Factsheet 03/03

Carrots

Project No. FV 5a–f

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Carrot cavity spot

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Cavity spot of carrot, caused by slow-growing *Pythium* species, is currently the most economically important disease problem in UK carrot crops. Affected carrots, with only one or two visible lesions, are rejected at grading. When disease incidence in the field passes a relatively low threshold it becomes uneconomical to harvest crops. This means that virtually 100% control is necessary to avoid economic losses. In a severe cavity spot season, 15–20% or more of crops can be rejected by pack-houses. This amounts to an estimated loss of £10.2–13.6 million based on the 2000–2001 value of the crop (DEFRA Horticultural Statistics, 2001).

Although good control of the disease was achieved in the early 1980s with metalaxyl and related fungicides, there have recently been increasing problems in the management of cavity spot. This factsheet summarises recent HDC funded research and its application for management of the disease.

Symptoms of cavity spot

The appearance of cavities normally starts as small, pale, sunken elliptical spots, under an apparently intact outer skin. These lesions gradually darken in colour to a greyish brown and, depending on environmental conditions (see below), they may increase in size rapidly, or expand more slowly with the natural growth of the carrot root. Eventually, the outer skin ruptures, leaving an open cavity where the tissues underneath have been attacked by the fungus and secondary organisms. Primary cavity spot lesions are not normally greater than 10–15 mm in diameter and 2–3 mm deep; larger lesions are usually the result of secondary rotting.

Cavity spot is usually most prevalent in main crop carrots and tends to increase with the time the crop is in the ground over Autumn and Winter. Sudden increases in cavity spot are a feature of the disease and usually develop when crops are at least 12 weeks old.

Typical medium to large cavity spot lesions showing range of shades possible

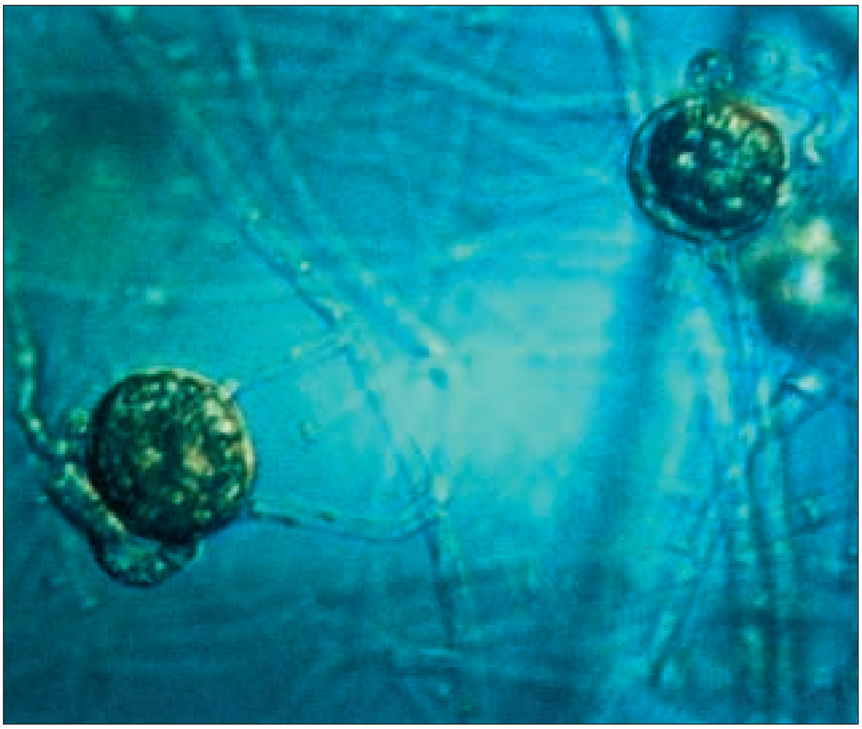
Occurrence and cause of cavity spot

Cavity spot is a common disease of carrots throughout UK carrot growing areas but severe attacks tend to occur sporadically. Two *Pythium* species are known to cause the disease in the UK: *P. sulcatum* and *P. violae*. Of these two, *P. violae* is by far the most prevalent species, causing at least 90% of disease outbreaks.

