Pythium in carrots

Cavity spot and forking in carrots

What causes cavity spot and forking in carrots?

Two *Pythium* species are mostly responsible for forking and cavity spot of carrots in Australia. In most cases, *P. sulcatum* cause the symptoms. In an earlier survey, *P. violae*, has only been identified in South Australia. Further studies are in progress to investigate the spread of *P. violae*.

P. sulcatum, the main pathogen causing cavity spot of carrots in Australia, (Davison and MacKay 2000), mostly affects the carrot family of plants. It also causes severe root rot diseases of parsley and coriander. *P. violae* is the main cause of cavity spot of carrots in most other countries and has a much wider host range that includes plants from several plant families.

Apart from *P. sulcatum* and *P. violae*, other species of *Pythium* or *Rhizoctonia* pathogenic to carrots, nematodes or any other type of early damage to the root tip can cause forking.

***Pythium* spp. survives as resting spores between susceptible crops.**

The primary source of *Pythium* inoculum, causing cavity spot and forking of carrots, are dormant resting spores formed during colonisation of plant tissue. They can survive in the soil for several years.

Figure 1: Forking of carrots. Source: Len Tesoriero

Cavity spot caused by *P. sulcatum* is most severe in summer and autumn harvested crops. In wet soils this species also produces motile spores (zoospores) which are attracted to roots where they encyst and create infection. Although zoospores only survive for a day or so they can increase the population concentration of this pathogen by over 1000-fold, which greatly increases chances of finding roots to infect. This can lead to multiple infection sites on any one carrot.

P. violae does not produce motile spores; it produces spherical swellings which spread with irrigation water. Cavity spot caused by *Pythium violae* is most severe in winter harvested crops.

Factors affecting cavity spot development and management approaches

The main factors affecting cavity spot development are soil temperature, soil pH and soil moisture. Temperatures can be controlled to a degree via site selection and scheduling planting times. Other factors can be controlled by crop management approaches.

Temperatures - The prime growth temperatures for *P sulcatum* are: minimum 2 to 3°C, optimum 20 to 28°C, and maximum 36 to 37°C. The optimum temperature for saprophytic growth of *P. sulcatum* (25°C) is higher than that for *P. violae* (19°C).

Temperatures of 30°C and above are lethal for *P. violae*1[1]. This sensitivity to high temperatures may be a reason for the low number of *P. violae* detections in Australia. The relatively high optimum temperature for *P. sulcatum* may be one reason why it is not a predominant species causing carrot cavity spot in most Northern Hemisphere countries.

Soil moisture – high soil moisture leads to greater incidence and higher severity of *Pythium* infections.

1 Suffert F., M. Guibert. 2006. The ecology of a *Pythium* community in relation to the epidemiology of carrot cavity spot. Applied Soil Ecology 35 (2007) 488–501

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Previous work on a *Pythium* species showed that cyclic wetting and drying reduced the in field population in the absence of host plants[2]. Observations by growers confirm that high soil moisture levels support the development of cavity spot. However, the critical crop growth stages, the threshold soil moisture and the period required at that threshold to cause infection with *P. sulcatum* or *P. violae* are still unknown. Recommendations in recent published literature suggest minimising total water inputs at key production times (e.g. < 30 mm/wk for *P. violae* control under UK production conditions). UK research showed that using fungicides early in the season, with at least 15 mm of water applied simultaneously to activate fungal growth, achieved good disease control.

Varieties, genetic tolerance – some varieties are more susceptible than others. Variety selection can greatly help in minimising the occurrence of cavity spot. However, market demands and other production considerations have to be taken into account.

Chemical control – Metalaxyl-M can reduce the incidence and severity of cavity spot disease when applied at or shortly after seeding. However, if it is used too frequently it can lose its effectiveness because of an increase in its rate of breakdown in the soil[3]. Various researchers have demonstrated this effect caused by soil bacteria using the fungicide as a food source. There have been reports where the metalaxyl half-life in sandy soils has been reduced to as little as 1 day. Enhanced breakdown of metalaxyl appears to be a widespread problem; growers should not rely on it for cavity spot control. Overseas work demonstrated that some *Pythium* species have developed resistance to metalaxyl. Metalaxyl leaches from sandy soils.

Metham sodium has failed to control cavity spot[4] in trials in WA. Enhanced breakdown with repeated use has been implicated. Still, Metham sodium is used commercially for carrot production to manage the disease.

Soil pH - In WA, it has been shown that liming soil to increase pH reduces the incidence and severity of cavity spot[5]. The recommended pH range is pH 6.5-7.5 with a target pH of 7.2 or higher (measured in calcium chloride)[6]. The positive effect of lime (calcium carbonate) may be due to inducing a soil microflora that is inhibitory to filamentous fungi like *Pythium*. However, this is not confirmed. The application of lime may also be beneficial in the longer term via positive effects on soil structure and thus aeration as well as increased calcium availability to the crop.

