# Does resistance to cavity spot in carrot confer resistance to forking?


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## INTRODUCTION

Cavity spot of carrot (Fig. 1) is caused by several Pythium species, especially *Pythium violae* and *P. sulcatum.* Pythium root dieback (PRD) of carrot is also caused by *Pythium* species, mostly *P. ultimum*, *P. irregulare* and *P. sulcatum.* PRD often results in forked roots, which are not marketable but other factors can cause forking of carrot roots. Screening of USDA carrot breeding material for resistance to cavity spot is continuing and assessment of forking has been included. It is useful to select lines with resistance to cavity spot that are also less susceptible to other carrot pathogens.

### Objective

To determine if resistance to cavity spot also confers resistance to forking caused by Pythium root dieback, over time and on different soil types.

## MATERIALS AND METHODS

- Two sites: 1. Muck soil (pH 5.7-6.5, organic matter 60-78%) from 2018 - 2021 in the Holland Marsh, Ontario, Canada (44º5'N, 79º35' W) where the pathogens occur naturally. Seeded in June and harvested in October.
- 2. Mineral soil (4.5% organic matter) in Washington State that was inoculated annually with *P. sulcatum* and *P. violae* since 2018. Direct seeded in May and harvested in October.
- Carrot lines (~ 60) from the USDA Univ. of Wisconsin carrot breeding program were assessed, also cv.'s Cellobunch, Envy, Triton, Propeel, Maverick, Istanbul, Nairobi, susceptible red and a resistant purple carrot.
- Plots were arranged as a RCBD with 4 replicates per line. Means comparison with Protected LSD, with $P \leq 0.05$. Linear regression was performed to compare DSI and percent forking.
- Leaf blight severity was assessed in late September using a 0-5 scale, where 0 was no disease and 5 was leaves completely dead.
- After harvest carrots were washed and percent forking and cavity spot severity was recorded.
- Carrots were assigned to classes based on the length of the largest cavity spot lesion. Classes were: (0 – no cavity spot, 1= 1 mm, 2= 1-2 mm, 3= 2- 5 mm, 4= 5-10 mm, 5= >10 mm). A disease severity index (DSI) was calculated.

## RESULTS

- In Ontario, cavity spot ranged from 0 - 70% and forked roots from 0 - 44%(Fig.'s 5 A, B).
- The $r^2$ for cavity spot and forking was 0.08 (P=0.01) in 2019 (data not shown) and 0.02 and 0.22 in 2020 and 2021.
- In Washington State cavity spot severity ranged from 0-59% and forked roots from 0 – 59% (Fig. 5C) and there was no relationship between cavity spot and forking ($r^2$ = -0.02).
- Some lines for each site year had low cavity spot and low forking.


