FINAL REPORT
PROJECT FV 167a

PARSNIP : CONTROL OF CANKER

(ADAS Contract XHAAH/A/2)
(formerly C001/346)

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Project Leader :	Dr P Gladders ADAS Boxworth Boxworth Cambridge CB3 8NN
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CONTENTS

Practical Section for Growers

This report presents the results from a three year investigation of canker and other diseases of parsnips. Seed treatments, foliar fungicides and soil ridging have been investigated in this project. Crop monitoring using agar plates was undertaken to monitor the development of the canker pathogen in plots and commercial crops in eastern England.

The project has been undertaken during three years with below average rainfall. Despite double cropping, the use of infected seed and high risk sites, canker incidence has been low. It is clear that there are a wide range of diseases and symptoms affecting parsnips and problems other than canker have caused complete loss of crops. Monitoring has shown that problems can develop rapidly (within a 4 week period) and close monitoring is essential for ensuring quality production. Previous reports of canker may not always relate to *Itersonilia pastinacae* as phoma canker (*Phoma complanata*) is common and rather similar in appearance at the young lesion stage. Cavity spot symptoms have been detected and the problem should not be overlooked particularly as Fubol provided useful control. Large roots are particularly vulnerable to disease attack and the soil borne fungus *Mycocentrospora acerina* was the main problem in 1994/95. *Cylindrocarpon destructans* is a common soil fungus and was frequently associated with small brown spot. Rhizoctonia caused scarring and black scurf and is another component of the root disease complex.

In 1995/96 spray programmes were initiated from 19 July or from first sign's of canker activity (18 October). The crop was severely checked by hot dry conditions and new foliage re-growth was produced in the autumn. Foliar diseases failed to develop and this highlighted the need for careful crop monitoring to ensure fungicides are not used unnecessarily. Root symptoms included brown spotting and cavity spot but these were unaffected by treatment. Powdery mildew was very active from 22 July onwards in 1996 and all the fungicides showed good activity reducing disease severity from 14% to 4% or less by 12 August and from 19% to 5% or less on 24 September. There was an increase in green leaf retention following fungicide applications particularly from Bravo. Current products are therefore capable of providing good control of powdery mildew provided they are applied during the early stages of active development. There were some indications that mildew control could improve yield and root size. Control of *Itersonilia* spp. was monitored using agar plates. There were complex interactions with fungicides and programmes of sprays did not reliably reduce the numbers of spores detected. Indeed, *Itersonilia* activity appeared to be higher in some treated plots in 1995/96, there were indications that Bravo and Folicur had useful activity against *Itersonilia* but fungicides were not providing control for 4 weeks. Spray intervals were reduced to 3 weeks in 1996/97 and whilst control of the canker pathogen was demonstrated with programmes of Folicur and Bravo (3 weeks after treatment), the other products tended to increases *Itersonilia* activity. The related *Itersonilia perplexans* currently being investigated on carrots as a possible cause of crown rot, showed similar effects of treatments and, if anything, appears to be more difficult to control. This new information on *Itersonilia* control suggest that further work with Folicur and Bravo should be considered in parsnips and carrots and other crops where *Itersonilia* is a pathogen.

Seed treatments were investigated in three experiments and explored the potential for developing product formulations available on other crops for use on parsnips. UK226 (tebuconazole) and a high rate of Baytan were found to be toxic and reduced germination and crop establishment. Use of a seed germination test before sowing enabled seed rates to be adjusted so that target populations were established. Seed rates were increased from 30 to 43 seed/m row in 1996 for the two phytotoxic treatments. Canker incidence was low in all experiments and treatments had no significant effect on canker or other diseases. In 1996/97 a foliar application of Fubol was made to control cavity spot within the seed treatment experiment and thus reduce cavity spot from 9% roots affected to 3%. There was no indication that seed treatments had any effect on cavity spot. Carrot fly damage was severe in 1996/97 but was unaffected by seed treatments. Whilst novel seed treatments have potential for use on parsnips, advantages for disease control and yield have not been demonstrated.

The foliar fungicides examined were Bayleton, Bravo, Corbel and Folicur which represented currently available products for parsnips plus potentially useful products used on other crops (Bravo, Compass and Folicur). Both timing and the number of treatments was investigated in a single experiment last year. In 1994, all programmes initiated on 19 July gave complete control of powdery mildew which affected 2.6% leaf area on 9 September. Single sprays of Corbel were included at various timings and the 12 August treatment also proved highly effective. Downy mildew during the autumn affected 32% leaf area on 1 November. It was suppressed by all the fungicides but there was a clear advantage from Bravo (3 sprays) which reduced disease severity to 5% leaf area. There is potential to develop recommendations for the use of Bravo on parsnips to control this disease. Canker affected 4% untreated roots and was not controlled by fungicides. The incidence of canker and other diseases, however, was generally lowest where Folicur and Bravo had been used.

Soil ridging prior to leaves meeting across the row and/or at die-down of leaves was investigated at 9 sites on soil types ranging from sandy loam to silty clay loam and peaty loam. Some benefits from ridging were identified for both spotting blemishes, splitting and carrot fly damage but these have not been consistent across a range of sites. The late ridging can cause root damage if roots are large but would be worth considering in exceptional circumstances. During the project, dry conditions have led to rather deep placement of crowns and this may have provided some natural protection against spores from foliage reaching the crown. Soil ridging would be worthy for farm-scale investigation in seasons with above average rainfall and where crowns were exposed or shallow.

This project has highlighted the diversity of foliar disease and root diseases which affect parsnips. There are opportunities to control foliar disease, but soil-borne pathogens which are the major cause of root disease have not responded to fungicide sprays. Control of *Itersonilia* species is complex and whilst novel treatments might be effective, currently available products are likely to have little beneficial activity.

Science Section

Introduction

Parsnips are currently cropped on about 3,500 ha per annum in the UK. Output value appears to be increasing and was valued at £12.3 million in 1992 and £17.5 million in 1993 (provisional) (MAFF Basic Horticultural Statistics for the United Kingdom, 1994). Almost 75% of production is concentrated in East Anglia and the East Midlands at present. Supermarkets represent the major outlet for the crop and emphasis is given to producing small, high quality roots. Good skin finish and freedom from blemishes are of paramount importance. Whilst cultivars with some resistance to canker are available, market requirements for quality and agronomic performance limit cultivar choice. Canker and other diseases therefore continue to cause serious economic losses.

Parsnip canker has caused serious losses in parsnip crops over the last two years. Whilst black canker, caused by the fungus *Itersonilia pastinacae* (Channon, 1963a), has been confirmed on badly affected samples, a range of pathogens can cause parsnip canker. In recent years, *Phoma complanata* has been a major pathogen causing losses over 50% in Somerset. Its importance in the UK has not been established. *Mycocentrospora acerina* (Channon, 1965) and *Cylindrocarpon destructans* (Channon and Thomas, 1981) are also known to cause parsnip canker. These diseases have received little attention in the UK since the work of Channon at Wellesbourne over 30 years ago. More recently, Phoma canker has been investigated in Canada (Cerkauskas, 1987) and fungicidal control of this disease has been investigated (Cerkauskas and McGarvey, 1998). *Itersonilia* species are currently of interest in carrot crops where they appear to be involved in crown rot disorder. The demonstration that carrot crown rot can be controlled with fungicides (HDC Project FV136) has led to off-label approval for the use of fenpropimorph on both carrots and parsnips. However, growers have little guidance on how to use fungicides for Itersonilia control in these crops.

Investigations on parsnips are being co-ordinated with fundamental studies at Horticulture Research International by Dr M McPherson. Whilst *Itersonilia* species are the main target of this investigation, opportunity will be taken to establish the benefits of treatments on other foliar and root diseases.

Objectives

The objectives of this project are:

1. To investigate control of canker with fungicides applied as foliar sprays.
2. To evaluate seed treatments for control of canker and other diseases.
3. To investigate soil ridging and soil amendment techniques for canker control.
4. To develop an integrated control strategy for parsnip canker.

Materials and Methods

All experiments were carried out in commercial parsnip crops, grown on loamy sand at Wilby, Norfolk. Agronomic inputs followed local practice; fungicide treatments are given in the Appendix.

Experiment 1: Seed treatments

1994/95

A range of seed treatments (Table 1) was applied by Seedcote Systems Ltd. to parsnip cv. White Gem and polymer coating alone was used as a control treatment (Table 2). Seed was sown using an air-assisted Stanhay drill (Singulaire 785) in 4 row (1.55m) beds on 4 May 1994. The plot length was 10m and the seed rate adjusted to achieve approximately 14 plants/m row. Each treatment was replicated 5 times in a fully randomised block design. Plant counts were made on 4 x 1m row lengths in each plot on 19 July. Final root numbers and canker were assessed on the whole plot at harvest on 24 January 1995.

