Horticultural Development Company

Grower summary

FV 353

Carrot cavity spot: (i) using quantitative PCR to predict disease in strawed crops; (ii) controlling moisture for optimum disease management

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Further information

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HDC
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

Headline

Cavity spot development can be limited by careful irrigation management, but PCR testing for *Pythium violae* is not an appropriate disease prediction tool.

Background and expected deliverables

Cavity spot remains a major problem in the UK where the disease seems to be caused almost entirely by *Pythium violae*. Using conventional mycological techniques *P. violae* is very difficult to detect and quantify in soil and so until recently we had very little understanding of the biology of *P. violae*. As part of earlier work at Warwick HRI, a quantitative fluorescent PCR (qPCR) technique has been developed. Through DEFRA funding and an HDC studentship (CP 46), we have used this qPCR to greatly increase our understanding of the fungus both in the soil and during disease development.

It now seems that although *P. violae* can cause damage to carrots, it is better understood as a rhizosphere organism capable of growing in association with a range of hosts. It is now clear that *P. violae* does not behave like other "classic" soil-borne diseases where disease is directly proportional to initial inoculum levels. Rather, during the carrot season the fungus grows, sometimes rapidly, from low levels of inoculum and disease levels are determined by conditions during the growing season with the main determinant being soil moisture. Preliminary data suggests that soil temperature and the soil microbiota can modify levels of the disease by affecting the "efficiency" relating levels of fungus to root disease..

Disease prediction

The strong effect of environmental and other factors on final disease levels suggested that pre-planting levels of the fungus in the soil would not be correlated with final disease levels and this was confirmed both at the local level (in a Defra-funded project) and more widely in a previous (2005/7) HDC-funded project (FV5g).

However, cavity spot developing during the winter in strawed crops remains a problem and it would be useful for growers to be able to predict final disease levels when deciding on harvest dates and whether to straw crops. Main-crop plantings in which cavity spot can be seen in late summer will not improve and should be harvested early, but the primary lesions caused by *P. violae* are often small with secondary infections by other fungi causing damage

during winter. Moreover in some crops where no lesions are visible, disease will still develop during the winter. Previously we found amounts of *P. violae* in the soil collected from near the root surface (SOCS) in late summer/early autumn, broadly correlated with disease during the winter suggesting that testing at this time might be a useful management tool. However, only a small number of commercial fields were tested in FV5g and the Defra project concentrated on one field at Warwick HRI.

Part of this project aimed at developing a management decision tool for determining which crops should be harvested immediately and which can be safely strawed-down. This part of the project looked at late summer testing of SOCS as a predictive tool for final disease levels.

Expected deliverable: evidence that testing for the presence of *P. violae* by qPCR in late Summer could provide a valuable disease management tool.

Water levels and optimised disease management

Fungicide applications can help control cavity spot but timing is important. *P. violae* increases rapidly during the main-crop carrot season with the main influence of the timing of growth being soil moisture. However, this has only been tested at two very different levels of water input. At high levels of water, growth was rapid in the early part of the season with peak levels of fungus reached in July. In contrast with only natural rain in a dryish season, maximum levels were seen in September. Growers cannot control rain on crops but it is easily measured. If growth of the fungus could be linked to total added water (which in commercial practice would be rain + irrigation) then it should be possible to make more finely tuned recommendations as to the timing of fungicide applications and so achieve better disease control. In practice, with growers wishing to schedule fungicide applications, the practical outcome would be to provide recommendations to ensure appropriate amounts of water had been applied to allow the fungus to begin to grow, before the application of a fungicide.

The second part of this project therefore looked at applied irrigation in a covered environment and correlated this with growth of the fungus on carrots and the time of appearance of disease. Syngenta funded simultaneous complementary work on the effectiveness of fungicide in controlling disease. This part of the work focused on SL567A but the results will probably apply to other fungicides applied to the soil for cavity spot control, as the important stage in the disease is probably when rapid growth of the fungus is occurring.