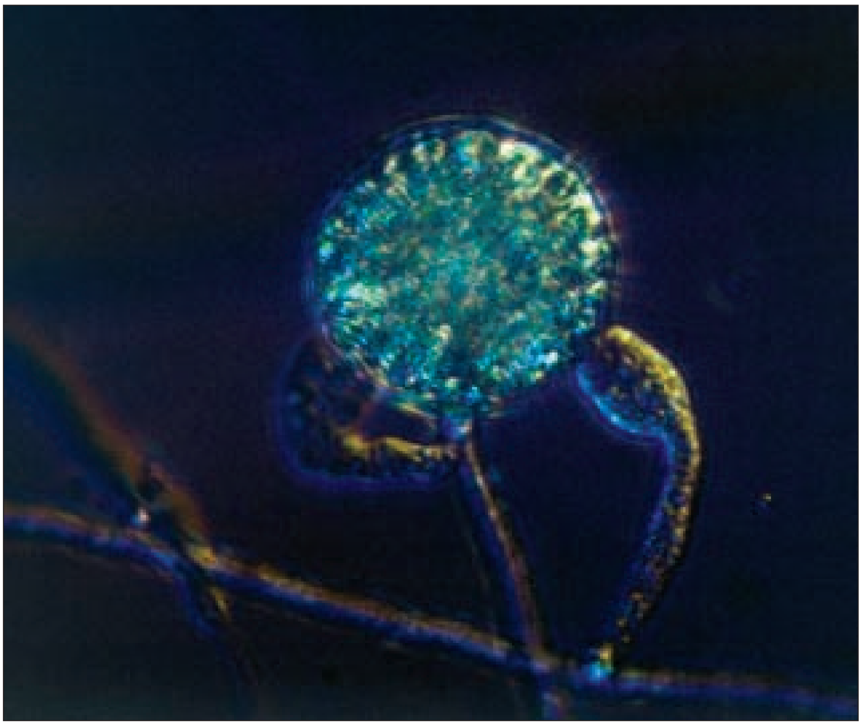
Biology of cavity spot

Infections of carrot taproots are thought to form rapidly following periods of prolonged rainfall. This may be a direct effect of the water and can be exacerbated by poor aeration, compaction or impeded drainage which encourage pathogen attack. Temperature appears to be less important, although the optimum temperature for cavity development is 15^{o}C. The pathogen grows directly through the outer cell layers. Penetrated cells and those around the point of infection die and collapse forming a cavity. The dying cells in a cavity produce phenolic chemicals that are toxic to the fungus and normally the effect of these is to contain individual infections to discreet lesions or spots.

P. violae and *P. sulcatum* can survive in soil, as resting mycelium or as resistant thick-walled oospores, for at least 3 years. These resting spores are comparatively sparse in infected soils when compared to other common *Pythium* species and this, combined with their slower growth rates makes these species very difficult to isolate from soil. An immunodiagnostic test for soils works very well but can only give reliable results on soil samples collected between October and February. The result of having no reliable techniques for measuring changes in soil inoculum *throughout the season* is that there is currently little clear information on the effects of environmental conditions on the disease cycle.



Resting spores (oospores) of *P. sulcatum*



Resting spores (oospores) of *P. violae*

Control Measures

Cultural control

Although cultural techniques such as improving soil aeration and drainage are currently available, they offer only partial control, and new options have been investigated in HDC work which will reduce disease pressure and thereby potentially improve fungicide efficacy.

