

**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, 2018

**MATERIALS:** USDA experimental carrot breeding lines, commercial cultivars Cellobunch, Envy (Seminis), 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  $\approx$  72.1%) 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 cone seeder on 7 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 11 July, plots were rated on a 0 to 5 scale for plant stand where 0 = < 5 carrots, 1 = very poor, 2 = poor, 3 = good, 4 = very good and 5 = excellent stand. On 2 and 13 October, plots were visually assessed for: leaf blight, (0-5 scale where 0= no blight to 5= leaf/ petiole necrosis), and bolting, (0-3 scale where 3 = more than 50% flowering, 2 = 5 to 49%, 1 = <5% and 0 = no flowering). On 26 and 27 October, 50 carrots from each replicate were harvested, placed into cold storage, and assessed for cavity spot on 7-16 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: 0 = no disease, 1 = very light (< 1 mm), 2 = light (1-2 mm), 3 = medium (3-5 mm), 4 = heavy (6-10 mm), and 5 = very heavy (> 10 mm). The disease severity index (DSI) was determined using the above classes and 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 average, air temperatures in 2018 were above average for May (15.8°C), August (21.9°C), September (17.5°C), average for June (18.4°C), July (22.0°C) and below average for October (8.3°C). The 10-year average temperatures were: May 13.9°C, June 18.6°C, July 21.2°C, August 20.1°C, September 16.0°C and October 9.4°C. Monthly rainfall was above the 10-year average for August (109 mm), average for May (82 mm), July (104 mm), October (69 mm) and below average for June (59 mm) and September (20 mm). The 10-year rainfall averages were: May 74 mm, June 101 mm, July 97 mm, August 75 mm, September 67 mm and October 72 mm. 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 2018, the weather was wetter than average in August and cavity spot incidence and severity were mostly higher than in 2017. A wide range of susceptibility to cavity spot was observed among the lines tested (Table 1). The purple/orange line D1137 (A & B) had low cavity spot incidence (2.5 & 4.5% respectively) similar to Purple Haze (0.5%). This is consistent with results from previous years. Orange carrot lines B1111A and B1111B also had low severity, but these were not different from Cellobunch Triton, Upper Cut or Sugar Snax. The line B1111 produces smooth orange roots and is a promising line for cavity spot resistance. Atomic Red had high incidence and severity and continues to be a useful susceptible check.

There were also differences in the percent of forking. Percent forking was not correlated to cavity spot resistance, but the lines with the greatest resistance to cavity spot also had a low incidence of forked carrots. Significant differences in leaf blight and bolting were also identified among the lines tested (Table 2).