Expected deliverables: a better understanding of the amount of water required to instigate growth of the fungus and development of disease. Also a demonstration that early applications of fungicide can be effective in controlling disease (and the fungus) if sufficient water is present to ensure that the fungus is in a susceptible state of growth when the product is applied.

Summary of the project and main conclusions

Disease prediction

31 fields spread from East Anglia through to Scotland were identified and samples of 60 roots (from four locations within each field) and associated soil were collected during late August or early September. These were assessed visually for disease and soil collected from the roots was tested for the presence of *P. violae* by qPCR. These sites were visited again in late October/early November and, if the crops were still in the ground for a third time in late January/early February. As on the first occasion roots and associated soil were collected, assessed for disease and tested for *P. violae*. The results are summarised in Table 1 below.

Table 1 Summary table for samples collected from UK fields. Disease determined in most cases by visual inspection of four groups of 15 roots per field and *P. violae* by qPCR of soil off carrot surfaces. “No cavity spot” means no lesions seen and “no *P. violae*” means no reliable detection of the fungus (see Table 2 of Results section for full details).

Cavity spot	*Pythium violae*	Detection date	Number of fields	Notes
NO	NO		11	
NO	YES	Aug/Sept Oct/Nov or Jan/Feb	0 2	Very low levels *P. violae* detected
YES	NO		11	Possibly not cavity spot In 4 fields; 5 fields only low numbers of lesions.
YES	YES	Aug/Sept Oct/Nov or Jan/Feb	0 6	4/6 moderate (>10) to high numbers lesions

High levels of cavity spot were found in six fields and high levels of *P. violae* in a similar number of fields. Low levels of either disease or fungus were found in many fields, but 11 fields had neither. 4 fields had roots with lesions but these were highest at the first visit and

reduced later; this is atypical of cavity spot and it is thought that these lesions were probably due to infection by another fungus (as has been found in other projects). No *P. violae* was detected in these fields.

Crucially, *P. violae* was **not** reliably detected at any site in August/September. Therefore no useful predictions could be made of later development of disease.

There was a correlation of *P. violae* with disease when tested in October/November but this was neither strong enough nor robust enough to use as a good predictive tool and was far too late to be of use to growers making decisions as to early harvesting/strawing anyway.

Main conclusions from disease prediction work

- No *P. violae* was detected in any sample of carrots and associated soil from commercial field sites in late August/early September and so no useful prediction of the later development of cavity spot could be made.

- PCR testing cannot be recommended to carrots growers as being a useful management tool at any time of the year.

Water levels and optimised disease management

Two poly-tunnels, each containing three 35+ m beds of carrots (var Nairobi) were established in Cottage Field at Warwick HRI. Each bed was drilled as four triple rows of beds at standard spacing for main crop carrots intended for the fresh market. In one tunnel, plots were trickle irrigated at five different levels (7.5, 15, 30, 45 and 60 mm of water applied/week; the 30 mm/week level was duplicated to allow the separation of the high irrigation levels from the low levels). Each applied water level was replicated 3 times. Beds were sampled at roughly monthly intervals with carrots being washed and assessed for disease and the SOCS tested for the presence of *P. violae* by qPCR.

In the second tunnel, plots of carrots were irrigated at four levels (7.5, 15, 30 and 45 mm water/week); a fifth set was initially irrigated at a low level but this was raised later (7.5 mm/week raised to 45 mm/week). In this second tunnel plots were divided into two sub-plots and six weeks after drilling, one of each pair was sprayed with SL567A (1.3l/1000l water). Again plots were sampled regularly with roots being assessed for disease and SOCS tested

for *P. violae*. In both tunnels soil from between the rows of carrots was sampled 5 weeks after drilling and tested for *P. violae.* No fungus was detected in any of these “open soil” samples.

