70% > 2" - \$18.30; 51-60% > 2" - \$17.70; < 51% > 2" - \$17.13.
 - Slicing carrot contract: Minimum size accepted is 3/4 inch diameter; discard class includes culls and carrots below the minimum diameter. Slicing base price per ton is: < 10% over 1 3/4" diameter - \$54.05; 10-19% > 1 3/4" - \$51.80; 20-29% > 1 3/4" - \$49.64; 30-39% > 1 3/4" - \$46.54; 40-49% > 1 3/4" - \$43.54; >49% > 1 3/4" - \$40.68.
- 3 Breeding line from UW Department of Horticulture carrot and onion breeding program, see Table 1 for complete breeding line numbers
- 4 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at P = 0.10.

Table 4. Carrot length, count and quality observations (Data from S. Keil, Agrilink Foods)

Cultivar or Breeding Line	Root length (in)		Count		Defects									
	Range (over all reps)	Average	Range (over all reps)	Average	Forks		Cracks		Rot		Aster Yellows		Curve/Twist	
					Range (over all reps)	Average	Range (over all reps)	Average	Range (over all reps)	Average	Range (over all reps)	Average	Range (over all reps)	Average
B1833	3-7.5	4.7	101-154	122.3	5-15	8.7	0-1	0.3	1-3	1.7	1	1.0	2-3	2.3
Bangor	3-9	4.9	120-236	169.7	1-8	4.0	0	0.0	0	0	3-4	3.7	1-6	3.0
Bolero	3-8	5.0	101-249	172.3	6-11	9.0	0	0.0	0	0.0	1-4	2.3	2-9	4.3
Calgary	3-8	4.8	44-70	60.3	5-6	5.3	0-3	1.7	0-2	0.7	2-3	2.3	0-1	0.3
Canada	3-8	4.8	44-122	89.3	6-15	9.3	0	0.0	0-2	1.3	0-3	1.3	1-2	1.3
Carson	3-7	4.8	79-97	64.7	1-13	11.7	0	0.0	0-1	0.3	0-7	3.7	0-1	0.3
Cheyenne	3-15	6.5	69-195	118.3	0-8	3.3	0-3	1.3	0	0	0-2	1.0	3-9	5.3
Danvers 126	3-8.3	5.7	57-78	68.7	3-5	4.0	0-2	1.0	0-1	0.3	1	1.0	0	0.0
Eagle	3-10.5	6.7	117-138	124.3	6-8	7.0	0-3	1.3	0-1	0.7	0-4	2.0	2-4	3.0
Enterprise	3-11.5	6.5	91-174	137.0	8-36	21.0	0	0.0	0	0.0	0	0.0	1-6	3.3
First Class	3-9	5.5	104-131	118.0	4-12	8.7	1-3	2.0	0-1	0.3	0-1	0.7	3-6	4.0
Fontana	3-8.3	4.7	48-86	68.0	5-20	12.0	0-1	0.3	0-1	0.3	0-6	3.0	0-1	0.7
Gold King	3-7.5	5.0	58-102	74.7	4-5	4.3	0-2	0.7	0-1	0.3	1	1.0	0-3	1.0
Goldman -1 ¹	3-6.5	4.3	50-70	59.3	0-9	5.7	0-1	0.3	0	0.0	0-1	0.7	0-1	0.3
Goldman -2 ¹	3-8.3	4.5	46-75	63.3	0-4	2.0	0-2	1.0	0	0.0	0	0.0	0-2	1.0
Goldman -3 ¹	3-6.3	4.2	54-80	70.3	1-3	2.3	0	0.0	0	0	0-1	0.3	0-2	1.3
Goldman -4 ¹	3-6.5	4.2	82-153	122.7	2	2.0	0-2	0.7	0	0	0-3	1.3	0-2	1.3
Goldman -5 ¹	3-6.5	4.3	63-136	98.3	0-1	0.3	0-1	0.3	0	0	0	0.0	0-2	0.7
Goldman -6 ¹	3-6	3.8	69-95	82.7	0-5	1.7	0-3	1.0	0	0	0	0.0	2	2.0
Infinity	3-10	6.3	151-167	160.0	6-22	12.7	0-1	0.3	0	0	0-1	0.3	6-9	7.0
KXPC-020	3-10	5.8	44-92	74.7	1-16	8.3	1-3	2.3	0-1	0.3	0-1	0.7	1-3	1.7
Lucky B	3-9	4.7	106-150	125.0	8-25	15.0	0-3	1.7	0	0.0	0-3	1.0	2-4	3.0
Prospector	3-10.5	6.0	126-192	167.0	5-18	10.0	0-2	0.7	0-2	0.7	0-3	1.0	7-8	7.7
PS 302295	3-8.8	5.3	64-85	75.7	4-22	11.3	0-1	0.3	0	0.0	0-1	0.3	2-3	2.3

