

**CROP:** Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.)  
**PEST:** Cavity spot (*Pythium intermedium* de Bary, *Pythium irregulare* Buisman, *Pythium sulcatum* Pratt & Mitchell, *Pythium sylvaticum* W.A. Campbell & J.W. Hendrix, *Pythium ultimum* Trow and *Pythium violae* Chesters & C.J. Hickman)

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**TITLE:** EVALUATION OF CARROT BREEDING LINES FOR SUSCEPTIBILITY TO CAVITY SPOT, 2016

**MATERIALS:** USDA experimental carrot breeding lines, commercial cultivars Cellobunch and Envy (Seminis Vegetable Seeds), Atomic Red and Purple Haze (Johnny's Select Seeds), Upper Cut, Honey Snax and Maverick (Nunhems), and Triton (Sakata)

**METHODS:** The trial was conducted on organic soil (pH  $\approx$  5.7, organic matter  $\approx$  71.6%) naturally infested with *Pythium* spp. at the Muck Crops Research Station, Holland Marsh, Ontario. Carrots were direct seeded ( $\approx$ 70 seeds/m) onto raised beds using a push seeder (Jang model JP-2) on 2 June. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of one row, 6 m in length, spaced 66 cm apart. On 20 August, where plant stand numbers permitted, 25 carrots were removed from every replicate, placed in storage and assessed for cavity spot on 24 August. On 30 September, plots were visually assessed for: leaf blight, (0-5 scale where 0= no blight to 5= leaf/ petiole necrosis), and plant stand, (3-1 scale where 3 = excellent stand, 2 = poor stand, 1 = very poor stand). On 23, 26 and 27 October 50 carrots from each replicate were harvested, placed into cold storage, and assessed for cavity spot on 17-24 November. Carrots were washed in a small drum washer, visually examined for cavity spot lesions, and sorted into classes based on the size of the largest lesion (measured as horizontal width). The six classes were: no disease, very light (< 1 mm), light (1-2 mm), medium (3-5 mm), heavy (6-10 mm), and very heavy (> 10 mm). The disease severity index (DSI) was determined using the following equation:

$$DSI = \frac{\sum [(class\ no.) (no.\ of\ carrots\ in\ each\ class)]}{(total\ no.\ carrots\ per\ sample) (no.\ classes - 1)} \times 100$$

Compared to the previous 10 year averages, air temperatures in 2016 were average for June (18.7°C), and above average for July (22.0°C) August (22.6°C), September (17.4°C) and October (10.9°C). The 10-year average temperatures were: June 18.7°C, July 21.0°C, August 19.8°C, September 15.8°C and October 9.4°C. Monthly rainfall was below the 10-year average for June (39 mm), July (51 mm), August (58 mm), September (25 mm), and October (41 mm). The 10-year rainfall averages were: June 85 mm, July 96 mm, August 71 mm, September 82 mm and October 73 mm. All data were analyzed using the General Analysis of Variance function of Statistics V.10. Means separation was obtained using Fisher's Protected LSD test with  $P = 0.05$  level of significance.

**RESULTS:** as presented in Tables 1, 2 & 3

**CONCLUSIONS:** In 2016, the weather was hotter and drier than average and the incidence of cavity spot was lower than in previous years. However, a wide range of susceptibility to cavity spot was identified (Table 1). Orange carrot lines 356-1 (1137B) and 365-1 (5367B) have been in the trial since 2014, and have had cavity spot incidence of 9.8, 9.8 & 8.7% and 21.2, 13.8 & 5.5% respectively over three years. In 2016, lines 104073-2 (2226B), 5277-1 (6526B), and C105R2 (Nb2159B) look relatively resistant, with cavity spot incidence of 1.6, 6.8 & 7.2% respectively.

There was also a wide range in susceptibility to carrot leaf blight, with lines 638-2, 706-7, and 5277-1 having very low ratings (Table 2). Poor emergence for some of the BR x 6274 derivatives meant that there were very few or no carrots to assess for cavity spot (Table 3).

