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| <b>Project title</b>   | Symptomatic survey of virus complexes                    |
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| <b>Project leader:</b>                                       | Mr Adrian Fox, Fera                                      |
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

**AUTHENTICATION**

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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## CONTENTS

|   | Page |
|---|------|
| <b>Grower Summary</b>                       | 5    |
| Headline                                    | 5    |
| Background and expected deliverables        | 5    |
| Summary of the project and main conclusions | 6    |
| Action points for growers                   | 8    |

## Grower Summary

### Headline

The presence of internal browning in carrot is associated with the presence of viruses from the Carrot Motley Dwarf complex (CMD).

### Background and expected deliverables

The principle viruses affecting carrot crops in the UK are *Parsnip yellow fleck virus* (PYFV) and the Carrot Motley Dwarf Complex (CMD) consisting of *Carrot red leaf virus* (CtRLV), *Carrot mottle virus* (CMoV) and Carrot red leaf associated viral RNA (CtRLVaRNA). Both PYFV and Motley Dwarf Complex are transmitted by the Willow-carrot aphid (*Cavariella aegopodii*). These viruses affect crops sporadically but when they occur they can have devastating consequence, however, there is considerable variation in incidence of these viruses from season to season. As the symptoms tend to be internal there are obvious practical issues in grading out affected carrots. The 2009 growing season saw some growers with up to 10% of yield affected by these symptoms.



**Figure 1.** Carrot samples submitted as part of the 2010 survey.

(a) Showing blackening/necrosis of root tip. This sample was positive for *Carrot mottle virus*.

(b) External browning/necrosis of carrot root. This sample was positive for *Carrot mottle virus*.

(c) Foliar reddening and chlorosis. Sample positive for *Carrot mottle virus* and Carrot red leaf associated viral RNA.

(d) Internal necrosis. Sample positive for CMD.

PYFV is aphid transmitted and occurs only in association with a helper virus, *Anthriscus yellows virus* (AYV) which is necessary for aphid transmission. However, carrot is not susceptible to AYV. Early infection can result in severe stunting and the death of individual plants. Later in the season larger plants can develop mottled foliage, discoloured with yellow flecks. Affected plants may develop secondary and/or misshapen roots, whilst tops may die back. Infection with this virus has also historically been associated with development of symptoms similar to crown rot. Foliar and root symptoms associated with carrot viruses are shown in Figure 1.

Current aphid control measures are aimed primarily against PYFV, with intensive spray programmes through May and June. Recent diagnostic findings have suggested that the internal browning symptoms may be the result of infection with viruses from the Carrot Motley Dwarf complex. The research aimed to ascertain the extent of the problem of internal necrosis in the UK carrot industry and to ascertain the virus/es present when symptoms were found. The survey was undertaken to test samples from across the UK carrot industry to look at the prevalence of the different viruses in plants with symptomatic foliage or root necrosis.

The aim of this survey was to test samples from UK carrot crops exhibiting foliar symptoms of virus and to look for associations between the presence of virus and internal browning symptoms in carrot roots. Samples were submitted from UK carrot crops by both growers and agronomists. On receipt, samples were examined and symptoms of both leaves and roots were recorded as well as information on variety, and source of sample. All samples were then tested for the presence of the four main viruses affecting carrot:

- *Parsnip yellow fleck virus* (PYFV)
- *Carrot red leaf virus* (CtRLV)
- *Carrot mottle virus* (CMoV)
- Carrot red leaf associated RNA (CtRLVaRNA)

Testing was carried out using Kingfisher magnetic bead extraction and assays were carried out using conventional PCR.

### **Summary of the project and main conclusions**

In total 35 samples were received from crops, all showing foliar symptoms consistent with virus infection, such as yellowing or reddening of leaves or mottled foliage. The first sample was received in late June and the last one late November. Where variety was given, all samples were cv. Nairobi, reflecting the predominance of this variety within the carrot industry. Unfortunately this means that no conclusions can be drawn as to the relative varietal susceptibility to development of viral browning.