Calcium

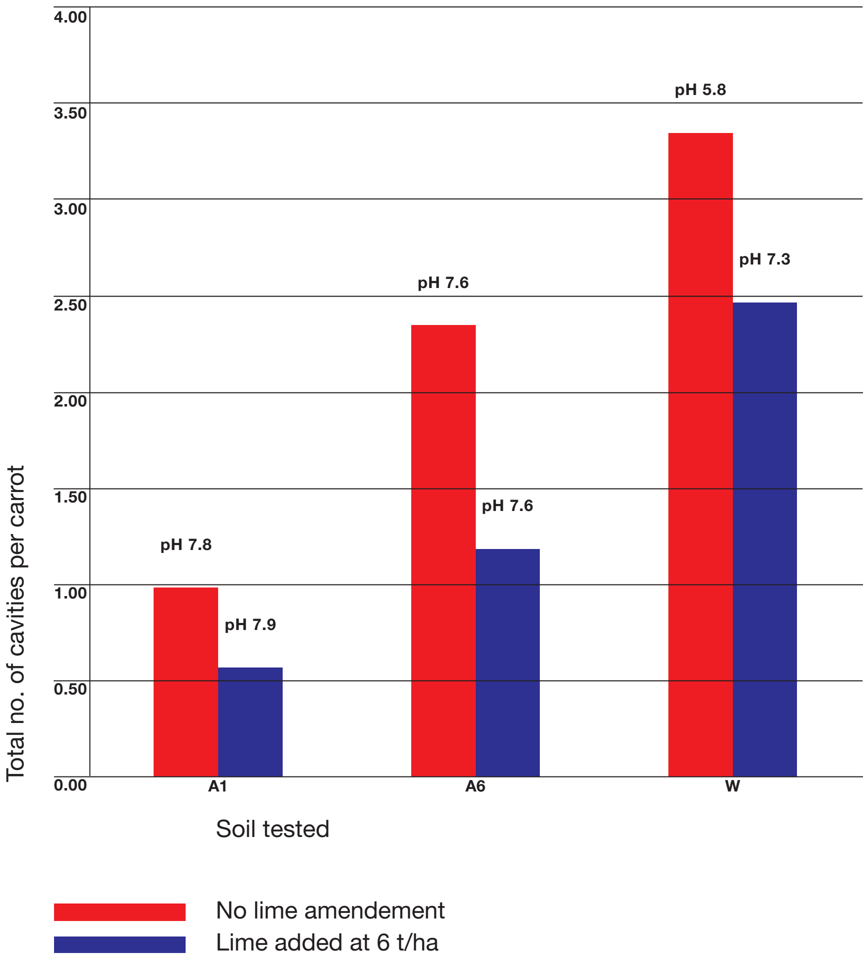
Additions of calcium to the soil reduce cavity spot. This effect is complex and is thought to operate in two ways.

- Altering the pH – cavity spot severity is at its maximum at pH 5 and minimum at pH 8.
- Increasing the 'exchangable' calcium in the soil, may cause changes in the soil micro-biota, making conditions unfavourable for the growth and development of *Pythium violae*.

Another possible mode of action not investigated in carrots is the direct effect of calcium on the crop's natural defense response.

The type of calcium compound added to soil is important. Compounds like lime (calcium carbonate) and calcium hydroxide will achieve the desired effects but *gypsum (calcium sulphate) will not,* and calcium nitrate will only have an effect on the total exchangeable calcium and will therefore not be quite as effective as lime (depending on the soil pH). Research has shown that a liming rate of 6 tonnes of product/ha can achieve a 25–50% reduction in disease severity (Graph 1) in a range of soils. However, it is best to obtain a lime response curve: (the pH response of the soil to lime dose) for individual soils before deciding a rate for such treatments – (this can be easily carried out by a soil testing laboratory). Ideally this should be supplemented with a measure of the increase in cation-exchangable calcium (this can also be obtained as part of a routine chemical soil analysis), which needs to be greater than 1 mg/g dry weight of soil.

Graph 1
Effect of liming at 6 t/ha on the severity of cavity spot in pot tests of a sandy East Anglian soil (A1), a peaty East Anglian soil (A6) and Wellesbourne soil (sandy loam) (w).



Crop Rotation

The direct benefits of crop rotations on cavity spot are unclear and often conflicting, though *P. violae* and *P. sulcatum* inoculum can survive for long periods in soil. One reason that *P. violae* is more common than *P. sulcatum* in UK crops may be that it has a wider host range – of the more commonly grown crops only onions appear not to support *P. violae* infections, whereas *P. sulcatum* has a narrow host range and does not seem able to colonise wheat. This may also explain why *P. violae* infections have occurred in carrot crops grown in fields where there has been *no previous carrot cultivation within living memory*.