Table 1. **Treatments, active ingredients and formulations of products used as seed treatments in Experiment 1, 1994/95**

Treatment	Active ingredient (a.i.)	Formulation	Dose (g.a.i./100,000 seed)
Baytan Flowable	fuberidazole + triadimenol	22.5 + 187.5 g/l FS	0.33 + 2.75 g
UK226	tebuconazole	250 g/l EC	2.75g
Lindex-Plus FS	fenpropimorph + gamma HCH + thiram	43 + 545 + 73 g/l FS	0.72 + 9.125 + 1.22 g
Polycote Select	metalaxyl + thiabendazole	45 + 24% w/w WS	5.0 + 2.67 g
Rovral WP	iprodione	50% WP	18.0 g

Table 2. **Seed treatments and dose rates used in Experiment 1, 1994/95**

	Treatment	Dose rate (g product/100,000 seeds)
1.	Polymer coated seed (Control)	-
2.	Polycote Prime (=Polycote Select + Rovral WP)	11.11 + 36.0 g
3.	Baytan Flowable	16.18 g
4.	Baytan Flowable	1.618 g
5.	Lindex-Plus FS	16.74 (21.26 g)
6.	UK226	11.0 g

Table 3. Treatments, active ingredients and formulations of products used as seed treatments in Experiment 1, 1995/96 and 1996/97

Treatment	Active ingredient (a.i.)	Formulation	Dose (g.a.i./100,000 seed)
Baytan Flowable	fuberidazole + triadimenol	2.064% w/w + 17.2% w/w FS	0.018 + 0.15 g or 0.225 +1.875 g
Lindex-Plus FS	fenpropimorph + gamma HCH + thiram	43 + 545 + 73 g/l FS	0.473 + 5.995 + 0.803 g
Polycote Select	metalaxyl + thiabendazole	45 + 24% w/w WS	0.27 + 0.144
UK226 *	tebuconazole	2.5% L	0.15 g

* UK226 @ 0.1875g rate - not drilled in 1995/96

Table 4. Seed treatments and dose rates used in Experiment 1, 1995/96 and 1996/97

	Treatment	Dose rate (g product/100,000 seeds)
1.	Polymer coated seed (Control)	-
2.	Polycote Select	0.6
3.	Baytan Flowable	10.9
4.	Baytan Flowable	0.872
5.	Lindex-Plus FS	11.0 ml(13.979 g)
6.	UK226	6.96

Experiment 1: Seed treatments

1995/96

A range of seed treatments (Table 3) was applied by Seedcote Systems Ltd. to parsnip cv. New White Skin and polymer coating alone was used as a control treatment (Table 4). Rates of fungicide application were comparable to those recommended on the product label for other crops. Seed was sown using an air-assisted Stanhay Singulaire 785 drill (seed tests indicated that *Itersonilia* was present on 11% of seeds in this stock) in 4 row (1.8m) beds on 25 April 1995. The plot length was 10m and the seed rate adjusted to achieve approximately 14 plants/m row. Seed rates were adjusted for reduced germination in a seed germination test at NIAB. Treatments 1-3 were sown at 23 seeds/m row, Lindex-Plus FS at 33 seeds/m row and Baytan (High) and UK226 at 46 seeds/m row. Each treatment was replicated 6 times in a Latin square design; subsequently, 3 blocks were given a soil ridging treatment on 15 December and 3 blocks remained untreated. Plant counts were made on 4 x 0.5m row lengths in each plot on 30 May. The Lindex - Plus FS and UK226 treatments had higher plant populations than the other treatments and these were hand thinned to 17 plants/m row on 28 June. Final root numbers, yield and root diseases were assessed on the harvested sample (4m row) on 5 March 1996.

1996/97

Seed treatments (Table 3) were applied by Seedcote Systems Ltd. to parsnip cv. Javelin (believed not have seed-borne *Itersonilia)* and polymer coating alone was used as a control treatment and seed was prepared as Procote pellets(Table 4). Rates of fungicide application were comparable to those recommended on the product label for other crops and pelleting was used to reduce risks of phytotoxicity compared with direct treatment application to seed. Seed was sown using an air-assisted Stanhay Singulaire 785 drill in 4 row (1.8m) beds on 14 June 1996. The plot length was 10m and the seed rate adjusted to achieve approximately 14 plants/m row. Seed rates were adjusted for reduced germination in the light of results from a seed germination test at NIAB. Baytan (High) and UK226 treatments were sown at 43 seeds/m row and other treatments were sown at 30 seeds/m row. Each treatment was replicated 6 times in a randomised block design; subsequently, half the plots were given a cavity spot treatment (Fubol 58WP at 12 kg/ha) on 26 June. The site was irrigated on both 15 and 26 June with 25 mm water. Plant counts were made on 5 x 0.5m row lengths in the two middle rows of each plot on 31 May. Final root numbers, yield and root diseases were assessed on the harvested sample (4m row) on 19 March 1997.

Experiment 2: Foliar fungicide treatments

1994/95

This experiment was located in a commercial crop of cv. Javelin situated adjacent to the Seed Treatment experiment (Experiment 1) and sown on 3-4 May 1994 using untreated seed. Five fungicides (Table 5) were evaluated in various 1-4 spray programmes (Table 6) using a 5m length of 4 row (1.8m) bed for each plot. Treatments were replicated 4 times in a fully randomised block design. An adjacent 4 row bed of the same crop remained untreated during the experiment and was used to monitor the development of foliar diseases and canker.

Spray treatments were applied at approximately monthly intervals from mid-July until early October by knapsack sprayer in 500 litres of water/ha (Table 6). Foliar diseases were assessed at each spray date and on 1 November. Root diseases were assessed on washed root samples taken from an adjacent untreated area. Initially 25 roots were examined; when roots reached a marketable size (7 October onwards), a sample of 100 roots was examined at each visit. The final harvest assessment was made on 6 February 1995 when at least 20% roots were affected in the untreated crop.

1995/96

This experiment was located in a commercial crop of cv. Javelin situated adjacent to Experiment 1 and sown on 21 April 1995 using Polycote Prime treated seed. Five fungicides (Table 5) were evaluated in either routine spray programmes from late July or from first detection of canker spores (Table 7) using a 5m length of 4 row (1.8m) bed for each plot. Treatments were replicated 4 times in a fully randomised block design. An adjacent 4 row bed of the same crop remained untreated during the experiment and was used to monitor the development of foliar diseases and canker.

Spray treatments were applied at approximately monthly intervals from mid-July until mid-December by knapsack sprayer in 500 litres of water/ha (Table 7). The crop was examined for foliar diseases at each spray date. Root diseases were assessed on washed root samples taken (50-100 roots) from an adjacent untreated area at each spray date. The final harvest assessment for diseases and yield was made on 5 March 1996.

Table 5. Fungicide, formulations, active ingredients and dose rates used in fungicide spray timing experiments (Experiment 2), 1994-1996

Fungicide	Active ingredient	Formulation	Dose rate product/ha
Bayleton	triadimefon	25% w/w WP	0.5 kg
Bravo 500 + Agral	chlorothalonil + alkyl phenolethylene oxide	5 00 g/l SC + 900 g/l	3.0 l + 0.1% Agral
Corbel	fenpropimorph	750 g/l EC	1.0 l
Compass	iprodione + thiophanate methyl	167 + 167 g/l SC	2.0 l
Folicur	tebuconazole	250 g/l EC	1.0 l

1996/97

An early sown crop cv. Improved Marrow grown on sandy loam near East Harling, Norfolk and which could be irrigated was used for the foliar fungicide experiment in 1996/97. Treatment dose rates were the same as those used in the first two years of the project (Table 5) but the interval between treatments was reduced from four weeks to three weeks to improve activity against *Itersonilia.* Treatments were applied routinely from 22 July or from first signs of *Itersonilia* in agar plate tests (3 September) until foliage had died down (15 December) (Table 7). Plot size, replication and sampling followed methods used in 1995/96. A final harvest assessment was carried out on 4 March 1997. An adjacent untreated bed was used to monitor disease progress and samples of 100 roots were examined after washing at each visit.

Table 6. Treatments, rates and dates of application of spray treatments in Experiment 2, 1994/95

	Treatment	Rate of product/ha	Date(s) of application			
			19 July	12 Aug	9 Sept	7 Oct
1.	Untreated control		-	-	-	-
2.	Bayleton	0.5 kg	+	+	+	+
3.	Bayleton	0.5 kg	+	+	+	-
4.	Bayleton	0.5 kg	+	+	-	-
5.	Bayleton	0.5 kg	+	-	-	-
6.	Corbel	1.0 l	+	+	+	+
7.	Corbel	1.0 l	+	+	+	-
8.	Corbel	1.0 l	+	+	-	-
9.	Corbel	1.0 l	+	-	-	-
10.	Compass	2.0 l	+	+	+	+
11.	Compass	2.0 l	+	+	+	-
12.	Compass	2.0 l	+	+	-	-
13.	Compass	2.0 l	+	-	-	-
14.	Corbel	1.0 l	-	+	-	-
15.	Corbel	1.0 l	-	-	+	-
16.	Corbel	1.0 l	-	-	-	+
17.	Folicur	1.0 l	+	+	+	+
18.	Bravo + 0.1% Agral	3.0 l	-	+	+	+

All sprays were applied in 500 litres of water /ha

Table 7. Treatments, rates and dates of application of spray treatments in Experiment 2, 1995/96 and 1996/97

	Treatment	Rate of product/ha	
1.	Untreated control		
2.	Bayleton	0.5 kg	Full programme
3.	Corbel	1.0 l	"
4.	Compass	2.0 l	"
5.	Folicur	1.0 l	"
6.	Bravo + 0.1% Agral	3.0 l	"
7.	Bayleton	0.5 kg	First disease
8.	Corbel	1.0 l	"
9.	Compass	2.0 l	"
10.	Folicur	1.0 l	"
11.	Bravo + 0.1% Agral	3.0 l	"

All sprays were applied in 500 litres of water /ha

Dates of spray applications

1995/96

Full programme sprayed	19 July	24 August	28 September
	18 October	14 November	15 December
First disease programme sprayed	18 October	14 November	15 December

1996/97

Full programme sprayed	22 July	10 August	3 September
	24 September	15 October	5 November
	26 November	17 December	14 January
First disease programme sprayed	3 September	24 September	15 October
	5 November	26 November	17 December
	14 January		

Experiment 3: Soil ridging

1994/95

Observations on the effects of soil ridging were carried out in the same crop cv. Javelin as that used for Experiment 2. Four beds of crop were selected for this investigation. A ridging treatment was carried out on two beds and two beds remained untreated. Within each of the beds, the effects of chitin applications (as finely ground crab shells 0.67 kg/20m row, Ocean Organics) on 19 July (prior to ridging) and 12 August or 19 July only, were compared with an untreated control. Chitin treatments were randomised within each block and there were 3 blocks within each of the 4 beds used for the ridging comparison. Soil ridging was carried out using a 4 row tractor-mounted set of small ridging bodies which produced soil cover 2.5-5cm deep over the crown of the parsnip. This treatment was carried out just prior to the crop forming a full canopy between the rows. Corbel (1.0 l/ha) was applied overall on 6 August.