In the higher irrigation levels*, P. violae* was detected from the 9th October sampling onwards whilst in the lower levels it was first detected in November or February or not at all. Where disease was found, its first appearance generally coincided with that of the fungus but whereas the levels of fungus tended to peak and fall away, at the higher irrigation levels at least, the disease levels continued to rise until the last sampling in February. The repeated sets of 30 mm/week water were very different in terms of fungal growth/disease but the lower threshold for good growth of the fungus was at about this level. Maximum growth of the fungus and levels of disease occurred at about 45 mm water/week and no further increase was found above this.

In the tunnel where sub-plots were sprayed with fungicide, this gave 100% control of both fungal growth and of disease development where water levels were 15 mm water/week and above. At 7.5 mm water/week no disease was seen and *P. violae* was only detected in the last sampling (February) with the fungus being found in both sprayed and un-sprayed sub-plots.

It is clear that water levels strongly influence growth of *P. violae* and the development of disease with maximum levels of both requiring around 45 mm water/week in the form of irrigation in these tunnels.

It had been expected that effective control of fungal growth by SL567A would require the fungus to be in a state of rapid growth at the time of application. However, it seems that even at quite low levels of irrigation (15 mm water/week) fungicide applied at 6 weeks post-drilling can be very effective. Under these conditions (i.e. in a poly-tunnel) very low amounts of disease was seen at this level of irrigation in the unsprayed sub-plot and none in the sprayed plot. The fungicide was not effective at the lowest level of irrigation in that *P. violae* was detected at the last sampling (February) in both sprayed and unsprayed plots but at this level of irrigation no disease was seen either.

In this project no attempt was made to measure relative yields but the results suggest two things growers should be aware of.

1. Combined natural water (rainfall) and irrigation should be kept as low as possible consistent with good yields in order to minimise the development of disease. In these experiments keeping this below approx 30 mm/week strongly limited disease (and growth of the fungus).

2. Fungicide treatments early in the season can give very effective control of both disease and fungal growth providing there is sufficient water applied to allow growth of the fungus (in these experiments down to 15 mm water/week). Limiting water to give some natural control of the disease is obviously at odds with having enough water to get the fungus growing but growers can aim at the "gap" between the two (in these experiments between 15 and 30 mm/week) or rely on one strategy or the other.

Main conclusions from water level and optimised disease management work

- Approximately 30 mm water/week seems to be the cut-off for rapid growth of *P. violae* and strong development of cavity spot disease.

- Above 45 mm water/week there was no further increase in growth of the fungus or development of the disease.

- Around 15 mm water/week is the lower limit for effectiveness of fungicide applied early in the season.

- Growers need to manage total water on the crop to give optimal yields but if possible limit this to naturally limit disease development, consistent with getting some early growth of the pathogen if intending to use fungicide for the control of cavity spot.

Financial benefits

Disease prediction

As no predictive information was obtained by PCR testing in late summer growers are not recommended to undertake such testing. In previous projects (FV5g and Defra funded) we have shown that as conditions during the growing season determine the amount of disease, pre-plant testing also does not give information of value to growers. Therefore, commercial

growers would obtain no financial benefit from testing at any time for the presence of *P. violae.*

Water levels and optimised disease management

Growers can maximise the likelihood of fungicides being effective by ensuring sufficient water has been applied to give growth of the fungi. On the other hand limiting total water (rain plus irrigation) to just enough for optimal yields of the crop may give control of the disease.

As no attempt was made to measure crop yields in these experiments and no data is available on loss of efficiency of fungicides in commercial fields due to dry soils the financial benefits could not be quantified here.

Action points for growers

- Growers are advised that at present there is no evidence that testing for the presence of *P. violae* at any stage of the season will provide them with any information of predictive value for the management of cavity spot disease.

- If intending to use fungicides to control cavity spot, growers should (a) apply them early in the season (here six weeks post-drilling was used) and (b) ensure that sufficient water has been applied for growth – here 15 mm water/week but likely to vary on different soil types.

- Growers should apply only sufficient irrigation to give optimal yields of the crop and if total applied water (rain + irrigation) is kept below the threshold for rapid growth of the fungus (here about 30 mm/week) then disease development will be limited.