Disease Resistance

All currently available commercial carrot varieties have some susceptibility to cavity spot. NIAB ratings of varietal resistance on a scale A = high to D = low do give a reasonable estimate of relative differences. It is a wise precaution to select a variety with a high resistance score when considering later crops or cropping on land with a previous history of cavity spot.

Disease avoidance

Using the immunodiagnostic soil test (October-February when the majority of soil inhabiting *Pythium* species are inactive) to give an indication of potential disease risks, cavity spot can be avoided either by selection of sites with low risk ratings or by the timing of harvesting on sites were there is a known risk of disease. The risk of disease expression increases with the time the crop is in the ground over Autumn and Winter so crops in higher risk fields can be lifted earlier than those in low risk fields.

Hygiene

There is a high risk of transferring this pathogen from badly affected sites to those with low or no disease, on transport and machinery. Good hygiene, including cleaning machinery, is desirable if spread to increasingly scarce clean sites is to be avoided. This is a costly and time-consuming operation, but it can be cut to a minimum by using soil test information to group high and low risk sites together in time-tabling cultivation and harvest operations. Do not dump waste carrots on land for carrot cropping.

Fungicide control

The following metalaxyl-M products are approved for use on carrots (December 2002):

Approved metalaxyl-M products for use on carrots

Active ingredient	Trade name	Approval type	Expiry	Label details
Metalaxyl-M	SL567A	Label	None stated	Maximum individual dose 1.3 l/ha Maximum total dose 1.3 l/ha per year Latest time of application 6 weeks after drilling
Cymoxanil + fludioxinil + metalaxyl-M	Wakil XL	SOLA 1191/02	Unstipulated	0.42 kg/100 kg seed Average grower drilling rate 4.4 kg/ha

NB **Whilst being part of an integrated disease control programme, Wakil XL alone will not control cavity spot.**

Use pesticides safely. Always read the label or the Specific Off-Label (SOLA) notice of approval. Check with suppliers for full details of any side effects on biological control agents. Mention of a product does not constitute endorsement, nor does failure to mention products imply criticism. Regular changes occur in the status of pesticides arising from changes in the pesticide legislation or for other reasons. For the most up to date information, please check with a professional supplier or with the Information Officer at the Pesticide Safety Directorate (PSD), tel: 01904 640500; or on their website listing revocations (www.pesticides.gov.uk).