A single harvest assessment was carried out (when the adjacent untreated area of crop showed at least 20% roots with canker lesions) on 14 February 1995.

1995/96 and 1996/97

Observations on the effect of soil ridging were made on a range of soil types representing the major areas of production. Four treatments were evaluated:-

1. Untreated
2. Ridge early (first prior to the crop forming a full leaf canopy between the rows)
3. Ridge late (at die-down of foliage in autumn)
4. Ridge early + late

The following sites were used:-

Site name	Soil type	Date of early ridging	Date of late ridging
1995/96			
Wilby 1	loamy sand	20 July	15 December
Wilby 2	sandy loam	20 July	-
Wilby 3	loamy sand	-	15 December
Bodney	loamy sand	17 July	-
Saracens Head	silty clay loam	11 August	19 December
Beck Row	sandy loam	14 July	12 December
1996/97			
East Harling	sandy loam	late July	20 December
Mepal	peaty loam	13 September	10 December

At the Wilby sites 1-3 and Bodney, ridging was carried out using tractor-drawn small ridging bodies to provide 2.5 - 5cm of soil cover over the crown of the parsnips. Each treatment was carried on at least 30m length of a single bed and 4 adjacent beds were used at each site. Harvest samples consisted of 25 roots from the central 2 rows, with 8 sampling points (2m apart) per bed. All disease symptoms on crown and lateral root surface were assessed after washing. The total weight of each sample of 25 roots was also recorded at all sites except Beck Row. Root diameter was recorded on two average-sized roots from each plot. In addition, a late soil ridging treatment was applied to half of the seed treatment experiment.

1996/97

The foliar ridging treatments were used at two sites in 1996/97

1) East Harling, Norfolk on sandy loam.

2) ADAS Arthur Rickwood, Mepal, Cambs on peaty loam.

Farm equipment was used at Mepal and for the early ridging at East Harling. A hand hoe was used to produce the late ridging treatment at East Harling. Sampling was carried out on 8 sub-samples per treatment as in 1995/96 experiments.

Monitoring of *Itersonilia* spp

1994/95

The development of *Itersonilia* spp. in parsnip crops was monitored using the agar plate technique devised by Channon (1963b) at Wellesbourne. Ten petri dishes containing Waksman's Albumen agar were exposed for 15 minutes in each crop at approximately monthly intervals from July to October. The plates were then incubated in the laboratory for 5-10 days and the number of colonies of both *Itersonilia perplexans* and *Itersonilia pastinacae* was counted after microscopic examination.

The crops monitored were as follows:-

Site 1. Wilby, Norfolk

1. Untreated plots of Experiment 1(Seed treatments) cv. White Gem.
2. Untreated crop adjacent to Experiment 2 (Foliar fungicides) cv. Javelin.

Site 2. Wilby, Norfolk (3km from Site 1)

3. Commercial crop cv. Improved Marrow (natural seed)
4. Commercial crop cv. Javelin (natural seed)

Site 3. Wilby, Norfolk (3.5km from site 1, adjacent to site 2. Double cropped with parsnips).

5. Commercial crop cv. Javelin (natural seed)
6. Commercial crop cv. Javelin (Polycote Prime treated seed).

(All the Javelin crops at Sites 2 and 3 were grown from the same seed lot).

Details of fungicides applied at sites 2 and 3 are provided in the Appendix.

Monitoring of *Itersonilia* spp.

1995/96

The crops monitored with the Waksman's agar plates were as follows:-

Site: Wilby, Norfolk

1. Untreated plots of Experiment 1(Seed treatments) cv. White Skin
2. Untreated crop adjacent to Experiment 2 (Foliar fungicides) cv. Javelin.
3. Commercial crop adjacent to Experiment 2, which received fungicide sprays detailed in Appendix I.

1996/97

Monitoring of *Itersonilia* spp. using selective agar medium was continued for third year at the two experimental sites, East Harling, Norfolk and Mepal, Cambs. The adjacent commercial crop at East Harling was also monitored to provide comparison between untreated and fungicide treated areas.

Disease assessments

Foliar diseases were assessed using 'Whole plot' methods to determine the mean percentage leaf area affected. Root diseases were distinguished on the basis of colour of the lesion (black or brown) and position on the root. Results are expressed as 'crown' cankers which were confined to the top or shoulder of the root and 'lateral' canker which occurred on the side of the root. The numbers of each lesion type and the severity expressed as the percentage of the crown or root circumference affected was recorded on the Foliar fungicide experiment and the Soil ridging experiment. The numbers of roots which were fanged were also recorded in these two experiments. Samples consisted of all roots from a total of 4 m row length in Foliar fungicide and seed treatment experiments and 25 roots per sample in soil ridging experiments.

Very severe lesions developed on very large roots in the Seed Treatment experiment in 1994/95 and assessments were limited to numbers of roots affected by slight to moderate lesions or severe lesions (>50% root circumference affected) and numbers of unaffected roots. All roots used for yield assessments were examined for disease.

Yield assessments

Two rows, each 2m long were dug by hand from the centre of each plot and weighed to obtain yield data in the Foliar fungicide and Soil ridging experiments in 1994/95. The whole plot (maximum 40m row length) was lifted with the assistance of a tractor-mounted horizontal cutting blade in the Seed Treatment experiment in 1994/95. Subsequent seed treatment experiments were evaluated by assessing and weighing all roots from a 2m length from the centre of the central two rows in each plot. Yield data and root numbers are expressed per metre row length. In 1995/96 and 1996/97, soil ridging experiments were evaluated by taking 8 sub-samples (2m between sampling points) of 25 roots from a single bed of each treatment.

Laboratory examinations

Small samples of foliage and roots were examined in the laboratory for the presence of *Itersonilia* spp. and other pathogens during the course of these experiments. At harvest, representative lesions were cultured to determine the range of pathogens present.

Statistical Analyses

Data were analysed using MINITAB and GENSTAT, with appropriate transformation of data when necessary. The results of the analysis of variance (F test) are shown in the tables of results. Where data showed a skewed distribution and this has not been overcome by transformations of the data, 'skew' is indicated in the table of results and only mean data are presented. Where no differences were detected, this is indicated by the abbreviation NS

Results

1994/5

Experiment 1: Seed treatments

This experiment established poorly and plant populations were well below commercial standards in the same field. The UK226 treatment was highly phytotoxic (Table 8) and only occasional plants grew in each plot. These effects were reflected in total harvested yield and, with the exception of Folicur, there were no differences between treated and untreated seed (Table 8).

As a result of the low plant population, roots grew very large (8-16cm diameter) and 78% roots in the control plots showed black canker lesions on the crown at harvest on 24 January (Table 11). Two replicates of the experiment were lifted in error prior to final harvest and results are based on 3 replicates.

Mycocentrospora acerina was isolated readily from these large lesions and is thought to be the main pathogen causing canker in this experiment. Low levels of powdery mildew were recorded from early August onwards (Table 15) but no treatment differences were apparent on 12 August. On 9 September, powdery mildew was less severe following treatment with Folicur, Lindex-Plus FS and Baytan (High rate). These results should be treated with caution because of differences in plant population between treatments. Both Ramularia leaf spot and downy mildew were recorded in the experiment but treatment differences were not significant (Table 16).

1995/96

This experiment was established in hot dry conditions and this cultivar (New White Skin) was more severely affected by herbicide treatments than cv. Javelin in the same field. The Folicur and Baytan (high rate) treatments were highly phytotoxic (Table 9) but this was overcome by increasing the seed rate. These two treatments gave higher establishment than that suggested by the seed germination test (Table 9) unlike the other 4 treatments. Plots of Lindex-Plus FS and UK226 were hand thinned to give a uniform plant population in all treatments but by harvest mature root numbers were very low (Table 12) indicating loss of more than half of the plants from June onwards. Crown diameter was recorded on 2 roots selected as being of average size in each plot and this suggested that there were treatment effects on root size (Table 12). There were no effects of treatment on yield. There was no effect of treatment on the proportion of healthy, fanged or diseased roots (Tables 13 and 14). Rhizoctonia producing black scurf and some crown lesions developed by December and a range of brown spotting symptoms were apparent from September onwards (Table 60).

Late soil ridging was carried out on 15 December 1995 on half the seed treatment experiment. This treatment had no effect on the incidence of a wide range of crown and lateral root symptoms or yield (Table 18). Larger roots did suffer some (10%) mechanical damage to the shoulder of the root which could limit the usefulness of this technique.

1996/97

There were no differences in plant populations between seed treatments in late July. Establishment was poorer in the High Rate of Baytan and UK226 treatments as indicated by the laboratory germination tests and higher seed rate was justified to produce at least 15 plants/m row (Table 10). At harvest in March, plant populations were only marginally lower than in July and there were again no treatment differences (Table 19).

A low incidence of fanged roots were recorded which was unaffected by treatment (Table 19). Roots were small, typically 3.6cm in diameter and yield of washed roots averaged 0.77kg per m row, neither factor affected by treatments (Table 19).

Only 32% root were blemish free at harvest and this was affected by treatment (Table 21). Crown symptoms included brown spotting, conspicuous sunken brown banding and carrot fly damage on an average of 11% roots, none of which were controlled (Table 21). On the lateral root, cavity spot was moderately well controlled by Fubol which reduced incidence from 9.1% to 3.6% but not influenced by seed treatment (Table 20). The main blemish was carrot fly mining which affected 52% of roots overall but not controlled by seed treatments (Table 22). Brown spotting and brown banding affected on 2% roots and were not controlled by any treatment (Table 22).