Cultivar or Breeding Line	Root length (in)		Count		Defects									
	Range (over all reps)	Average	Range (over all reps)	Average	Forks		Cracks		Rot		Aster Yellows		Curve/Twist	
					Range (over all reps)	Average	Range (over all reps)	Average	Range (over all reps)	Average	Range (over all reps)	Average	Range (over all reps)	Average
PX 80494	3-9.3	5.7	48-70	61.0	4-11	6.3	0	0.0	0-1	0.3	0-1	0.7	0-2	1.0
Recoleta	3-8.3	4.8	58-131	92.3	14-43	24.3	0-2	0.7	0	0.0	0-1	0.3	0-3	1.3
REX 248	3-11	6.5	69-190	118.3	11-26	21.0	0	0.0	0	0.0	0-2	0.7	4-5	4.7
SugarSnax 54	3-12.5	7.5	172-184	179.0	1-13	7.3	0-3	1.7	0-1	0.7	0-3	1.3	6-18	10.3
Sunrise	3-11.5	6.3	110-198	162.0	2-8	5.0	0-1	0.3	0	0.0	0-2	0.7	5-8	6.3
SXC 3293	3-13	7.2	106-224	162.0	10-12	11.3	1-3	2.0	0-1	0.3	0-3	1.3	12-17	15.0
USDA (5280x6366) x 6526 025-5	3-9.5	5.5	50-68	59.3	3-5	4.0	0-9	4.7	0	0.0	0-2	0.7	1-3	2.0
USDA (6253x2144) x7241 027-6	3-9	4.9	97-136	121.3	7-20	13.0	0-1	0.3	0	0.0	0-3	1.0	4-8	6.0
USDA 5280B 728-1	3-11	6.2	19-32	25.0	0-4	2.3	2	2.0	0	0.0	1-3	1.7	1-3	1.7
USDA 6526B Sun	3-6	3.5	19-42	28.0	1-4	2.0	0-3	1.0	0	0.0	0	0.0	0-1	0.7
USDA 7806B 742-1	3-6.5	3.6	45-85	59.7	0-3	1.7	0-2	1.0	0	0.0	0-1	0.7	0	0.0
XPH96W16	3-12	7.0	88-147	114.3	5-18	12.0	1-3	1.7	0	0.0	0-1	0.3	3-6	5.0
Yellowstone	4-11	7.3	36-62	77.3	0-11	4.7	0	0.0	0	0	1-3	2.0	1	1.0

¹ Breeding line from UW Department of Horticulture carrot and onion breeding program, see Table 1 for complete breeding line numbers

Table 5. Data ranked according to disease and yield measurements

Sorted by % Disease severity 9/10 (increasing)