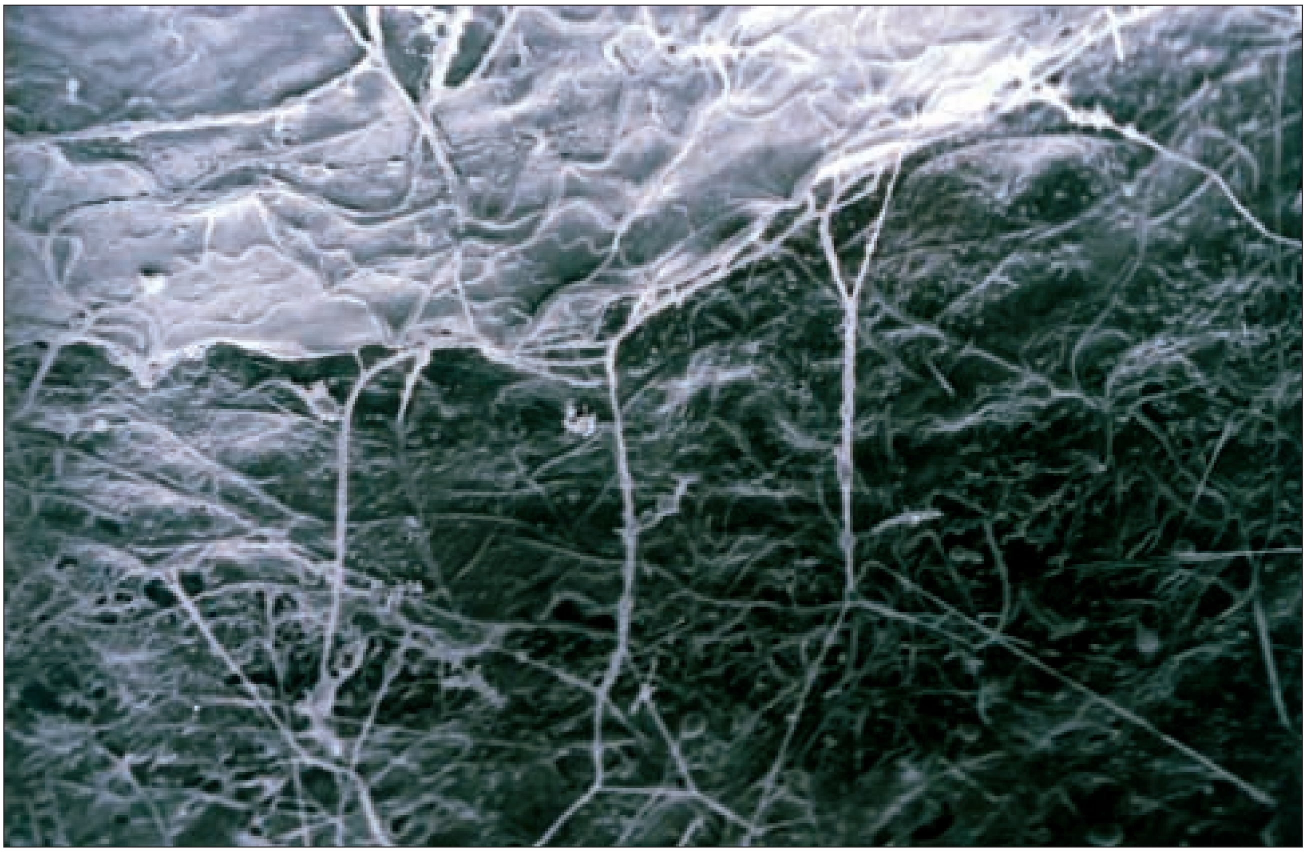
Recent fungicide trials have been disappointing with no new fungicides performing as well as metalaxyl-M. Metalaxyl-M is a refined preparation of the old metalaxyl; sold as SL567A, it is still the *only effective fungicide* available in the armoury against the disease. In HDC fungicide trials SL567A gave the best control and this was *significantly improved when SL567A was used in combination with lime ($CaCO_3$ @ 6 t/ha) treatments*. However, control generally declined after strawing down possibly due to further infection cycles resulting from the recent mild Autumns and Winters allowing greater pathogen activity.

Timing of SL567A applications

It is essential to apply SL567A by 6 weeks after drilling. Recent trial results indicate that the best time is when the crop is at the 1st true leaf stage and this has given significantly better results than pre-emergence timing in some experiments. Split dose applications appear to be of limited value.

Note

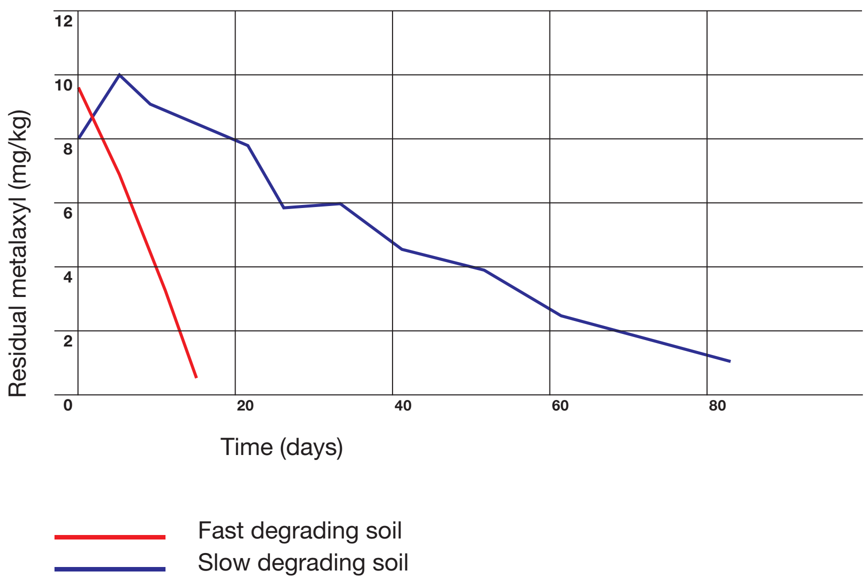
Reasons for the perceived decline in the efficacy of cavity spot control using metalaxyl or metalaxyl-M have been investigated in fields where poor control was obtained. Tests of a large number of representative *P. violae* isolates from such sites show that this is not due to the development of fungicide resistance in the pathogen, nor has there been a shift in populations to metalaxyl-M tolerant *P. sulcatum (*the manufacturers do not claim activity against *P. sulcatum*).