Table 8. Experiment 1: Effect of seed treatments on root numbers and yield, Wilby 1994/95

Treatment	Number of roots/m row 19 July	Number of roots/m row 24 January	Harvested weight kg/m row
Control (polymer only)	3.75	3.74	2.21
Polycote Prime	5.60	3.23	1.77
Baytan (High rate)	2.75	2.78	1.90
Baytan (Low rate)	4.50	3.96	2.37
Lindex-Plus FS	5.10	4.97	2.26
UK226	0.20	0.14	0.31
SED (10 df)	0.405*	0.636	0.283
CV (%)	17.5	24.8	19.2
F test	<0.1%	<0.1%	<0.1%

* 20 df. for this assessment

Table 9. Experiment 1: Effect of seed treatments on germination and initial establishment and yield, Wilby 1995/96

Treatment	% Germination in NIAB seed test	Seeds sown /m row	Plants/m row on 30 May	% Emergence
Control (polymer only)	93	23	17.5	76
Polycote Select	86	23	16.6	72
Baytan (High rate)	13	46	17.7	39
Baytan (Low rate)	76	23	16.6	72
Lindex-Plus FS	86	33	22.2	68
UK226	20	46	22.0	47
SED (20 df)			1.79	
CV (%)			16.5	
F test			1%	

Table 10. Experiment 1: Effect of seed treatments on germination and initial establishment, ADAS Arthur Rickwood 1996/97

Treatment	% Germination in NIAB seed test		Seeds sown /m row	Plants/m row on 31 July	% Emergence
	7 days	14 days			
Untreated seed	83	92			
Control (polymer only)	85	94	30	16.5	55
Polycote Select	87	90	30	15.1	50
Baytan (High rate)	37	45	43	15.5	36
Baytan (Low rate)	77	80	30	15.0	50
Lindex-Plus FS	72	91	30	16.9	56
UK226	65	74	43	18.7	43
SED (22 df)				1.73	
CV (%)				18.4	
F test				NS	

Table 11. Experiment 1: Effect of seed treatments on the weight of cankered and healthy roots, Wilby 1994/95

Treatment	Weight of roots (kg/m row) Healthy	Slight-Moderate canker	Severe canker
Control (polymer only)	0.31	1.55	0.36
Polycote Prime	0.35	1.15	0.27
Baytan (High rate)	0.17	1.42	0.31
Baytan (Low rate)	0.39	1.71	0.26
Lindex- Plus FS	0.56	1.40	0.30
UK226	0.07	0.24	0.00
SED (10 df)	0.075	0.224	0.112
F test	1%	1%	NS

NS - no significant differences.

Table 12. **Experiment 1: Effect of seed treatments on the number of harvested roots and yield, Wilby 1995/96**

Treatment	No. roots /m row	Weight of roots (kg/m row)	Crown diameter (cm)
Control (polymer only)	7.6	1.06	4.6
Polycote Select	6.4	1.04	4.8
Baytan (High rate)	9.0	1.13	4.8
Baytan (Low rate)	8.4	1.10	4.4
Lindex- Plus FS	9.1	1.10	4.5
UK226	9.5	1.09	4.3
SED (20 df)	0.79	0.091	0.188
CV (%)	16.3	15.0	7.0
F test	1%	NS	5%

NS - no significant differences.

Table 13. Experiment 1: Effect of seed treatments on the incidence of canker and healthy roots, Wilby 1994/95

Treatment	% roots affected - 24 January		
	Healthy roots	Canker Severity	
		Slight-Moderate	Severe
Control (polymer only)	22.3	67.5	10.2
Polycote Prime	33.0	57.5	9.5
Baytan (High rate)	15.0	74.4	10.1
Baytan (Low rate)	15.4	66.1	18.5
Lindex-Plus FS	32.1	59.7	8.2
UK226	23.4	76.6	0.0
SED (10 df)	10.14	7.29	6.91
F test	NS	NS	NS

NS - No significant differences

Table 14. Experiment 1: Effect of seed treatments on the incidence of canker, roots with crown brown spots, healthy and fanged roots, Wilby 1995/96

Treatment	% roots affected - 5 March			
	Healthy roots	Fangs	Black Canker	Crown brown spots
Control (polymer only)	47.5	8.7	0.7	8.4
Polycote Select	39.6	5.9	1.4	9.6
Baytan (High rate)	48.5	6.4	0.9	5.9
Baytan (Low rate)	57.6	6.3	1.3	5.6
Lindex-Plus FS	44.0	8.4	0.5	7.5
UK226	49.4	6.1	0.9	10.1
SED (20 df)	13.79	3.16	-	3.72
F test	NS	NS	Skew	NS

NS - No significant differences

Table 15. Experiment 1: Effect of seed treatments on the severity of powdery mildew, Wilby 1994/95

Treatment	% Leaf area affected Powdery mildew		
	12 Aug	9 Sept	7 Oct
Control (polymer only)	1.4	6.2	4.0
Polycote Prime	1.0	4.6	4.4
Baytan (High rate)	0.8	3.4	4.0
Baytan (Low rate)	1.2	5.0	4.4
Lindex-Plus FS	1.2	3.4	4.8
UK226	0.7	1.9	3.0
SED (20 df)	0.50	0.94	1.18
F test	NS	1%	NS

NS - No significant differences.

Table 16. Experiment 1: Effect of seed treatments on the severity of Ramularia leaf spot and downy mildew, Wilby 1994/95

Treatment	% Leaf area affected		
	Ramularia		Downy mildew
	7 Oct	1 Nov	1 Nov
Control (polymer only)	0.24	2.74	13.4
Polycote Prime	0.16	0.80	13.2
Baytan (High rate)	0.22	1.00	10.6
Baytan (Low rate)	0.21	1.42	10.4
Lindex FS	0.20	1.70	7.4
UK226	0.06	0.80	5.2
SED (20 df)	0.119	0.915	2.95
F test	NS	NS	NS

NS - No significant differences

Table 17. **Experiment 1: Effect of seed treatments on the incidence of lateral root symptoms, Wilby 1995/96**

Treatment	% roots affected - 5 March		
	Lateral large brown lesions	Lateral brown spots	Lateral cavity spot
Control (polymer only)	1.6	25.5	11.6
Polycote Select	1.9	28.9	16.8
Baytan (High rate)	0.0	22.3	10.0
Baytan (Low rate)	1.2	23.9	12.2
Lindex-Plus FS	0.0	19.7	16.0
UK226	0.5	22.7	10.8
SED (20 df)	-	14.53	6.18
F test	Skew	NS	NS

NS - No significant differences.

Table 18. **Experiment 1: Effect of late soil ridging on disease incidence, damage and yield, Wilby 1995/96**

Assessment	Unridged	Late ridged	SED (20 d.f.)	F test
Roots/m row at harvest	8.3	8.4	0.19	NS
Yield (kg/m row)	1.12	1.06	0.027	NS
% healthy roots	52.8	42.7	6.20	NS
Diseases on crown of root				
% roots with black canker	0.9	1.0	0.44	NS
% roots with brown canker	0.2	0.3	0.13	NS
% roots with brown spots	7.6	8.2	1.71	NS
% roots with rhizoctonia scars	0.5	0.9	0.75	NS
% roots with cavity spot	3.5	4.1	1.97	NS
Diseases on side of root				
% roots with mechanical damage	0.5	10.2	5.25	NS
% roots with large brown lesions	0.8	1.0	0.53	NS
% roots with brown spots	21.6	26.1	3.99	NS
% roots with spots	1.6	0.9	1.67	NS
% roots with dark rot on spots	0.4	0.6	0.29	NS
% roots with carrot fly damage	8.6	8.5	2.3	NS
% fanged roots	7.2	6.9	0.99	NS

NS - Not significant

Table 19. Experiment 1: Effect of seed treatments on root numbers, fanged roots and yield, ADAS Arthur Rickwood, 19 March 1997

Treatment	Number of roots/m row	% fanged roots	Harvested weight kg/m row
Control (polymer only)	15.3	9.2	0.75
Polycote Prime	14.5	4.6	0.83
Baytan (High rate)	16.1	6.7	0.75
Baytan (Low rate)	14.4	6.0	0.76
Lindex-Plus FS	16.1	6.0	0.71
UK226	18.5	4.2	0.81
SED (22 df)	1.69	2.06	0.052
CV (%)	18.4	58.2	11.7
F test	NS	NS	NS

Table 20 . Experiment 1: Effect of seed treatments on cavity spot incidence, ADAS Arthur Rickwood, 19 March 1997

Treatment	% roots with cavity spot		
	+ Fubol	- Fubol	Mean
Control (polymer only)	7.9	7.9	7.9
Polycote Prime	2.5	9.7	6.1
Baytan (High rate)	2.9	9.2	6.0
Baytan (Low rate)	2.7	14.0	8.3
Lindex-Plus FS	3.1	6.0	4.6
UK226	2.6	7.6	5.1
Mean	3.6	9.1	6.3
SED (22 df)		2.83(1.16 Fubol)	2.00
F test		NS (0.1% Fubol)	NS

Table 21. Experiment 1: Effect of seed treatments on the incidence of healthy roots, crown symptoms and carrot fly damage, ADAS Arthur Rickwood, 19 March 1997

Treatment	% roots affected			
	Healthy roots	Crown carrot fly*	Crown brown banding	Crown brown spots
Control (polymer only)	31.5	15.4	12.0	4.9
Polycote Select	33.2	17.9	10.2	7.0
Baytan (High rate)	29.9	16.6	20.3	1.4
Baytan (Low rate)	36.0	12.3	7.8	5.1
Lindex-Plus FS	28.8	17.1	9.4	4.1
UK226	28.6	24.5	11.6	4.0
SED (22 df)	7.56	5.37	4.18	1.96
F test	NS	NS	NS	NS

NS - No significant differences
* Angular transformed data analysed

Table 22. Experiment 1: Effect of seed treatments on the incidence of lateral root symptoms, ADAS Arthur Rickwood 1996/97

Treatment	% roots affected		
	Lateral root carrot fly damage	Lateral brown spots*	Lateral brown banding*
Control (polymer only)	50.0	8.0	3.6
Polycote Select	50.6	6.6	6.3
Baytan (High rate)	52.4	3.6	7.2
Baytan (Low rate)	45.4	10.3	1.4
Lindex-Plus FS	59.6	7.3	3.1
UK226	56.4	6.6	7.0
SED (22 df)	9.38	3.15	3.29
F test	NS	NS	NS

