

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, 2015

MATERIALS: USDA experimental carrot breeding lines, commercial cultivars Cellobunch and Envy (Seminis Vegetable Seeds), Atomic Red (Johnny's Select Seeds) and Purple Haze.

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 75 seeds/m) onto raised beds using a push cone seeder 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, 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), plant stand, (3-1 scale where 3 = excellent stand, 2 = poor stand, 1 = very poor stand) and bolting (0-4 scale where 0 = no seeders, to 4 = almost all plants bolted). On 23, 26 and 27 October 50 carrots in 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 length). 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 2015 were above average for September (18.9°C), below average for June (17.7°C), and average for July (20.5°C), August (19.5°C) and October (9.3°C). The 10 year average temperatures were: June 18.9°C, July 20.9°C, August 19.6°C, September 15.5°C and October 9.5°C. Monthly rainfall was below the 10 year average for July (36 mm), September (27 mm) and October (54 mm), above average for June (171 mm), and average for August (79 mm). The 10 year rainfall averages were: June 75 mm, July 94 mm, August 69 mm, September 85 mm and October 72 mm. All data were analyzed using the General Analysis of Variance function of Statistics V.10. Means separation was obtained using Tukey's HSD test with $P = 0.05$ level of significance.

RESULTS: as presented in Tables 1 & 2.

CONCLUSIONS: Cavity spot was not as severe in 2015 as in previous years. However, a wide range of susceptibility to cavity spot was identified, including several orange carrots with promising levels of resistance. Two orange carrot lines were included in 2014 and 2015. Both had low cavity spot incidence and severity and responded in a similar manner in both years. Line 1137B had 7.8% cavity spot in both years, with DSI of 6.5 in 2014 and 3.5 in 2015. Line 5367 B had 13.8 and 21.2 % cavity spot in 2014 and 2015, respectively, with a DSI of 7.8 and 7.1.

There was also a wide range in susceptibility to carrot leaf blights. Bolting ranged for zero to almost all plants bolted.

Table 1. Stand, blight severity and bolting ratings made on 30 September, for carrot breeding lines from University of Wisconsin grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2015.

Name	Leaf Blight Severity Rating ¹	Stand Rating ²	Bolting Rating ³
6416	0.7 a ⁴	3.0 a	0.0 a
5127	0.7 a	3.0 a	0.0 a
6456	1.0 ab	2.7 ab	2.3 def
6182	1.0 ab	3.0 a	0.0 a
6171	1.0 ab	3.0 a	0.0 a
6158	1.0 ab	3.0 a	0.7 abc
Envy	1.3 abc	3.0 a	0.0 a
6497	1.3 abc	2.7 ab	0.0 a
6183	1.3 abc	2.7 ab	1.0 a-d
6170	1.3 abc	2.7 ab	1.7 b-f
5197	1.3 abc	3.0 a	0.0 a
5123	1.3 abc	2.3 abc	0.3 ab
Purple Haze	1.7 a-d	3.0 a	1.0 a-d
Nb6526	1.7 a-d	2.8 ab	4.0 g
6149	1.7 a-d	2.5 abc	2.7 efg
5740	1.7 a-d	3.0 a	0.0 a
5675	1.7 a-d	3.0 a	1.0 a-d
5162	1.7 a-d	2.8 ab	0.3 ab
6415	2.0 b-e	2.2 abcd	0.0 a
5164	2.0 b-e	3.0 a	0.7 abc
5436	2.0 b-e	2.3 abc	0.0 a
5203	2.0 b-e	2.0 bcd	1.0 a-d
5125	2.0 b-e	3.0 a	0.0 a
6306	2.3 c-f	2.3 abc	0.0 a
5745	2.3 c-f	2.8 ab	0.3 ab
5158	2.3 c-f	2.7 ab	0.0 a
6411	2.3 c-f	1.0 e	0.3 ab
5182	2.3 c-f	2.7 ab	2.0 c-f
Cellobunch	2.7 d-g	3.0 a	0.7 abc
665-1 Purple Susc.	2.7 d-g	2.0 bcd	0.3 ab
6085	2.7 d-g	3.0 a	0.3 ab
5790	2.7 d-g	1.7 cde	1.3 a-e
5696	2.7 d-g	1.3 de	1.0 a-d
6473	3.0 e-h	2.3 abc	1.3 a-e
6314	3.0 e-h	3.0 a	4.0 g
5629	3.0 e-h	3.0 a	0.7 abc
5142	3.0 e-h	2.7 ab	4.0 g
5322	3.0 e-h	2.5 abc	0.3 ab
5166	3.0 e-h	3.0 a	0.0 a
5141	3.0 e-h	2.7 ab	0.0 a

1137B	3.0	e-h	1.7 cde	0.0 a
6361	3.3	f-i	2.0 bcd	4.0 g
6262	3.3	f-i	2.5 abc	1.0 a-d
5432	3.3	f-i	2.7 ab	0.0 a
6410	3.3	f-i	2.5 abc	0.0 a
6320	3.7	g-j	2.0 bcd	1.3 a-e
Atomic Red	3.7	g-j	2.3 abc	0.7 abc
6285	3.7	g-j	1.3 de	1.3 a-e
5752	3.7	g-j	2.3 abc	2.7 efg
5280	3.7	g-j	2.3 abc	0.0 a
6360	4.0	h-k	2.3 abc	4.0 g
5265	4.0	h-k	2.7 ab	4.0 g
5367B	4.2	h-k	2.2 abcd	0.0 a
5763	4.3	ijk	2.7 ab	0.0 a
5748	4.3	ijk	2.7 ab	3.0 fg
6282	4.7	jk	2.0 bcd	0.3 ab
5293	4.7	jk	1.3 de	0.3 ab
5196	4.7	jk	2.2 abcd	0.0 a
Ns5154	4.8	jk	2.5 abc	0.3 ab
6281	5.0	k	2.0 bcd	0.0 a