**Table 1.** Cavity spot incidence and severity index (DSI) for carrot breeding lines from the University of Wisconsin grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

Seed Source/Name	Colour <sup>1</sup>	% Forked (18 Aug)	Disease Incidence (%)		DSI <sup>2</sup>	
			18 Aug	14 Nov	18 Aug	14 Nov
656-1	P	--	-- <sup>3</sup>	0.0 a	--	0.0 a
Purple Haze	P	12.0 abc	0.0 a <sup>4</sup>	0.0 a	0.0 a	0.0 a
355-2	P	13.3 a-d	2.7 abc	0.0 a	0.8 a	0.0 a
122-1	P	0.0 a	0.0 a	0.5 a	0.0 a	0.2 a
355-1	P	5.6 abc	2.7 abc	0.5 a	1.1 ab	0.2 a
<b>104073-2 (2226B)</b>	<b>O</b>	9.3 abc	<b>0.0<sup>5</sup> a</b>	<b>1.6 ab</b>	<b>0.0 a</b>	<b>0.8 ab</b>
151681	P	--	---	2.0 ab	--	1.1 abc
<b>365-1 (5367B)</b>	<b>O</b>	--	---	<b>5.5 abc</b>	--	<b>3.0 a-d</b>
<b>5277-1 (6526B)</b>	<b>O</b>	8.0 abc	<b>1.3 ab</b>	<b>6.8 a-d</b>	<b>0.8 a</b>	<b>3.6 a-d</b>
<b>C105R2 (Nb2159B)</b>	<b>O</b>	8.1 abc	<b>4.2 abc</b>	<b>7.2 a-d</b>	<b>3.7 abc</b>	<b>2.8 a-d</b>
268-2	P	31.7 efg	2.6 abc	7.6 a-e	1.3 ab	2.9 a-d
<b>356-1 (1137B)</b>	<b>O</b>	--	--	<b>8.7 a-e</b>	--	<b>3.5 a-d</b>
Uppercut	O	5.3 abc	15.9 d	9.7 a-f	7.4 c	4.3 a-e
356-2	O	--	--	10.0 a-g	--	3.5 a-d
Nun 151721	O	14.5 a-d	10.3 cd	11.7 a-h	5.4 bc	5.0 a-f
Cellobunch	O	10.7 abc	4.0 abc	13.1 b-h	0.8 a	5.8 a-g
Pro Peel	O	--	--	13.8 b-h	--	6.5 a-g
120-1	O	--	--	14.5 b-h	--	5.0 a-g
Maverick	O	8.1 abc	9.4 bcd	16.1 c-h	2.4 ab	8.8 d-h
Nun 151761	O	--	--	16.2 c-h	--	7.0 a-h
B101-1	O	34.7 g	2.7 abc	16.6 c-i	0.8 a	7.7 b-h
306-1	O	15.9 a-e	6.7 abc	17.1 c-i	2.9 ab	8.9 d-i
Atomic Red	R	--	--	17.2 c-i	--	9.6 d-i
110996	O	17.3 b-f	1.3 ab	17.3 c-i	0.5 a	8.2 c-h
5306-1	O	32.8 fg	4.1 abc	17.9 c-i	1.4 ab	8.6 d-h
104068-2	O	29.3 d-g	2.7 abc	18.7 d-i	1.6 ab	9.4 d-i
B104-1	O	18.7 b-g	1.3 ab	19.9 e-i	0.5 a	10.8 e-i
268-1	P	16.2 a-e	9.5 bcd	21.5 fi	3.6 abc	11.8 f-i
Triton	O	16.0 a-e	1.3 ab	21.6 f-i	0.5 a	9.2 d-i
111031	O	12.0 abc	4.0 abc	21.7 f-i	1.3 ab	12.7 ghi
941-1	O	--	--	22.1 f-i	--	13.8 hi
N110101	O	17.2 b-f	7.9 a-d	22.3 ghi	3.7 abc	11.8 f-i
Envy	O	2.7 ab	5.6 abc	23.6 hi	2.5 ab	11.8 f-i
Honey Snax	O	6.7 abc	5.3 abc	23.9 hi	2.4 ab	12.4 ghi
310-1	O	20.1 c-g	3.9 abc	29.7 i	1.6 ab	16.6 i