NS - No significant differences.
* Angular transformed data analysed

Table 23. Experiment 2: Effect of foliar sprays on numbers of roots, incidence of fanged roots and root yield, Wilby 1994/95

Treatments	Number of roots /m row	Harvested weight (kg/m row)	Number of fanged roots /m row
Untreated control	14.4	2.86	0.56
Bayleton x 4 (July+Aug+Sept+Oct)	13.1	2.78	0.63
Bayleton x 3 (July+Aug+Sept)	13.6	2.77	0.88
Bayleton x 2 (July+ Aug)	14.1	2.74	1.50
Bayleton x 1 (July)	14.1	2.78	0.56
Corbel x 4 (July + Aug + Sept + Oct)	13.6	2.86	0.63
Corbel x 3 (July + Aug + Sept)	14.2	2.81	0.38
Corbel x 2 (July + Aug)	14.2	2.69	0.94
Corbel x 1 (July)	15.2	2.70	0.63
Compass x 4 (July + Aug + Sept + Oct)	15.1	2.82	0.81
Compass x 3 (July + Aug + Sept)	14.4	2.84	1.31
Compass x 2 (July + Aug)	14.1	2.83	1.00
Compass x 1 (July)	15.1	2.70	0.88
Corbel x 1 (Aug)	12.4	2.54	0.88
Corbel x 1 (Sept)	13.4	2.74	0.88
Corbel x 1 (Oct)	14.6	2.91	1.50
Folicur x 4 (July + Aug + Sept + Oct)	14.7	2.78	1.63
Bravo x 3 (Aug+Sept+Oct)	13.3	2.70	1.44
SED (51 df)	1.88	0.168	0.718
CV (%)	18.9	8.6	107.5
F test	NS	NS	NS

NS - No significant differences

Table 24. Experiment 2: Effect of fungicide spray treatments on foliar diseases, Wilby 1994/95

Treatments	% Leaf area affected				
	Powdery mildew	Ramularia			Downy mildew
	9 Sept.	7 Oct	1 Nov		1 Nov
Untreated control	2.63	0.93	-0.72	(4.50)	32.5
Bayleton x 4	0	0.03	-0.11	(0.35)	16.0
Bayleton x 3	0	0.01	-0.33	(1.40)	18.8
Bayleton x 2	0	0.13	-0.22	(1.13)	19.0
Bayleton x 1	0	0.33	-0.43	(2.53)	20.5
Corbel x 4	0	0.13	-0.14	(0.55)	16.8
Corbel x 3	0	0.08	-0.22	(0.78)	18.8
Corbel x 2	0	0.05	-0.15	(0.58)	18.8
Corbel x 1	0	0.43	-0.36	(1.63)	20.0
Compass x 4	0	0.002	-0.05	(0.15)	16.3
Compass x 3	0	0.03	-0.05	(0.15)	17.0
Compass x 2	0	0.15	-0.17	(0.63)	16.3
Compass x 1	0	1.03	-0.50	(2.75)	22.5
Corbel x 1 (Aug)	0	0.06	-0.21	(0.78)	19.3
Corbel x 1 (Sept)	2.63	0.05	-0.31	(1.35)	25.5
Corbel x 1 (Oct)	1.38	0.40	-0.31	(1.28)	22.5
Folicur x 4	0	0.03	-0.11	(0.33)	16.8
Bravo x 3	0.38	0.00	0.00	(0.00)	5.0
SED (51 df)	0.595	0.251	0.122		3.80
F test	Skewed data	Skewed data	0.1%		0.1%

* Analysis as negative reciprocal transformation, untransformed means in parentheses.

Table 25. Experiment 2: Effect of fungicide spray treatments on the incidence of crown and root cankers, Wilby 6 February 1995

Treatments	% Roots affected by canker			
	Crown black	Crown brown	Lateral black	Lateral brown
Untreated control	4.4	9.3	0.4	3.4
Bayleton x 4	2.1	15.1	0.9	2.1
Bayleton x 3	1.4	11.9	1.8	2.2
Bayleton x 2	1.9	13.8	0.7	7.4
Bayleton x 1	6.6	12.6	1.5	3.9
Corbel x 4	2.8	10.3	1.2	6.2
Corbel x 3	4.5	19.0	0.0	10.2
Corbel x 2	1.7	13.6	1.0	7.3
Corbel x 1	2.6	9.2	1.8	3.4
Compass x 4	2.1	15.7	0.3	4.5
Compass x 3	2.5	16.1	1.0	7.0
Compass x 2	4.8	9.1	1.8	3.2
Compass x 1	3.3	12.1	0.0	5.0
Corbel x 1 (Aug)	4.3	10.7	1.8	3.0
Corbel x 1 (Sept)	4.4	14.3	0.0	6.0
Corbel x 1 (Oct)	5.1	15.3	1.7	6.0
Folicur x 4	0.5	4.5	0.4	1.8
Bravo x 3	1.5	6.1	0.5	0.8
SED (51 df)	2.71	4.96	1.05	2.76
F test	NS	NS	NS	NS

NS - No significant differences

Table 26. Experiment 2: Effect of fungicide spray treatments, on root number, yield, root size and fanged roots. Wilby 1995/96

	Treatment	Number of roots/m	Harvested weight (kg/m row)	Root diameter (cm)	% fanged roots /m row
1.	Untreated control	11.4	1.44	5.2	8.7
2.	Bayleton x 6	11.1	1.52	4.8	16.7
3.	Corbel x 6	11.2	1.33	5.0	15.7
4.	Compass x 6	12.8	1.31	5.2	14.9
5.	Folicur x 6	12.9	1.30	4.9	11.1
6.	Bravo x 6	12.9	1.56	5.2	14.1
7.	Bayleton x 3	11.5	1.44	5.4	6.7
8.	Corbel x 3	11.4	1.36	5.1	16.6
9.	Compass x 3	12.0	1.33	5.2	8.5
10.	Folicur x 3	11.5	1.46	5.0	16.4
11.	Bravo x 3	11.9	1.36	5.1	16.8
SED (30 df)		0.74	0.185	0.25	6.44
CV (%)		12.5	18.9	6.8	68.5
F test		NS	NS	NS	NS

NS - No significant differences

Table 27. Experiment 2: Effect of fungicide treatments on the incidence of healthy roots, and disease symptoms on the root crown, Wilby 1995/96

	Treatment	% roots affected		
		Healthy	Brown Spot	Cavity Spot
1.	Untreated control	73.9	2.9	2.2
2.	Bayleton x 6	60.7	7.1	2.3
3.	Corbel x 6	60.2	5.7	3.5
4.	Compass x 6	69.7	6.3	0.6
5.	Folicur x 6	76.1	5.6	2.4
6.	Bravo x 6	68.4	4.7	3.3
7.	Bayleton x 3	70.4	9.6	2.8
8.	Corbel x 3	62.7	3.6	3.5
9.	Compass x 3	77.1	3.8	1.1
10.	Folicur x 3	70.0	7.5	1.1
11.	Bravo x 3	66.4	5.4	3.0
SED (30 df)		8.93	3.69	1.60
F test		NS	NS	NS

NS - No significant differences

Table 28. **Experiment 2: Effect if fungicide treatments in the incidence of disease symptoms and splitting of the lateral root surface, Wilby 1995/96.**

	Treatment	% roots affected			
		Brown Spots	Cavity Spot	Black Scurf	Splits
1.	Untreated control	3.2 (6.0)	2.2 (4.9)	3.0 (6.0)	6.0
2.	Bayleton x 6	5.5 (7.8)	3.3 (6.0)	0.6 (1.4)	5.5
3.	Corbel x 6	10.3 (12.0)	3.6 (5.0)	3.3 (4.9)	3.5
4.	Compass x 6	3.1 (6.9)	2.1 (4.9)	2.8 (6.0)	4.5
5.	Folicur x 6	1.9 (4.9)	3.4 (6.6)	0.0 (0.0)	2.4
6.	Bravo x 6	4.9 (8.1)	2.4 (4.3)	3.3 (6.6)	3.2
7.	Bayleton x 3	4.8 (7.2)	3.6 (6.1)	2.1 (3.9)	5.7
8.	Corbel x 3	5.8 (6.9)	5.1 (7.0)	5.2 (6.0)	4.5
9.	Compass x 3	3.6 (5.3)	2.1 (3.9)	1.6 (3.5)	3.8
10.	Folicur x 3	3.3 (6.0)	3.6 (5.3)	0.0 (0.0)	4.5
11.	Bravo x 3	4.1 (6.7	3.1 (5.7	2.2 (3.9)	3.6
SED (30 df)		3.53	3.57	3.26	3.10
F test		NS	NS	NS	NS

NS - No significant differences

Analysed data are angular transformation of percentages and are shown in parentheses

Experiment 2: Foliar fungicides

1994/95

The foliar fungicide experiment was well established before the first treatments were applied. There were no differences in root number or in the incidence of fanging between the treatments (Table 23). There were no yield differences between treatments (Table 23). Foliar diseases were present at low levels until October when downy mildew developed rapidly to affect 32.5% leaf area on 1 November. All treatments appeared to partially reduce the severity of downy mildew but only Bravo gave effective control (Table 24). Powdery mildew occurred at trace levels only in early August and this increased on the oldest leaves and petioles to affect 2.6% leaf area in control plots on 9 September (Table 24). Subsequently, there was little further development and on 7 October disease severity was comparable to that recorded on 9 September.

All treatments except Bravo which had been applied in July and/or August gave complete control of powdery mildew (Table 24) on 9 September. Bravo applied in August gave good control at the September assessment.

Typical 'shot-hole' symptoms of Ramularia leaf spot developed in small patches or foci in the plots and were recorded from October onwards. This patchy distribution hampered analysis of the data from the October assessment but on 1 November all fungicides reduced the severity of Ramularia infection particularly where September and October sprays were included (Table 24).