Figure 2: Severe cavity spot on carrots. Source: Len Tesoriero

Nutrition – UK research found that increasing the level of exchangeable calcium above 8 meq/100 g soil decreased the incidence of cavity spot[7]. High inputs of available calcium pre-planting (e.g. 15 t/ha of a product called Limex) also decreased cavity spot incidence. In both cases, *P. violae* was the target organism. There does not appear to be any consistent relationship between cavity spot disease severity and other plant nutrients, although Canadian research experience suggests that moderate mineral fertiliser use overall, compared to their industry standard, reduced this disease.

Calcium (Ca) is known to suppress diseases by the following mechanisms: it is involved with recognition and early defence by the plant when the pathogen contacts the cell membrane; it binds to pectate in the cell walls making them resistant to enzymes secreted by the pathogen to attack the cell wall; Ca also inhibits the pathogen from secreting plant cell degrading enzymes called polygalacturonase; and it inhibits sporangial germination in *Pythium* species.

Rotation – Views on the positive effect of rotation differ in the international literature. Rotation with broccoli has shown promising results in WA where the primary pathogen was *P. sulcatum*. Other research on this pathogen suggests that rotation with lettuce or onions

2 Stanghellini ME, Burr TJ (1973) Effect of soil water potential on disease incidence and zoospore germination of *Pythium* aphanidermatum. Phytopathology 63, 1496–1498.
3 Davison, E.M. and McKay, A.G. (1999). Reduced persistence of metalaxyl in soil associated with its failure to control cavity spot of carrots. Plant Pathology 48, 830-835.
4 Davison E.M. and McKay A.G. 2000. Cavity spot in Australia. Agriculture Western Australia. Proceedings of the Carrot conference Australia, Perth 2000.
5 Galati, A. and McKay, A.G. (1996). Carrot yield decline. Final Report HRDC Project VG036.
6 Davison, E.M. and McKay, A.G. (1999). Cavity spot disease of carrots. Farmnote 29/99, Agriculture Western Australia.

7 Scaife et al. 1983. Cavity spot of carrots—observance on a commercial crop. Ann. Appl. Biol. 102: 567–575.

may also be beneficial. However, *P. violae* can attack broccoli[8] and using this as a rotational crop may exacerbate cavity spot if *P. violae* is present. In this case, rotation with onions, corn, potatoes or beans may be more beneficial.

Cover crops / biofumigation – Reports on the benefits of cover crops and biofumigants vary. In some instances, good control or reduction of disease incidence were achieved, especially with mustards. In other trials and field experiments by growers, cavity spot incidence or severity were not altered or the disease was worse. It appears that biofumigation or cover crops may not reduce inoculum levels, even in cases where disease expression is reduced. The conclusion is that the effect of cover crops on *P. sulcatum* and *P. violae* is currently not understood well enough to make general or regional recommendations.

Other - Crop hygiene, selection of planting date and crop density, tillage approaches that ensure good soil structure and drainage, crop residue management to foster their breakdown, and timely harvest are some cultural practices that reduce the impact of root diseases.

Some integrated crop protection (ICP) strategies that may help reduce the likelihood of infection in combination with other management practices listed above include: application of the products formulated with the beneficial bacterium, *Bacillus subtilis* or other biopesticides[9], Calcium Cyanamide or the use of silicon (which provokes plant defences). To date, reports on the efficacy of integrated approaches vary.

Conclusions

While some general rules apply, especially the need for managing soil moisture, pH, soil calcium and crop maturity; carrot producers should find their own optimum combination of additional management strategies that fit their production systems and growing conditions.

8 Schrandt, J.K., Davis, R.M. and Nuñez, J.J.(1994). Host range and influence of nutrition, temperature and pH on growth of *Pythium violae* from carrot. Plant Disease 78, 335-338.

9 Seaman, Abby, Editor. (2015) Production Guide for Organic Carrots for Processing. Publisher: New York State Integrated Pest Management Program, Cornell University (New York State Agricultural Experiment Station, Geneva, NY).

Figure 3: Moderate cavity spot
Source: Dr Michael Rettke, PIRSA_SARDI

Disease prediction

A substantial research effort has been made to predict *Pythium* inoculum levels and disease risks in vegetable crops, including carrots. So far, most research had a focus on identifying threshold levels of inoculum rather than identifying conditions (e.g. temperature, soil moisture, soil nutrient levels, levels of other diseases or pests) that cause infections to occur in different commercial production systems.

Researchers from the South Australian Research and Development Institute (SARDI) are currently developing soil DNA tests for detecting soil populations of *P. sulcatum* and *P. violae*. Once these have been developed and tested, the next step is to understand the relationship between cultural practices, environmental factors and soil inoculum levels.

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