¹ 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

² Plant Stand was rated comparatively on a 3-1 scale where 3 = excellent stand, 2 = poor stand, 1 = very poor stand

³ Bolting was rated on a comparative 0-4 scale where 0 = no seeders, 1 = few seeders, 2 = more seeders, 3 = many seeders, 4 = almost all plants bolted

⁴ Numbers in a column followed by the same letter are not significantly different at $P=0.05$, Tukey's HSD test.

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 2015.

Number	Disease Incidence (%)		DSI ¹	
	24 Aug	10 Nov	24 Aug	10 Nov
5629 – purple	6.7 a-d ²	2.0 a	4.1 a-d	2.9 ab
5322 – purple	5.3 ab	3.1 ab	3.5 abc	2.7 a
6282	--- ³	4.2 abc	---	3.1 ab
Nb6526	---	5.2 a-d	---	4.9 a-e
6361	14.7 b-h	5.4 a-e	8.0 b-f	9.1 a-k
Purple Haze	19.5 f-i	7.0 a-f	10.6 d-g	4.9 a-d
6314	16.8 c-i	8.5 a-g	9.5 b-g	6.4 a-g
6281	6.7 a-d	8.8 a-h	2.9 ab	4.7 abc
6320	2.8 a	9.0 a-i	1.1 a	5.6 a-f
1137b	---	9.8 a-j	---	6.5 a-g
5293	---	10.4 a-k	---	7.3 a-h
5280	---	10.5 a-k	---	5.3 a-f
5142	---	10.7 a-l	---	11.5 c-n
5436	---	11.0 a-l	---	8.0 a-j
5432	---	12.9 a-m	---	8.4 a-j
5748	5.7 abc	13.0 a-n	4.1 a-d	7.0 a-h
5123	---	13.7 a-o	---	7.9 a-i
5367b	---	13.8 a-o	---	7.8 a-i
5196	---	14.0 a-o	---	8.1 a-j
5745	8.1 a-e	16.3 a-p	4.3 a-d	8.6 a-j
Cellobunch	15.9 b-i	19.1 a-p	9.8 c-g	10.3 a-l
Envy	9.1 a-f	19.8 b-q	4.5 a-d	10.3 a-l
Ns5154	---	20.1 b-q	2.9 ab	10.6 a-l
5203	---	21.3 c-r	---	12.8 c-n
5125	14.6 b-h	22.1 d-s	5.8 a-e	11.0 b-m
5197	---	22.7 e-s	---	12.8 c-n
5127	---	23.1 f-s	---	12.0 c-n
6497	---	24.4 g-s	---	13.0 d-n
665-1 Purple Susc.	---	25.2 g-s	---	13.2 f-n
5790	---	25.6 g-s	---	13.1 e-n
5166	---	25.8 g-s	---	12.4 c-n
5740	10.7 a-g	26.1 h-s	6.9 a-f	13.9 g-o
5752	---	26.3 i-s	---	14.3 g-p

Number	Disease Incidence (%)		DSI	
	24 Aug	10 Nov	24 Aug	10 Nov
6262	10.5 a-g	26.8 j-t	5.2 a-e	12.7 c-n
5182	---	27.6 k-t	---	13.3 f-n
5675	---	27.9 l-u	---	12.8 c-n
5141	21.3 ghi	28.5 m-u	11.7 efg	14.2 g-p
6415	---	29.0 m-u	---	14.7 h-q
6285	---	29.2 m-v	---	15.1 h-q
6149	12.8 a-h	29.3 m-v	6.6 a-f	15.2 h-q
5158	---	29.8 m-v	---	15.1 h-q
6158	15.8 b-i	29.8 m-v	8.4 b-g	15.9 i-q
Atomic Red	23.1 hi	30.1 n-v	13.3 fg	17.1 k-s
6473	---	30.4 o-v	---	13.4 f-n
6183	14.7 b-h	30.5 o-v	7.3 a-f	15.5 i-q
6416	18.7 e-i	30.5 o-v	11.7 efg	15.7 i-q
6170	---	30.7 o-v	---	16.1 j-r
6306	---	31.8 p-w	---	18.1 l-t
5696	---	32.5 p-x	---	18.2 l-t
6182	14.5 b-h	36.7 q-x	8.5 b-g	19.6 n-t
5763	26.7 i	37.8 r-x	14.9 g	18.2 l-t
6456	---	38.7 s-x	---	18.8 m-t
6411	---	38.9 s-x	---	24.4 st
6085	---	43.8 t-x	---	22.8 q-t
6171	16.9 d-i	44.9 u-x	8.1 b-f	22.3 p-t
5164	9.4 a-f	46.5 vw-x	4.3 a-d	22.0 o-t
6410	---	48.7 w-x	---	24.2 r-t
5162	---	49.5 x	---	26.2 t
5265	---	---	---	---
6360	---	---	---	---

¹ Disease Severity Index (DSI) was determined using the following equation:

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

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

³ --- indicates plant stand was insufficient for sampling

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