<sup>1</sup> O = orange, P = purple, R = red

<sup>2</sup> Disease Severity Index (DSI) was determined using the following equation:

$$DSI = \frac{\sum [(class\ no.) (no.\ of\ carrots\ in\ each\ class)]}{(total\ no.\ carrots\ per\ sample) (no.\ classes - 1)} \times 100$$

<sup>3</sup> Numbers in a column followed by the same letter are not significantly different at  $P=0.05$ , Fisher's Protected LSD test.

<sup>4</sup> --- indicates plant stand was insufficient for sampling

<sup>5</sup> Bolded lines have low cavity spot incidence and have been included in the trial in previous years.

**Table 2.** Leaf blight ratings for carrot breeding lines from University of Wisconsin grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

Trt #	Seed Source	Line	Leaf Blight Severity Rating <sup>1</sup>
17	638-2	BR x 6274	1.0 a
27	706-7	BR x 6274	1.0 a
45	5277-1	6526B	1.0 a
63	Pro Peel	--	1.0 a
64	Maverick	--	1.1 ab
39	708-6	BR x 6274	1.1 ab
18	638-8	BR x 6274	1.2 abc
5	Nb1175B	310-1	1.3 abc
26	706-6	BR x 6274	1.3 abc
61	Triton	--	1.3 abc
55	N110101	Nb4001B	1.3 abc
54	B101-1	B101-1	1.3 abc
41	708-8	BR x 6274	1.3 a-d
22	641-6	BR x 6274	1.5 a-e
21	641-5	BR x 6274	1.5 a-e
51	5306-1	Nb1391B	1.5 a-e
57	Cellobunch	--	1.5 a-e
47	306-1	1391B	1.5 a-e
7	368-1	5494B	1.5 a-e
58	Envy	--	1.6 a-f
56	B104-1	Nb4002B	1.6 a-f
16	636-12	BR x 6274	1.6 a-f
44	104068-2	8524B	1.6 a-f
14	636-2	BR x 6274	1.8 a-g
65	Uppercut	--	1.8 a-g
2	355-2	1131A	1.9 b-h
62	HoneySnax	--	1.9 b-h
1	355-1	1131B	1.9 b-h
25	706-5	BR x 6274	1.9 b-h
53	C105R2	Nb2159B	1.9 b-h
48	Nun151761	Nb3271B	2.0 c-i
49	Nun151721	Nb2159B	2.0 c-i
52	110996	Nb1393B	2.0 c-i
43	941-1	9322B	2.0 c-i
59	Purple Haze	--	2.1 d-j
20	639-17	BR x 6274	2.1 d-j
8	268-1	P6245B	2.1 d-j
3	356-1	1137B	2.3 e-k
50	111031	9296B	2.3 e-k
9	268-2	PSC x 6245	2.3 e-k
4	356-2	1137A	2.4 f-l
15	636-10	BR x 6274	2.5 g-l
13	151681	PO114B	2.6 h-l

46	120-1	Nb1175B	2.8 i-l
60	Atomic Red	--	2.8 i-l
11	104073-2	2226B	2.9 j-l
12	122-1	P7262B	3.0 kl
6	365-1	5367B	3.0 kl
10	656-1	P6139	3.1 l

<sup>1</sup> Leaf blight was rated on a 0-5 scale where 0= no blight, 1= 1-10% leaf area blighted, 2= 11-25% leaf/petiole blighted, 3= 26-50% leaf petiole blighted, 4= > 75% leaf/petiole area blighted, 5= leaf/petiole necrosis.

<sup>2</sup> Numbers in a column followed by the same letter are not significantly different at  $P= 0.05$ , Fisher's Protected LSD test.