Cultivar or Breeding Selection	Disease Severity 9/10 (%) ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$) ⁵		Cultivar or Breeding Selection	Disease Severity 9/10 (%) ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$) ⁵	
				Slicers	Dicers					Slicers	Dicers
Carson	4.5	0.034	29.8	968.5	345.3	PS 302295	15.6	0.128	23.9	748.7	216.1
KXPC-020	6.0	0.044	15.0	511.3	92.4	PX 80494	15.6	0.102	16.9	610.3	184.5
Bolero	7.2	0.056	22.3	924.8	57.2	USDA 7806B 742-1	15.6	0.112	5.0	98.1	1.7
Cheyenne	9.0	0.070	16.5	518.0	47.7	Yellowstone	15.6	0.125	16.1	626.1	160.6
Calgary	9.0	0.076	19.7	582.5	210.6	Prospector	16.0	0.102	17.3	538.9	27.0
USDA 5280B 728-1	9.0	0.074	8.1	238.9	30.0	Sunrise	16.8	0.143	16.4	600.4	67.2
REX 248	9.4	0.068	13.3	230.2	11.6	Eagle	18.4	0.154	27.0	1141.9	181.2
USDA 6526B Sun	10.2	0.083	3.7	71.9	0	Bangor	18.7	0.160	23.9	1058.2	131.4
Goldman-2 ¹	10.2	0.078	11.9	473.0	117.3	Lucky B	19.1	0.135	21.7	708.9	124.4
SugarSnax	10.5	0.080	26.7	897.3	51.0	Danvers 126	19.3	0.134	22.1	750.3	267.4
Canada	10.9	0.070	23.9	803.1	253.7	Gold King	22.0	0.159	28.2	1018.7	349.1
XPH96W16	10.9	0.075	19.3	660.6	77.1	Goldman-4 ¹	29.7	0.227	13.0	557.2	42.3
B1833	11.7	0.084	20.1	680.2	125.6	Goldman-5 ¹	29.9	0.197	9.0	338.8	7.9
USDA 7241B 739-1	11.7	0.107	--	--	--	Goldman-1 ¹	32.2	0.214	10.5	357.1	60.5
Goldman-3 ¹	11.7	0.099	7.0	278.6	14.9	Fontana	33.9	0.205	19.8	577.1	170.4
SXC 3293	13.3	0.090	22.4	516.7	42.7	Pr > F ⁶	0.04	<0.01	<0.01	<0.01	<0.01
First Class	13.3	0.101	15.4	409.4	41.0	LSD ⁶	15.2	0.081	7.1	333.2	87.9
Recoleta	13.7	0.099	18.2	422.4	67.6						
USDA (5280x 6366) x6526 025-5	14.1	0.121	13.3	408.7	73.8						
Goldman-6 ¹	14.1	0.107	9.9	381.3	18.5						
Infinity	14.1	0.120	18.5	388.5	11.6						
USDA (6253x 2144) x7241 027-6	14.5	0.131	9.5	130.8	2.9						
Enterprise	14.8	0.109	14.7	300.8	19.1						

Sorted by Relative AUDPC (increasing)

Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$)		Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$)	
				Slicers ⁵	Dicers ⁵					Slicers ⁵	Dicers ⁵
Carson	4.5	0.034	29.8	968.5	345.3	Enterprise	14.8	0.109	14.7	300.8	19.1
KXPC-020	6.0	0.044	15.0	511.3	92.4	USDA 7806B 742-1	15.6	0.112	5.0	98.1	1.7
Bolero	7.2	0.056	22.3	924.8	57.2	Infinity	14.1	0.120	18.5	388.5	11.6
REX 248	9.4	0.068	13.3	230.2	11.6	USDA (5280x 6366)					
Cheyenne	9.0	0.070	16.5	518.0	47.7	x6526 025-5	14.1	0.121	13.3	408.7	73.8
Canada	10.9	0.070	23.9	803.1	253.7	Yellowstone	15.6	0.125	16.1	626.1	160.6
USDA 5280B 728-1	9.0	0.074	8.1	238.9	30.0	PS 302295	15.6	0.128	23.9	748.7	216.1
XPH96W16	10.9	0.075	19.3	660.6	77.1	USDA (6253x 2144)					
Calgary	9.0	0.076	19.7	582.5	210.6	x7241 027-6	14.5	0.131	9.5	130.8	2.9
Goldman-2 ¹	10.2	0.078	11.9	473.0	117.3	Danvers 126	19.3	0.134	22.1	750.3	267.4
SugarSnax	10.5	0.080	26.7	897.3	51.0	Lucky B	19.1	0.135	21.7	708.9	124.4
USDA 6526B Sun	10.2	0.083	3.7	71.9	0	Sunrise	16.8	0.143	16.4	600.4	67.2
B1833	11.7	0.084	20.1	680.2	125.6	Eagle	18.4	0.154	27.0	1141.9	181.2
SXC 3293	13.3	0.090	22.4	516.7	42.7	Gold King	22.0	0.159	28.2	1018.7	349.1
Recoleta	13.7	0.099	18.2	422.4	67.6	Bangor	18.7	0.160	23.9	1058.2	131.4
Goldman-3 ¹	11.7	0.099	7.0	278.6	14.9	Goldman-5 ¹	29.9	0.197	9.0	338.8	7.9
First Class	13.3	0.101	15.4	409.4	41.0	Fontana	33.9	0.205	19.8	577.1	170.4
Prospector	16.0	0.102	17.3	538.9	27.0	Goldman-1 ¹	32.2	0.214	10.5	357.1	60.5
PX 80494	15.6	0.102	16.9	610.3	184.5	Goldman-4 ¹	29.7	0.227	13.0	557.2	42.3
USDA 7241B 739-1	11.7	0.107	--	--	--	Pr > F ⁶	0.04	<0.01	<0.01	<0.01	<0.01
Goldman-6 ¹	14.1	0.107	9.9	381.3	18.5	LSD ⁶	15.2	0.081	7.1	333.2	87.9

Sorted by Total Yield (Ton/A) (decreasing)

Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$)		Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$)	
				Slicers ⁵	Dicers ⁵					Slicers ⁵	Dicers ⁵
Carson	4.5	0.034	29.8	968.5	345.3	Yellowstone	15.6	0.125	16.1	626.1	160.6
Gold King	22.0	0.159	28.2	1018.7	349.1	First Class	13.3	0.101	15.4	409.4	41.0
Eagle	18.4	0.154	27.0	1141.9	181.2	KXPC-020	6.0	0.044	15.0	511.3	92.4
SugarSnax	10.5	0.080	26.7	897.3	51.0	Enterprise	14.8	0.109	14.7	300.8	19.1
Canada	10.9	0.070	23.9	803.1	253.7	USDA (5280x 6366)					
PS 302295	15.6	0.128	23.9	748.7	216.1	x6526 025-5	14.1	0.121	13.3	408.7	73.8
Bangor	18.7	0.160	23.9	1058.2	131.4	REX 248	9.4	0.068	13.3	230.2	11.6
SXC 3293	13.3	0.090	22.4	516.7	42.7	Goldman-4 ¹	29.7	0.227	13.0	557.2	42.3
Bolero	7.2	0.056	22.3	924.8	57.2	Goldman-2 ¹	10.2	0.078	11.9	473.0	117.3
Danvers 126	19.3	0.134	22.1	750.3	267.4	Goldman-1 ¹	32.2	0.214	10.5	357.1	60.5
Lucky B	19.1	0.135	21.7	708.9	124.4	Goldman-6 ¹	14.1	0.107	9.9	381.3	18.5
B1833	11.7	0.084	20.1	680.2	125.6	USDA (6253x 2144)					
Fontana	33.9	0.205	19.8	577.1	170.4	x7241 027-6	14.5	0.131	9.5	130.8	2.9
Calgary	9.0	0.076	19.7	582.5	210.6	Goldman-5 ¹	29.9	0.197	9.0	338.8	7.9
XPH96W16	10.9	0.075	19.3	660.6	77.1	USDA 5280B 728-1	9.0	0.074	8.1	238.9	30.0
Infinity	14.1	0.120	18.5	388.5	11.6	Goldman-3 ¹	11.7	0.099	7.0	278.6	14.9
Recoleta	13.7	0.099	18.2	422.4	67.6	USDA 7806B 742-1	15.6	0.112	5.0	98.1	1.7
Prospector	16.0	0.102	17.3	538.9	27.0	USDA 6526B Sun	10.2	0.083	3.7	71.9	0
PX 80494	15.6	0.102	16.9	610.3	184.5	Pr > F ⁶	0.04	<0.01	<0.01	<0.01	<0.01
Cheyenne	9.0	0.070	16.5	518.0	47.7	LSD ⁶	15.2	0.081	7.1	333.2	87.9
Sunrise	16.8	0.143	16.4	600.4	67.2						