The development of canker on untreated area of crop adjacent to the experiment was monitored up to 26 February 1995 when 50% roots had canker lesions. Canker was first recorded on 1% roots on 1 November and developed slowly up to 24 January. Most lesions were small brown spots or blotches and by 1 February only 1% of roots showed large black lesions typical of Itersonilia canker.

A final harvest assessment was made on 6 February when both crown and 'lateral' cankers were present (Table 25) on about 20% of roots in the untreated area adjacent to the plots. Although *Itersonilia pastinacae* could be recovered from all lesions tested, the brown lesions have been attributed to *Phoma complanata* which was also sporulating on many of the lesions.

Black crown cankers were typical of those caused by *I. pastinacae*. There were no significant treatment differences for either crown or lateral cankers (Table 25). However, it is of interest to note that the lowest incidence of crown (black and brown lesions) and lateral brown lesions was in plots treated with either Folicur or Bravo.

Further analyses of lesion numbers and size of lesions on affected roots failed to reveal treatment differences and these data are not presented.

1995/96

Fungicides were applied to an unridged crop cv. Javelin whose growth was checked by high summer temperatures and drought. This checked disease development on the foliage during the summer and even when new growth was produced from September onwards, no foliar diseases were recorded. Mild conditions in the autumn resulted in prolongation of leaf retention well into December. Subsequently, severe frosty conditions prevented further spray applications. A single harvest assessment was made on 5 March 1996.

There were no effects of fungicide treatment on numbers of roots, harvested weight, root diameter or incidence of fanging (Table 26). Treatments had no effect on the percentage of healthy roots or the incidence of brown spots or cavity spot on the crown (Table 27). There was a low incidence of brown spotting, cavity spot, black scurf and splitting on the lateral root surface (Table 27) but treatment differences were not significant. Interestingly, no black scurf was recorded on the plots which received either full or limited programmes of Folicur (Table 28). Black scurf was first seen in December (Table 61) which suggests that both full and first disease programmes had opportunity to show protectant and curative properties.

Results

1995/96

Itersonilia spp. were not detected until late September at experimental sites in Norfolk (Table 67) but numbers increased rapidly in November. The control of *Itersonilia* spp was determined using agar plates exposed in individual treated plots 1, 2 and 4 weeks after treatment in mid October. Very low numbers of colonies were recorded after one week and results for 2 and 4 weeks after treatment are shown in Figures 1-4. The full programme which had received 4 sprays (19 July - 18 October) in Figs. 1 and 3 may be compared with the 'first disease' treatments which had received only a single spray in October (Figs 2 and 4).

The full programme showed traces of *I. pastinacae* in the Bayleton and Compass treated plots only. *I. perplexans* was present in the untreated control and Bayleton, Corbel and Compass treatments but not following sprays of Folicur or Bravo (Fig. 1). The single spray in October also revealed low colony numbers, with *I. pastinacae* present after Bayleton and Folicur treatments. *I. perplexans* was not found after the application of Corbel, Compass and Folicur (Fig.2).

Colony numbers had increased by more than 100 fold during the first two weeks of November and differences between treatments were detected ($P < 0.01$). Folicur and Bravo programmes gave lower colony numbers than Compass and Corbel but did not differ from the untreated control (Fig. 3). Differences in colony counts of *I. perplexans* were significant ($P < 0.001$). The Compass programme gave much higher counts than all other treatments and the untreated control (Fig. 3). Folicur sprays from July gave the lowest colony numbers and this treatment was lower than all the other fungicide treatments (but not the control) (Fig. 3). Single sprays in October had no effect on *I. perplexans* four weeks after treatment (Fig. 4). Bayleton applied in October appeared to aggravate *I. pastinacae* compared with most other treatments.

1996/97

When the first spray treatments were applied on 22 July, 55% plants showed powdery mildew symptoms. Disease severity was very low with affected plants showing a few small colonies on petioles or leaves and this early development was patchy within the crop. The foliage was well developed (0.3-0.5 m tall) and gave full ground cover. The oldest 1-2 leaves were already senescent but no *Itersonilia* was found when leaf pieces were tested. The first sprays were applied under high temperature conditions (25°C, although 32°C maximum was reported nearby) and some scorch from Corbel was apparent at the next visit on 12 August. Powdery mildew increased rapidly in late July/early August to affect over 50% area of the oldest leaves and 10-20% of other mature leaves. The most effective treatments reduced powdery mildew to occasional pustules on the petioles whilst moderately good treatments had occasional badly affected leaves. By early September, disease severity was still high and untreated plants had 5-6 green leaves and over 20% powdery mildew. *Itersonilia* spp. were first detected at the 12 August sampling and 'first disease' treatments were initiated from 3 September.

Powdery mildew increased rapidly after application of the first spray from c.1% to 13.8% leaf area in three weeks. All the fungicides provided control with Corbel, Compass and Folicur being particularly effective (Table 30). Three weeks after the second spray fungicides maintained good powdery mildew control under sustained disease pressure. On 24 September, half the treatments had received 3 sprays and the remainder a single spray (3 September) against established mildew. Folicur and Bravo appeared to be most effective against established disease, although Bravo no longer maintained control in the full programme. Bayleton, Corbel and Folicur were particularly effective in programmes (Table 30). A final assessment on petioles on 26 November indicated general suppression of powdery mildew by all treatments with only Corbel providing >50% control (Table 30).

A feature of these experiments was the prolongation of green leaf tissue. This was first apparent for Bravo on 15 October and although not significant on 5 November, large differences were least apparent for Corbel treatments and differences between the full and first disease programmes are thought to reflect phytotoxicity from the first spray of Corbel under high temperature conditions. The final root yield was correlated with green leaf area particularly on 15 October assessment.

Yield differences between treatments first failed to reach significance (probability 5.8%) (Table 29). The first disease programme of Bravo gave the highest yield, 0.28kg more than the control yield of 2.7 kg/m row. There were indications that treatments slightly increased root diameter but only Folicur (full programme) gave a significant increase (Table 29).

Monitoring of *Itersonilia* spp. was completed, one, two and three weeks after spray treatments applied on 3 September and enabled comparisons to be drawn between a single spray and a spray programme of three applications. *Itersonilia* activity was higher in the untreated control plots than in the adjacent farm crop which had received sprays of Corbel and Bayleton on 8 and 25 August respectively (Table 32). Compass, Bravo and Folicur increased *I. perplexans* on 10 September but *I. pastinacae* was not affected by fungicide treatments on 10 and 17 September assessments. Some rain fell during the sampling period on 17 September and this may have affected final results compared with other sampling dates. Three weeks after treatment, Folicur gave a reduction in *I. pastinacae* compared with the control and the full programmes of all the other fungicides except Bravo. Only Folicur gave control of *I. pastinacae* three weeks after a single spray. No fungicides controlled *I. perplexans* three weeks after treatment (Table 32). There were higher numbers of colonies of *I. perplexans* after 3 sprays of Bayleton than after one spray of Bayleton.

Fungicide sprays had no effect on the percentage of healthy roots at harvest (Table 33). Brown spotting and large brown lesions (Phoma canker) were present but not severe (Table 33) on crowns and there were traces of cavity spot, black warty growths and brown banding symptoms (Table 34). On lateral root surfaces, brown spotting, cavity spot, black surface splitting, large brown (phoma) lesions, carrot fly mining and brown banding were recorded at low incidence (Tables 35 and 36). Splitting was less common where fungicides had been applied, but treatment differences were not significant.

Table 29. Experiment 2: Effect of fungicide spray treatments, on root number, yield, root size and fanged roots, East Harling 1996/97

	Treatment	Number of roots/m	Harvested weight (kg/m row)	Root diameter (cm)	% fanged roots /m row
1.	Untreated control	10.1	2.71	6.9	6.8
2.	Bayleton x 9	10.9	2.61	6.9	1.7
3.	Corbel x 9	10.7	2.43	7.1	2.8
4.	Compass x 9	11.2	2.95	6.9	4.4
5.	Folicur x 9	10.7	2.97	7.5	5.1
6.	Bravo x 9	11.2	2.85	7.1	2.6
7.	Bayleton x 7	12.0	2.65	6.8	3.1
8.	Corbel x 7	9.9	2.69	7.1	6.3
9.	Compass x 7	10.4	2.62	7.0	2.4
10.	Folicur x 7	10.8	2.73	7.1	6.3
11.	Bravo x 7	11.7	2.99	7.1	3.7
SED (30 df)		0.75	0.172	0.17	1.89
CV (%)		9.8	8.9	3.3	64.8
F test		NS	NS	5%	NS

NS - No significant differences

Table 30. Experiment 2: Effect of fungicide treatments on the severity of powdery mildew on foliage, East Harling 1996/97

	Treatment	% powdery mildew			
		12 Aug	3 Sept	24 Sept	26 Nov (petiole)
1.	Untreated control	13.8	17.3	19.5	3.0
2.	Bayleton x 9	2.1	1.1	1.8	2.0
3.	Corbel x 9	1.1	0.8	0.6	1.3
4.	Compass x 9	1.2	2.4	4.8	1.5
5.	Folicur x 9	1.2	2.1	2.5	1.5
6.	Bravo x 9	4.4	4.8	17.3	2.3
7.	Bayleton x 7	13.3	16.0	13.8	1.8
8.	Corbel x 7	16.3	21.3	23.8	2.0
9.	Compass x 7	14.8	21.0	18.8	2.0
10.	Folicur x 7	12.6	16.0	10.5	2.0
11.	Bravo x 7	14.0	18.8	10.5	1.5
SED (30 df)		1.39	2.90	3.66	0.44
F test		<0.1%	<0.1%	<0.1%	5%

NS - No significant differences

Table 31. Experiment 2: Effect of fungicide treatments on the retention of green leaf tissue, East Harling 1996/97