**Table 1.** Cavity spot incidence and severity index (DSI) and percent forked for carrot breeding lines from the University of Wisconsin grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Field Number	Pedigree	Incidence (%)	DSI <sup>1</sup>	% Forked
CS 859	Purple Haze	0.5 a	0.2 a	1.0 abc
CS 802	D1131A	2.5 ab	0.7 ab	2.0 a-d
CS 801	D1131B	4.5 abc	2.0 abc	2.5 a-d
CS 851	B1111B	19.5 bcd	7.1 a-d	1.0 abc
CS 852	B1111A	21.5 bcd	8.2 a-e	4.5 a-f
CS 858	Cellobunch	23.5 d	9.1 a-f	0.1 ab
CS 810	(6253A x 6333B) x Exp 2575B	26.0 de	10.5 a-g	4.5 a-f
CS 811	(2144 x 6253) x 2575	28.0 def	11.9 a-g	7.5 a-h
CS 863	Triton	29.0 d-g	10.5 a-g	1.0 abc
CS 825	(1138A x L3303B) x 5367B	32.0 d-h	11.1 a-g	5.5 a-f
CS 862	Uppercut	32.0 d-h	13.6 c-i	0.5 ab
CS 864	Honey Snax	32.5 d-h	12.4 b-h	2.5 a-d
CS 826	5367B	35.1 d-h	15.4 d-k	4.7 a-f
CS 839	S.C. x 8524B	36.0 d-i	14.1 c-j	1.0 abc
CS 812	L2575A	37.2 d-j	14.1 c-j	24.3 j
CS 832	6526MjRA	42.0 e-k	19.5 e-n	8.8 c-h
CS 861	Maverick	42.5 e-l	16.4 d-l	3.0 a-d
CS 846	Nb6526B	46.0 f-m	20.4 f-n	8.5 b-h
CS 809	L2575B	46.5 g-m	18.0 d-m	12.5 f-i
CS 855	L1408B	46.6 g-m	20.5 f-n	7.7 a-h
CS 834	Mb4001A x Mb6526B	47.8 h-m	21.0 f-n	3.5 a-d
CS 808	S.C. x 2327B <sup>3</sup>	53.5 i-n	20.6 f-n	5.5 a-f
CS 814	97241 x 2144) x 4001 <sup>2</sup>	53.5 i-n	25.3 i-q	4.0 a-e
CS 806	S.C. x 2327 B <sup>3</sup>	54.0 i-o	25.5 i-r	5.0 a-f
CS 857	F3513	55.0 j-p	24.3 h-p	4.0 a-e
CS 819	5238B	56.7 k-q	26.0 i-r	1.5 abc
CS 847	Nb6526B	58.5 k-r	27.3 k-s	2.8 a-d
CS 865	Envy	60.3 l-s	21.9 g-o	0.5 ab
CS 856	L1408A	60.5 l-s	26.0 j-r	7.9 a-h
CS 817	Nb4001B	63.6 m-t	29.7 m-u	3.0 a-d
CS 842	Nb8524A	63.7 m-t	24.9 i-q	3.6 a-d
CS 803	dOr. S.C. x 1131B	66.0 n-u	28.2 l-t	0.0 a
CS 818	Nb4002B	66.1 n-u	34.6 p-w	3.5 a-d
CS 844	B4367B	67.8 n-v	40.3 t-y	3.0 a-d
CS 829	(6366 x 22260 x 5494 <sup>2</sup>	68.4 n-v	28.0 l-t	4.5 a-f
CS 848	Nb8524B	69.1 n-v	38.5 s-x	1.5 abc
CS 849	L0567B	70.1 n-v	33.6 o-v	11.9 e-i
CS 831	6526MjRB	71.3 n-w	34.7 p-w	17.2 ij
CS 822	5238A	71.8 o-w	37.4 r-x	3.5 a-d
CS 860	Atomic Red	72.6 p-w	43.8v-z	5.4 a-f
CS 823	5238A	72.8 p-w	41.4 u-y	2.7 a-d
CS 850	L0567A	75.1 q-x	38.6 s-x	15.4 hi

CS 828	5494B	75.3 q-x	30.3 n-u	9.6 d-i
CS 821	9304A x 5238B	75.4 q-x	39.1 s-y	14.5 ghi
CS 840	8524B	75.5 q-x	40.8 t-y	1.9 a-d
CS 830	(6366 x 2226) x 5494 <sup>3</sup>	75.8 r-x	26.7 k-s	4.5 a-e
CS 854	L1398A	76.0 r-x	38.8 s-x	4.6 a-f
CS 841	Nb8524B	76.0 r-x	35.7 p-w	4.3 a-e
CS 807	2327 B	78.2 s-x	36.9 q-x	3.1 a-d
CS 843	Nb8524B	79.3 t-x	41.7 u-y	7.9 a-h
CS 805	2327 B	79.7 t-x	42.8 v-z	8.2 b-h
CS 816	4001A x 4002B <sup>2</sup>	81.4 t-x	48.3 xyz	5.1 a-f
CS 853	L1398B	82.5 u-x	51.7 yz	7.1 a-g
CS 838	8524B	85.2 vwx	46.0 w-z	3.5 a-d
CS 845	Nb4001B	89.0 wx	46.4 w-z	2.1 a-d
CS 804	D1131B	89.0 wx	48.6 xyz	3.1 a-d
CS 815	4002B	91.2 x	54.9 z	7.9 a-h

<sup>1</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>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 2.** Leaf blight and bolting ratings (2 October) for carrot breeding lines from the University of Wisconsin, grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018