Sorted by Gross Value of Yield (\$) – Graded as Slicers (decreasing)

Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield ⁴ (Ton/A)	Gross Value of Yield (\$)		Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield ⁴ (Ton/A)	Gross Value of Yield (\$)	
				Slicers ⁵	Dicers ⁵					Slicers ⁵	Dicers ⁵
Eagle	18.4	0.154	27.0	1141.9	181.2	Lucky B	19.1	0.135	21.7	708.9	124.4
Bangor	18.7	0.160	23.9	1058.2	131.4	B1833	11.7	0.084	20.1	680.2	125.6
Gold King	22.0	0.159	28.2	1018.7	349.1	XPH96W16	10.9	0.075	19.3	660.6	77.1
Carson	4.5	0.034	29.8	968.5	345.3	Yellowstone	15.6	0.125	16.1	626.1	160.6
Bolero	7.2	0.056	22.3	924.8	57.2	PX 80494	15.6	0.102	16.9	610.3	184.5
SugarSnax	10.5	0.080	26.7	897.3	51.0	Sunrise	16.8	0.143	16.4	600.4	67.2
Canada	10.9	0.070	23.9	803.1	253.7	Calgary	9.0	0.076	19.7	582.5	210.6
Danvers 126	19.3	0.134	22.1	750.3	267.4	Fontana	33.9	0.205	19.8	577.1	170.4
PS 302295	15.6	0.128	23.9	748.7	216.1	Goldman-41	29.7	0.227	13.0	557.2	42.3
						Prospector	16.0	0.102	17.3	538.9	27.0
						Cheyenne	9.0	0.070	16.5	518.0	47.7
						SXC 3293	13.3	0.090	22.4	516.7	42.7
						KXPC-020	6.0	0.044	15.0	511.3	92.4

Goldman-21	10.2	0.078	11.9	473.0	117.3	Goldman-31	11.7	0.099	7.0	278.6	14.9
Recoleta	13.7	0.099	18.2	422.4	67.6	USDA 5280B 728-1	9.0	0.074	8.1	238.9	30.0
First Class	13.3	0.101	15.4	409.4	41.0	REX 248	9.4	0.068	13.3	230.2	11.6
USDA(5280x6366)x6						USDA(6253x2144)x7					
526 025-5	14.1	0.121	13.3	408.7	73.8	241 027-6	14.5	0.131	9.5	130.8	2.9
Infinity	14.1	0.120	18.5	388.5	11.6	USDA 7806B 742-1	15.6	0.112	5.0	98.1	1.7
Goldman-61	14.1	0.107	9.9	381.3	18.5	USDA 6526B Sun	10.2	0.083	3.7	71.9	0
Goldman-11	32.2	0.214	10.5	357.1	60.5	Pr > F ⁶	0.04	<0.01	<0.01	<0.01	<0.01
Goldman-51	29.9	0.197	9.0	338.8	7.9	LSD ⁶	15.2	0.081	7.1	333.2	87.9
Enterprise	14.8	0.109	14.7	300.8	19.1						

Sorted by Gross Value of Yield (\$) – Graded as Dicers (decreasing)

Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$)		Cultivar or Breeding Selection	Disease Severity (%) 9/10 ²	Relative AUDPC ³	Total Yield (Ton/A) ⁴	Gross Value of Yield (\$)	
				Slicers ⁵	Dicers ⁵					Slicers ⁵	Dicers ⁵
Gold King	22.0	0.159	28.2	1018.7	349.1	Bolero	7.2	0.056	22.3	924.8	57.2
Carson	4.5	0.034	29.8	968.5	345.3	SugarSnax	10.5	0.080	26.7	897.3	51.0
Danvers 126	19.3	0.134	22.1	750.3	267.4	Cheyenne	9.0	0.070	16.5	518.0	47.7
Canada	10.9	0.070	23.9	803.1	253.7	SXC 3293	13.3	0.090	22.4	516.7	42.7
PS 302295	15.6	0.128	23.9	748.7	216.1	Goldman-4 ¹	29.7	0.227	13.0	557.2	42.3
Calgary	9.0	0.076	19.7	582.5	210.6	First Class	13.3	0.101	15.4	409.4	41.0
PX 80494	15.6	0.102	16.9	610.3	184.5	USDA 5280B 728-1	9.0	0.074	8.1	238.9	30.0
Eagle	18.4	0.154	27.0	1141.9	181.2	Prospector	16.0	0.102	17.3	538.9	27.0
Fontana	33.9	0.205	19.8	577.1	170.4	Enterprise	14.8	0.109	14.7	300.8	19.1
Yellowstone	15.6	0.125	16.1	626.1	160.6	Goldman-6 ¹	14.1	0.107	9.9	381.3	18.5
Bangor	18.7	0.160	23.9	1058.2	131.4	Goldman-3 ¹	11.7	0.099	7.0	278.6	14.9
B1833	11.7	0.084	20.1	680.2	125.6	REX 248	9.4	0.068	13.3	230.2	11.6
Lucky B	19.1	0.135	21.7	708.9	124.4	Infinity	14.1	0.120	18.5	388.5	11.6
Goldman-2 ¹	10.2	0.078	11.9	473.0	117.3	Goldman-5 ¹	29.9	0.197	9.0	338.8	7.9
KXPC-020	6.0	0.044	15.0	511.3	92.4	USDA (6253x 2144)					
XPH96W16	10.9	0.075	19.3	660.6	77.1	x7241 027-6	14.5	0.131	9.5	130.8	2.9
USDA (5280x 6366)						USDA 7806B 742-1	15.6	0.112	5.0	98.1	1.7
x6526 025-5	14.1	0.121	13.3	408.7	73.8	USDA 6526B Sun	10.2	0.083	3.7	71.9	0
Recoleta	13.7	0.099	18.2	422.4	67.6	Pr > F ⁶	0.04	<0.01	<0.01	<0.01	<0.01
Sunrise	16.8	0.143	16.4	600.4	67.2	LSD ⁶	15.2	0.081	7.1	333.2	87.9
Goldman-1 ¹	32.2	0.214	10.5	357.1	60.5						

- Breeding line from UW Department of Horticulture carrot and onion breeding program, see Table 1 for complete breeding line numbers.
- Severity of leaf blight symptoms was rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage dead). No attempt was made to evaluate symptoms of *Alternaria* and *Cercospora* blights separately. Ratings were converted to percentages.
- Relative area under the disease progress curve. Data for each 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% 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 or culls (misshapen or rotted). The size classes were then grouped appropriately to conform to standards for slicing carrots. Yield samples were intended only to permit evaluation of quality and relative size distribution of carrots.
- Values are calculated based on typical 2001 processing contracts for uncrowned carrots.
 - Dicing carrot contract: Minimum size accepted is 1 1/4 inch; discard class includes culls and carrots below the minimum diameter. Dicing base price per ton is: >90% of crop over 2" diameter - \$22.33; 81-90% > 2" - \$20.90; 71-80% > 2" - \$19.01; 61-70% > 2" - \$18.30; 51-60% > 2" - \$17.70; < 51% > 2" - \$17.13.
 - Slicing carrot contract: Minimum size accepted is 3/4 inch diameter; discard class includes culls and carrots below the minimum diameter. Slicing base price per ton is: < 10% over 1 3/4" diameter - \$54.05; 10-19% > 1 3/4" - \$51.80; 20-29% > 1 3/4" - \$49.64; 30-39% > 1 3/4" - \$46.54; 40-49% > 1 3/4" - \$43.54; >49% > 1 3/4" - \$40.68.
- Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at P = 0.10.