	Treatment	% Green leaf area		
		15 Oct	5 Nov	26 Nov
1.	Untreated control	76.3	61.3	27.5
2.	Bayleton x 9	82.5	65.0	42.5
3.	Corbel x 9	76.3	50.0	16.3
4.	Compass x 9	86.9	82.5	53.7
5.	Folicur x 9	83.8	65.0	31.3
6.	Bravo x 9	92.5	92.5	86.2
7.	Bayleton x 7	79.4	58.8	40.0
8.	Corbel x 7	76.9	62.5	35.0
9.	Compass x 7	78.8	74.4	65.0
10.	Folicur x 7	81.9	85.0	68.7
11.	Bravo x 7	92.5	91.9	81.2
SED (30 df)		4.49	13.36	9.53
F test		1%	NS	<0.1%

NS - No significant differences

Table 32. Experiment 2: Effect of fungicide treatments on the number of *Itersonilia* colonies recorded on agar sampling plates one, two and three weeks after treatment, East Harling 1996/97

	Treatment	Number of Itersonilia colonies/plate					
		10 Sept		17 Sept		24 Sept	
		I pas*	I per*	I pas	I per*	I pas*	I per*
1.	Untreated control	25.9(1.4)	2.6(0.5)	0.4	3.8(0.7)	55.9(2.7)	7.9(1.1)
2.	Bayleton x 9	4.0(0.7)	5.5(1.1)	20.6	24.4(2.2)	137.6(3.3)	64.1(3.0)
3.	Corbel x 9	119.6(3.3)	4.9(0.6)	37.5	25.5(1.4)	144.8(3.7)	51.4(1.6)
4.	Compass x 9	15.0(1.5)	19.5(1.8)	2.3	40.1(2.0)	94.1(2.3)	45.8(2.1)
5.	Folicur x 9	4.1(0.7)	19.5(1.6)	1.1	74.6(2.6)	1.9(0.5)	7.9(0.8)
6.	Bravo x 9	17.3(1.7)	12.0(1.5)	0.0	55.1(1.6)	17.6(1.3)	24.0(2.0)
7.	Bayleton x 7	26.6(2.0)	0.0(0.0)	30.0	3.0(0.6)	63.4(2.8)	7.9(0.9)
8.	Corbel x 7	7.9(1.1)	2.3(0.5)	3.8	15.4(1.4)	23.3(1.5)	3.4(0.7)
9.	Compass x 7	10.1(1.2)	3.8(0.8)	0.8	11.3(0.7)	25.9(2.2)	3.8(0.7)
10.	Folicur x 7	27.0(1.7)	3.8(0.7)	0.8	25.1(1.1)	13.5(1.0)	10.1(1.3)
11.	Bravo x 7	60.4(2.2)	2.6(0.6)	6.8	23.6(1.2)	57.4(2.4)	43.9(2.1)
SED (30 df)		(0.81)	(0.37)		(0.77)	(0.74)	(0.69)
F test		NS	<0.1%	Skew	NS	1%	5%

NS - No significant differences
* Log(n + 1) transformed data analysed
I pas - *Itersonilia pastinacae*, causes parsnip canker
I per - *Itersonilia perplexans*, non- or weakly pathogenic leaf inhabitant

Table 33. Experiment 2: Effect of fungicide treatments on the incidence of healthy roots, and disease symptoms on the root crown, East Harling 1996/97

	Treatment	% roots affected			
		Healthy	Brown spot	Large brown*	
1.	Untreated control	71.3	14.2	0.6	(2.2)
2.	Bayleton x 9	78.0	14.7	0.5	(2.0)
3.	Corbel x 9	76.2	14.4	1.7	(5.2)
4.	Compass x 9	69.2	12.7	2.3	(7.4)
5.	Folicur x 9	73.3	12.6	1.2	(4.5)
6.	Bravo x 9	78.6	8.2	2.2	(7.2)
7.	Bayleton x 7	81.4	9.0	0.6	(2.2)
8.	Corbel x 7	69.6	11.4	1.3	(4.6)
9.	Compass x 7	77.8	6.5	1.2	(4.4)
10.	Folicur x 7	78.9	5.8	0.5	(2.0)
11.	Bravo x 7	73.8	9.9	0.5	(2.1)
SED (30 df)		5.33	3.99	3.54	
F test		NS	NS	NS	

NS - No significant differences
* Angular transformed data analysed, transformed data in parentheses.

Table 34. Experiment 2: Effect of fungicide treatments on the incidence of disease symptoms on the root crown, East Harling 1996/97

	Treatment	% roots affected			
		Black wart*		Cavity spot	Brown banding
1.	Untreated control	0.0	(0.0)	1.8	0.0
2.	Bayleton x 9	1.2	(4.4)	0.0	0.6
3.	Corbel x 9	2.5	(6.4)	0.5	0.5
4.	Compass x 9	1.8	(5.3)	1.7	1.1
5.	Folicur x 9	0.5	(2.1)	0.7	0.5
6.	Bravo x 9	1.3	(3.2)	0.0	0.5
7.	Bayleton x 7	2.7	(8.1)	0.0	2.2
8.	Corbel x 7	3.2	(8.8)	0.0	0.0
9.	Compass x 7	4.3	(10.0)	1.2	0.6
10.	Folicur x 7	3.0	(8.6)	0.0	0.7
11.	Bravo x 7	0.5	(2.0)	0.5	1.0
SED (30 df)			(3.53)	0.64	0.82
F test		NS		Skew	Skew

NS - No significant differences
* Angular transformed data analysed, transformed data in parentheses.

Table 35. Experiment 2: Effect of fungicide treatments in the incidence of disease symptoms and splitting of the lateral root surface, East Harling 1996/97

	Treatment	% roots affected					
		Brown spots		Cavity spot	Black scurf	Splits	
1.	Untreated control	2.4	(6.1)	0.6	0.0	6.6	(14.5)
2.	Bayleton x 9	1.7	(6.5)	0.5	1.7	1.6	(5.1)
3.	Corbel x 9	1.7	(3.8)	0.0	0.6	1.2	(4.5)
4.	Compass x 9	3.2	(6.9)	0.0	0.6	1.7	(6.5)
5.	Folicur x 9	1.7	(6.6)	1.9	0.0	1.2	(4.5)
6.	Bravo x 9	1.3	(4.6)	0.6	0.5	2.5	(6.1)
7.	Bayleton x 7	1.5	(5.0)	0.0	1.0	1.0	(2.9)
8.	Corbel x 7	1.3	(4.6)	0.6	0.6	0.6	(2.3)
9.	Compass x 7	1.8	(6.6)	1.2	1.2	1.7	(5.3)
10.	Folicur x 7	2.4	(7.7)	0.5	0.0	1.7	(5.2)
11.	Bravo x 7	3.7	(9.4)	1.5	3.8	1.0	(2.9)
SED (30 df)			(4.55)	0.96	0.95		(3.85)
F test			NS	Skew	Skew		NS

NS - No significant differences

Analysed data are angular transformation of percentages and are shown in parentheses

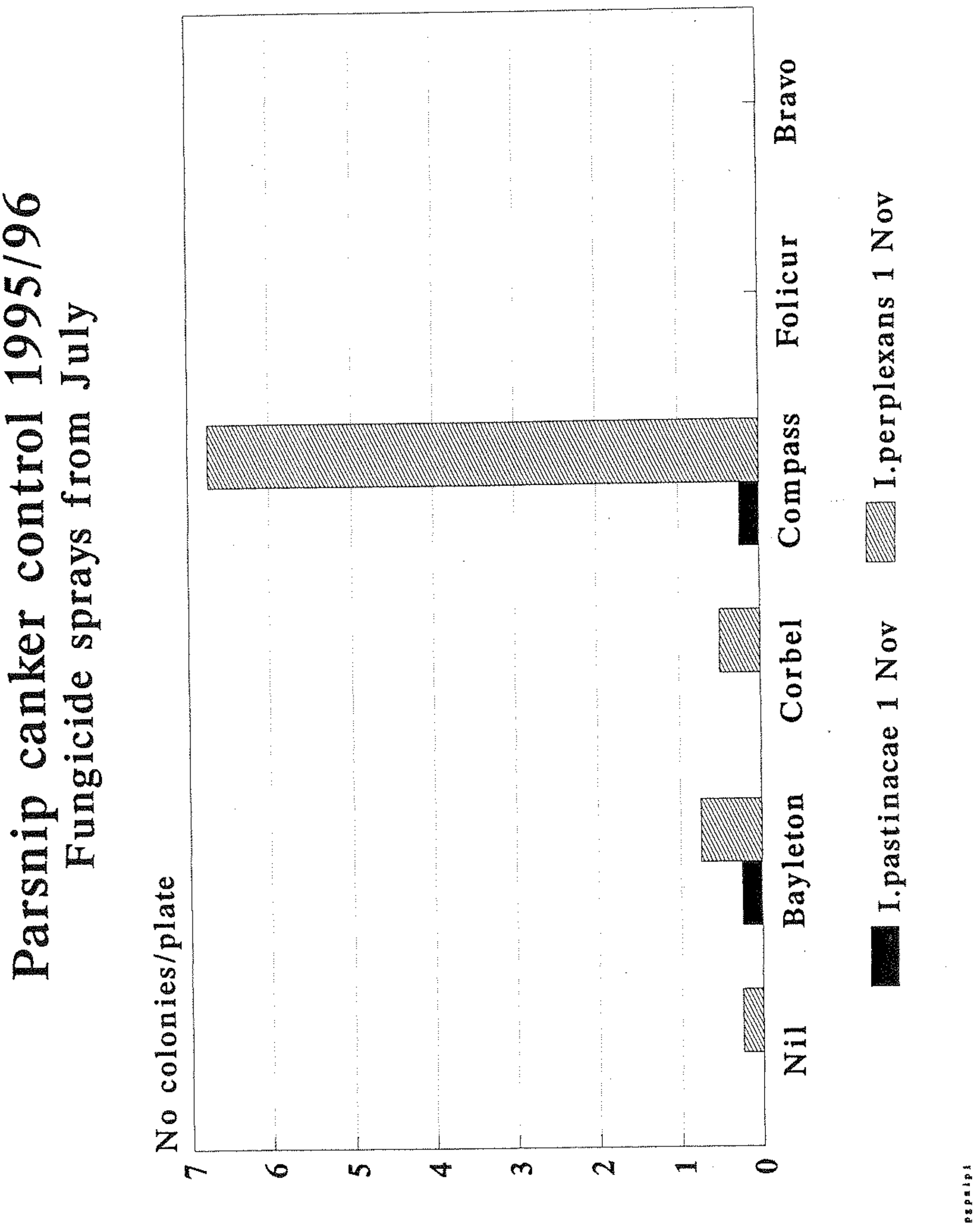
Table 36 **Experiment 2: Effect of fungicide treatments in the incidence of disease symptoms and splitting of the lateral root surface, East Harling 1996/97**