**Table 3.** Plant stands on 21 June and the sample size for final cavity spot assessment for breeding lines from University of Wisconsin grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

Seed Source	Line	Plants/m	Avg # Carrots Assessed for Cavity Spot
111031	9296B	81.5 a <sup>1</sup>	51.3
355-2	1131A	77.0 ab	50.0
C105R2	Nb2159B	74.5 abc	47.0
151681	P0114B	60.0 a-d	45.5
104073-2	2226B	58.3 a-d	48.3
104068-2	8524B	54.8 b-e	49.5
B101-1	Nb3284B	53.3 b-e	44.0
5306-1	Nb1391B	53.0 b-e	51.0
Maverick	--	51.8 b-f	50.8
268-2	PSC x 6245	50.3 c-f	50.3
355-1	1131B	45.0 d-g	46.8
N110101	Nb4001B	43.8 d-g	49.5
110996 (2013 B.P.)	Nb1393B	43.3 d-h	49.8
Nun151721	Nb2159B	41.5 d-h	41.0
Envy	--	41.0 d-h	49.5
Pro Peel	--	41.0 d-h	50.5
306-1	1391B	40.8 d-i	44.3
Nun151761	Nb3271B	40.8 d-i	30.8
Honey Snax	--	38.5 d-i	50.3
5277-1	6526B	37.3 d-i	34.8
Triton	--	36.3 d-j	51.0
122-1	P72762B	34.8 d-j	48.0
B104-1	Nb4002B	32.0 e-k	48.3
Cellobunch	--	31.0 e-l	50.3
Uppercut	--	30.3 e-m	49.3
268-1	P6245B	29.5 e-n	44.0
Purple Haze	--	29.0 e-o	50.3
310-1	Nb1175B	26.0 f-p	35.0*
365-1	5367B	24.0 g-q	32.5
941-1	9322B	24.0 g-q	45.5

120-1 (1475017)	Nb1175B	17.8 h-q	28.7*
Atomic Red	--	17.8 h-q	34.8
356-2	1137A	15.0 i-q	17.5
656-1	P6139	11.3 j-q	21.5
356-1	1137B	8.8 k-q	21.8
636-10 <sup>2</sup>	BR x 6274	5.8 l-q	7.0
641-5	BR x 6274	5.5 l-q	4.5
368-1	BR x 6274	4.5 m-q	8.8
706-6	BR x 6274	4.3 n-q	0.0
708-4	BR x 6274	4.3 n-q	0.0
707-7	BR x 6274	3.3 o-q	0.0
636-12	BR x 6274	3.0 pq	1.5
639-17	BR x 6274	3.0 pq	4.8
706-7	BR x 6274	3.0 pq	0.0
706-4	BR x 6274	2.8 pq	0.0
638-2	BR x 6274	2.5 pq	0.0
638-8	BR x 6274	2.5 pq	0.0
706-5	BR x 6274	2.5 pq	0.0
636-2	BR x 6274	2.3 pq	0.0
641-7	BR x 6274	2.3 pq	0.0
708-3	BR x 6274	2.0 pq	0.0
708-6	BR x 6274	2.0 pq	0.0
708-2	BR x 6274	1.8 pq	0.0
708-5	BR x 6274	1.8 pq	0.0
638-9	BR x 6274	1.3 pq	0.0
707-1	BR x 6274	1.3 pq	0.0
707-3	BR x 6274	1.0 pq	0.0
641-6	BR x 6274	0.8 pq	0.0
707-9	BR x 6274	0.8 pq	0.0
708-1	BR x 6274	0.8 pq	0.8
708-8	BR x 6274	0.8 pq	0.0
708-7	BR x 6274	0.5 pq	0.0
706-10	BR x 6274	0.3 pq	0.0
708-9	BR x 6274	0.3 pq	0.0
707-6	BR x 6274	0.0 q	0.0

<sup>1</sup> Numbers in a column followed by the same letter are not significantly different at  $P=0.05$ , Fisher's Protected LSD test.

\* This is the average of 3 reps

<sup>2</sup> Entries below the line were not assessed for cavity spot.

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