Fig. 1. Cavity spot on carrot a)Ontario and b)Califor

Fig. 2. Carrot forking

Fig. 3. *Cercospora* lesions on carrot leaflets

Fig. 4. *Alternaria* lesions on carrot leaflets

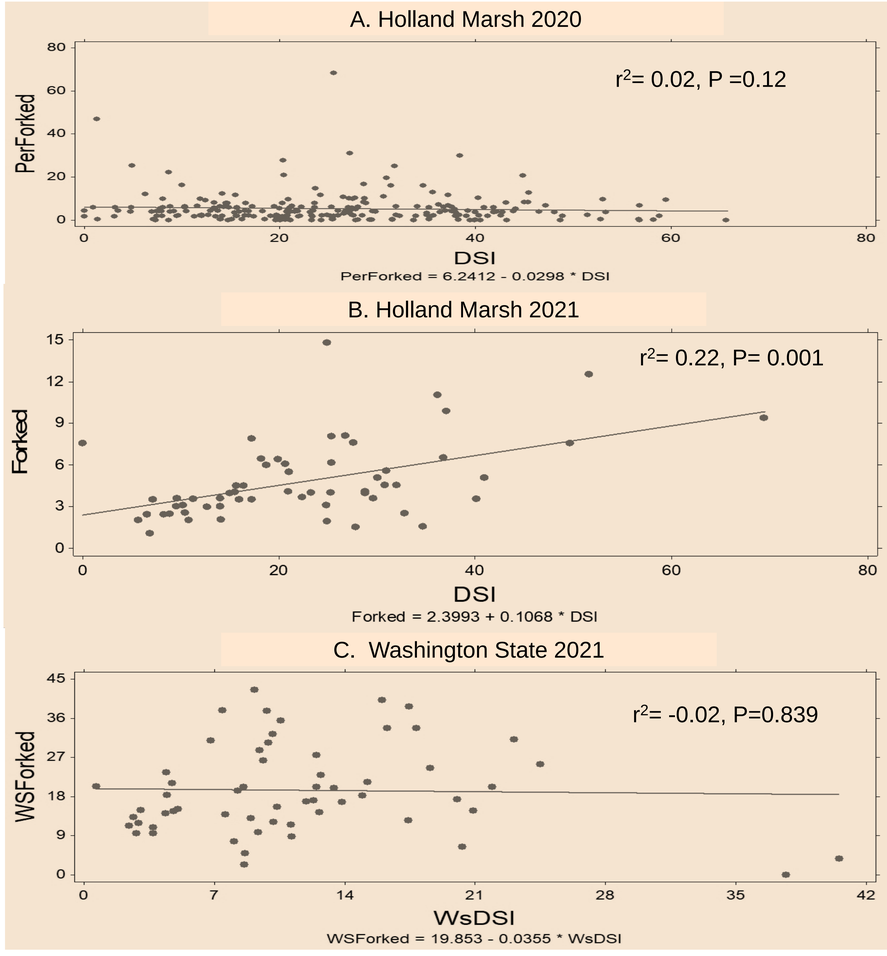


Fig. 5. Relationship between cavity spot and carrot forking in the Holland Marsh in 2020 (A) and 2021 (B) and in Washington State (C)
DSI and WSDSI= cavity spot disease severity index

Table 1. Disease ratings and forking on carrot lines – 2020

| Line | Cavity spot (%) | Severity (0-100) | Forking (%) | Leaf blight (0-5) |
|---|---|---|---|---|
| Purple Haze | 4.5 a* | 1 a | 4 | 0.9 |
| Nbh2306A | 24 ab | 9 ab | 4 | 1.0 |
| Nbh2306B | 37 a-e | 13 a-d | 9 | 1.0 |
| CS025 | 31 | 13 | 5 | 1.8 |
| F5367B | 31 | 13 | 4 | 2.0 |
| CS015 | 90 g | 51 j | 1.5 | 3.0 |

*Values in a column followed by the same letter are not significantly different, P < 0.05, Fisher's Protected LSD test

Table 2. Disease ratings and bolting on carrot lines - 2021

| Line | Cavity spot (%) | Severity (0-100) | Forking (%) | Leaf blight (0-5) |
|---|---|---|---|---|
| Deep Purple | 0 a* | 0 a | 8 | 3.0 |
| F7738B | 15 ab | 6 ab | 2 | 4.0 |
| F7738B 3 way x | 21 abc | 7 ab | 1 | 2.8 |
| F7738B 3 way x | 22 abc | 7 abc | 4 | 2.1 |
| Nbh2306B | 33 b-g | 10 a-f | 3 | 1.6 |
| Atomic Red | 90 g | 70 u | 9 | 2.4 |

*Values in a column followed by the same letter are not significantly different, P < 0.05, Fisher's Protected LSD test

The resistant purple carrots were highly resistant to cavity spot. There were orange lines with low cavity spot and forking. 'Nbh' lines are also resistant to southern root knot nematode and some also have relatively low leaf blight (Tables 1 and 2).

## CONCLUSIONS

- Cavity spot and forking occurred at both sites at relatively high rates on susceptible lines.
- The relationship between cavity spot and forking was low (but significant in 2 of 3 years) in Ontario and low in Washington State.
- Some lines had low cavity spot and low forking, suggesting that it will be possible to breed for resistance to multiple pathogens.


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