Approximately half of all samples submitted were found to contain at least one virus and a limited proportion of these samples were exhibiting root necrosis (Table 1). Not all samples with internal necrosis were found to contain virus, and it is thought that this was probably the result of infection with another, unidentified, pathogen. CMoV was most commonly detected, present in 35% of all samples and 65% of virus positive samples. PYFV was least commonly detected, with only 3 samples found to contain this virus. It is not known whether this is a reflection of the prevalence of this virus in relation to the other viruses in carrot crops or whether sampling on the basis of observed symptoms was skewed toward the presence of CMD viruses.

**Table 1.** Showing the individual viruses detected in samples and the number of samples exhibiting root necrosis infected with those viruses.

| Virus          | No of Positives | No. with Root Necrosis |
|----------------|-----------------|------------------------|
| PYFV           | 3               | 0                      |
| CtRLV          | 8               | 3                      |
| CMoV           | 11              | 5                      |
| CtRLaVRNA      | 8               | 1                      |
| Virus Positive | 17              | 6                      |
| Total          | 35              | 8                      |

All three samples where PYFV was detected, CtRLVaRNA was also found to be present (Table 2). This result was somewhat unexpected as this viral RNA is associated with transmission of the other CMD viruses which were not detected from the sample. This testing was repeated with identical results confirming the initial finding. From these limited data, PYFV does not appear to be associated with internal browning. Broader survey work would be required to validate this conclusion. Where combinations of viruses were detected, the association of the Motley Dwarf Complex of viruses with the development of necrotic root symptoms is evident. The symptoms are seen most commonly in virus combinations including CMoV. However, the presence of all three viruses and no visible symptoms, as well as single virus findings with symptoms indicate the situation is more complex than simply an effect of viral accumulation.

**Table 2.** Showing the virus combinations

| Virus combinations       | No. of Samples | No with Root Necrosis |
|--------------------------|----------------|-----------------------|
| None                     | 18             | 2                     |
| CtRLV Only               | 2              | 1                     |
| CMoV Only                | 3              | 2                     |
| CtRLaVRNA Only           | 1              | 0                     |
| PYFV & CtRLaVRNA         | 3              | 0                     |
| CMoV & CtRLaVRNA         | 2              | 1                     |
| CtRLV & CMoV             | 4              | 2                     |
| CtRLV & CMoV & CtRLaVRNA | 2              | 0                     |

Due to the limited number of samples submitted it is difficult to draw meaningful, conclusions as to geographic distribution or timing of symptom development from these results. Nor was it possible to infer differences between the causes of internal/vascular discolouration and patches of surface necrosis. As a consequence of the low numbers of samples tested results are not statistically significant. Further work would be required to explore links between the development of internal necrosis and all possible biotic and abiotic factors.

## **Results – main points**

- 35 carrot crop samples were submitted for testing with foliar virus symptoms
- 17 samples (49%) were positive for at least one of the main carrot viruses
- 8 samples (23%) showed symptoms of root necrosis
- 2 samples exhibiting internal necrosis tested negative for the main carrot viruses
- 5 samples were positive for internal symptoms and *Carrot mottle virus*.
- All samples which exhibited internal necrosis and were positive for virus were found to be infected with at least one virus from the Carrot Motley Dwarf Complex.

## **Main conclusions**

- The development of internal browning symptoms in carrot is not solely a response to infection with viruses.
- *Parsnip Yellow fleck virus* does not appear to be associated with root browning of carrot.
- Virus combinations including CMoV are most commonly associated with the presence of root necrosis.

## **Action points for growers**

- Aphid transmitted viruses are strongly associated with internal browning of carrots and can also cause yield and quality reduction
- These viruses are not seed borne; therefore effective aphid management measures can help reduce the appearance of both internal and external virus symptoms and associated yield losses.
- These results indicate that current management regimes may not be adequate for control of CMD. Measures to manage both CMD and PYFV in carrots may require longer term control strategies.
- Season long aphid control programmes will require monitoring and understanding of aphid flights and more sophisticated aphid control programmes (e.g. IPM).