Electron microscope image of a cavity showing fungel strands (hyphae) of *P. violae*

Control usually breaks down in late crops, especially when strawed-down. This could be linked to poor fungicide persistence in the soil and shifts in the climate towards milder, wetter Autumns which would favour late season infections. In addition, HDC research has shown that in some fields metalaxyl is rapidly degraded (Graph 2). It is not known how widespread this presumed microbial action phenomenon is, but it appears to be linked with a history of repeated metalaxyl usage. A soil test has been developed to detect soils that rapidly degrade metalaxyl and fields with high disease risk and fast metalaxyl degradation should be avoided.

Graph 2
Comparison between metalaxyl concentrations with time in a fast degrading (red line) and a slow degrading soil. The fast degrading soil showed poor disease control.



Severe cavity spot

Tests

The immunodiagnostic soil test for cavity spot risks is available at Horticulture research International (HRI). Contact HRI (01789 470382) for details.

Soil tests for metalaxyl/ metalaxy-M degradation rate (using a procedure developed with HDC funding) are also available at HRI.

Action points for growers

General disease management

- Ensure careful site selection. Avoid and record fields with a history of cavity spot. Such land may be unsuitable for carrots, unless particular problems can be identified and remedied (e.g. acid pH).
- Adopt good field hygiene; do not dump waste carrots on carrot land, clean machinery used on high-risk sites.
- Practice good crop husbandry, and promote crop health by accurate use of fertilisers and irrigation (using soil analyses and scheduling respectively).
- Adjust soil pH to 7–7.5.
- Nutrition – avoid high levels of both K and N as both have been linked with increased cavity spot.
- Crop rotation – The benefits gained from crop rotations depend on the predominant cavity spot pathogen. *Pythium sulcatum* has a narrow host range and where it is predominant, rotations with crops like cereals or other vegetables such as broccoli can work very well. However, the predominant cavity spot pathogen in UK fields is *Pythium violae,* which has a very broad host range, including conifer seedlings, alfalfa, wheat and ryegrass, and it is unclear how effective rotations would be in most UK fields.
- Assess disease risk before drilling, based on crop history (including rotation and history of cavity spot), and harvest period (later crops are at greater risk), use cavity spot test to give an indication of high risk sites.

Management on farms with known high disease risk

- When disease detection has identified high-risk farms, test a selection of fields for metalaxyl / metalaxyl-M degradation.
- Determine the rate of degradation of metalaxyl-M in the soil – if this is rapid then harvest early and do not straw down.
- Use metalaxyl-M treatment at full rate at early post-emergence (1st true leaf) stage.
- Consider liming soil to exploit cation exchangeable calcium responses of the soil (whilst considering other likely crops in the rotation – especially that liming may aggravate common scab in subsequent potatoes).
- Chose the least susceptible varieties.
- Monitor crops regularly especially to establish which crops are suitable for strawing down.
- Harvest promptly when cavity spot is detected.
- Establish a forward plan with a long rotation of carrots.
- Keep clear records of cavity spot and other problems so that forward plans can be updated.
- Maintain good hygiene between identified high risk and low risk sites to avoid cross-contamination.

Further information may be obtained from the HDC Project Reports FV 5a–f available from the Office.

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