Field name	Pedigree	Leaf Blight Rating <sup>1</sup>	Bolting Rating <sup>2</sup>
CS 837	5280A x 8524B	0.75 a	0.0 a
CS 854	L1398A	1.0 ab	0.0 a
CS 853	L1398B	1.0 ab	0.0 a
CS 845	Nb4001B	1.0 ab	1.0 cde
CS 844	B4367B	1.0 ab	0.0 a
CS 849	L0567B	1.0 ab	0.0 a
CS 856	L1408A	1.0 ab	0.0 a
CS 850	L0567B	1.0 ab	0.0 a
CS 840	8524B	1.0 ab	1.3
CS 864	Honey Snax	1.0 ab	0.0 a
CS 851	B1111B	1.0 ab	1.0cde
CS 838	8524B	1.0 ab	1.8 fgh
CS 834	Nb4001A x Nb6526B	1.0 ab	1.3def
CS 836	3080A x 8524B	1.0 ab	0.0a
CS 801	D1131B	1.0 ab	0.8bcd
CS 830	(6366 x 2226) x 5494 <sup>3</sup>	1.0 ab	
CS 820	5238A	1.0 ab	0.3 ab
CS 814	(7241 x 2144) x 4001 <sup>2</sup>	1.0 ab	0.3 ab
CS 810	(6253A x 6333B) EXP 2575B	1.0 ab	0.0 a
CS 807	2327B (Gen. X <sub>3</sub> M <sub>5</sub> )	1.0 ab	0.0 a
CS 805	2327B (Gen XM <sub>5</sub> )	1.0 ab	0.0 a
CS 823	5238A (Gen. BC <sub>3</sub> )	1.0 ab	1.3 def
CS 817	Nb4001B	1.0 ab	0.5 abc
CS 812	L2575A	1.0 ab	0.3 ab
CS 806	S.C. x 2327B <sup>3</sup>	1.0 ab	0.3 ab

CS 816	4001A x 4002B <sup>2</sup>	1.0 ab	0.5 abc
CS 813	4001B	1.0 ab	0.8 bcd
CS 815	4002B	1.0 ab	0.8 bcd
CS 832	6526MjRA	1.1 abc	1.5 efg
CS 859	Purple Haze	1.3 a-d	2.8 ij
CS 862	Upper Cut	1.3 a-d	0.0 a
CS 861	Maverick	1.3 a-d	0.0 a
CS 855	L1408B	1.3 a-d	0.3 ab
Triton	--	1.3 a-d	0.0 a
CS 833	6526MjRB	1.3 a-d	1.5 efg
CS 841	Nb8524B	1.3 a-d	2.0 gh
CS 811	(2144 x 6253) x 2575	1.3 a-d	0.0 a
CS 828	5494B (F <sub>3</sub> M <sub>3</sub> )	1.3 a-d	0.0 a
CS 827	5494B (F <sub>3</sub> M <sub>2</sub> )	1.3 a-d	0.0 a
CS 809	L2575B	1.3 a-d	0.0 a
CS 821	9304A x 5238B	1.3 a-d	0.0 a
CS 808	S.C. x 2327B <sup>3</sup>	1.3 a-d	0.0 a
CS 822	5238A	1.3 a-d	2.0 gh
CS 818	Nb4002B	1.3 a-d	0.3 ab
CS 824	5367B	1.3 a-d	0.0 a
CS 846	Nb6526B	1.4 bcd	2.8 ij
CS 857	F3513	1.5 bcd	0.5 abc
CS 847	Nb6526B	1.5 bcd	3.0 j
CS 843	Nb8524B	1.5 bcd	1.3 def
CS 803	dOR. S.C. x 1131B	1.5 bcd	0.0 a
CS 848	Nb8524B	1.5 bcd	1.0 cde
CS 839	S.C. x 8524B	1.5 bcd	0.8 bcd
CS 835	8524B	1.5 bcd	0.3 ab
CS 831	6526MjRB	1.5 bcd	0.8 bcd
Envy	--	1.5 bcd	0.3 ab
CS 819	5238B	1.6 cd	2.6 ij
CS 804	D1131B	1.8 de	0.3 ab
CS 829	(6366 x 2226) x 5494 <sup>2</sup>	1.8 de	0.0 a
CS 826	5367B	1.8 de	0.0 a
CS 802	D1131A	1.8 de	0.3 ab
CS 842	Nb8524A	2.3 ef	2.3 hi
CS 852	B1111A	2.3 ef	1.5 efg
Cellobunch	--	2.5 f	0.0 a
CS 825	(1138A x L3303B) x 5367B	2.5 f	0.0 a
Atomic Red	--	2.8 f	0.5 abc

<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> Bolting was rated on a comparatively 0-3 scale where: 0 = no seeders, 1 < 5%, 2 = 5 – 49%, 3 > 50 %

<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.

**Funding was provided by the California Fresh Carrot Advisory Board.**