Treatment		% roots affected		
		Large brown	Carrot fly damage	Brown banding
1.	Untreated control	1.2	3.1	0.7
2.	Bayleton x 9	0.5	0.0	0.0
3.	Corbel x 9	0.0	0.0	0.5
4.	Compass x 9	2.3	0.6	1.6
5.	Folicur x 9	0.5	3.9	0.5
6.	Bravo x 9	0.0	3.4	0.0
7.	Bayleton x 7	0.0	1.5	1.0
8.	Corbel x 7	0.6	3.2	1.3
9.	Compass x 7	0.6	0.0	0.6
10.	Folicur x 7	0.5	1.5	1.0
11.	Bravo x 7	0.5	1.5	1.0
SED (30 df)		0.93	2.45	0.84
F test		Skew	Skew	Skew

NS - No significant differences

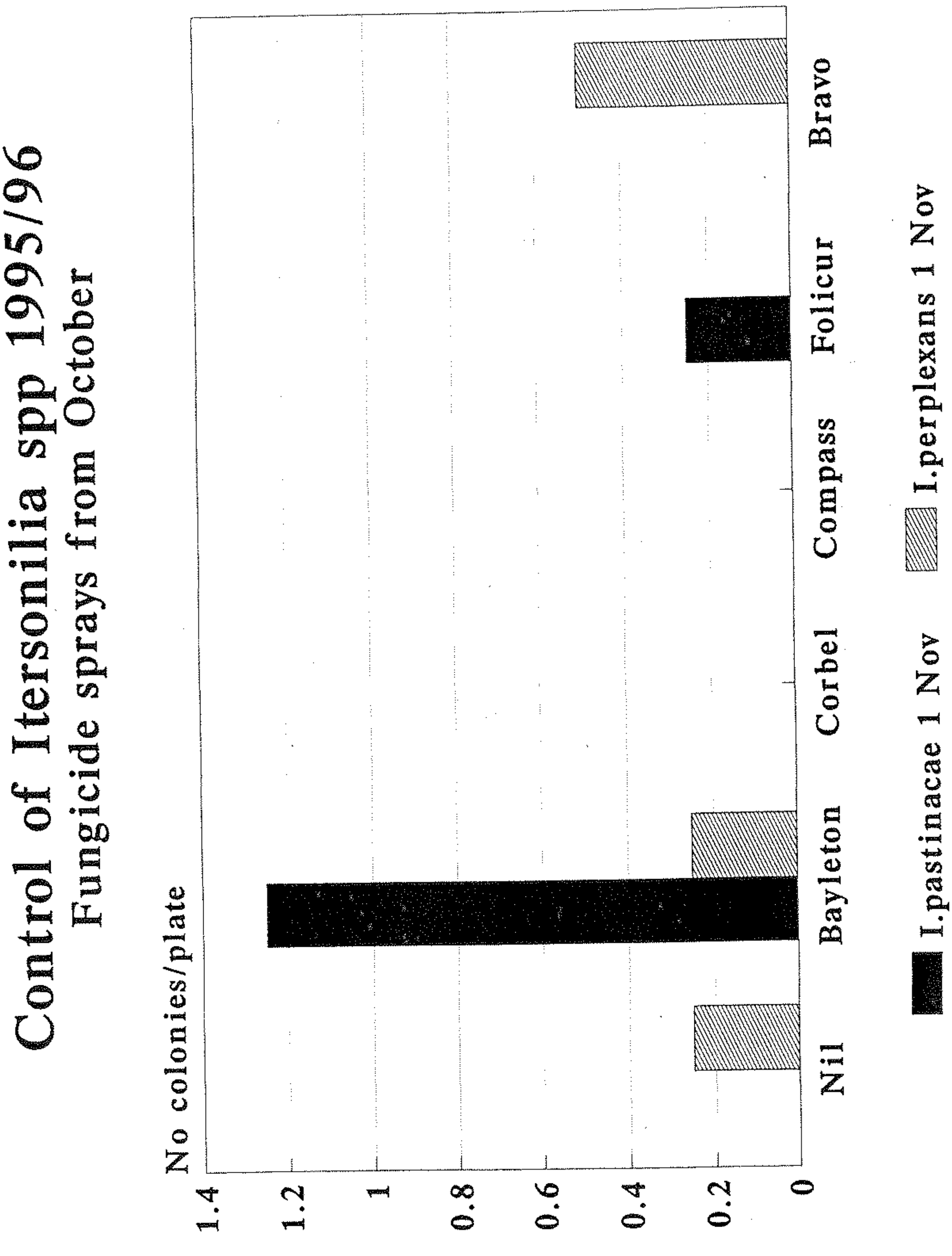
Analysed data are angular transformation of percentages and are shown in parentheses

Fig. 1



Parsnip canker control 1995/96
Fungicide sprays from July
No colonies/plate
7
6
5
4
3
2
1
0
Nil
Bayleton
Corbel
Compass
Folicur
Bravo
I.pastinacae 1 Nov
I.perplexans 1 Nov

Fig. 2



Control of Itersonilia spp 1995/96
Fungicide sprays from October
No colonies/plate
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Nil
Bayleton
Corbel
Compass
Folicur
Bravo
I.pastinacae 1 Nov
I.perplexans 1 Nov

Fig. 3

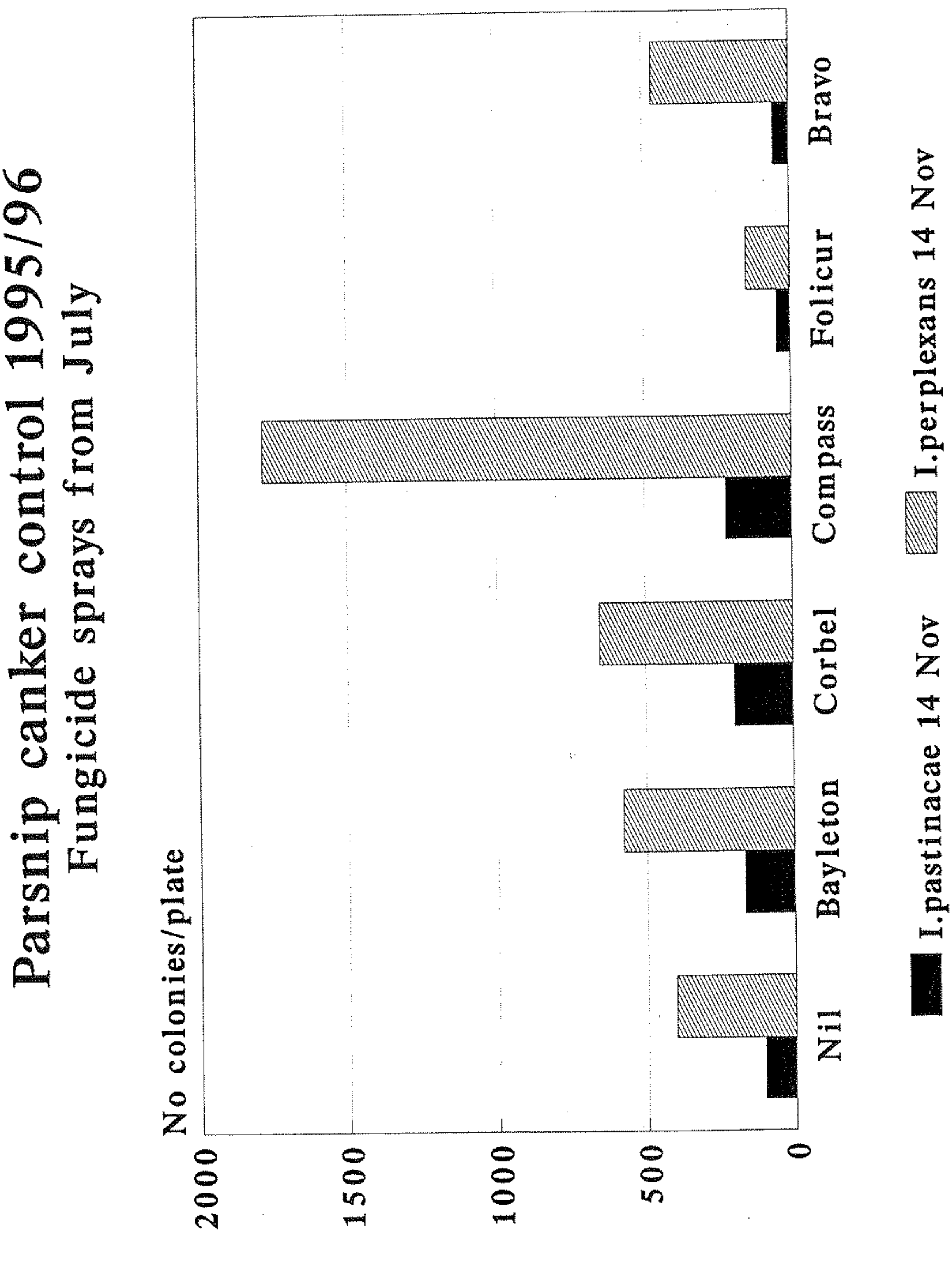

Parsnip canker control 1995/96
Fungicide sprays from July
No colonies/plate
2000
1500
1000
500
0
Nil
Bayleton
Corbel
Compass
Folicur
Bravo
I.pastinacae 14 Nov
I.perplexans 14 Nov

Fig. 4

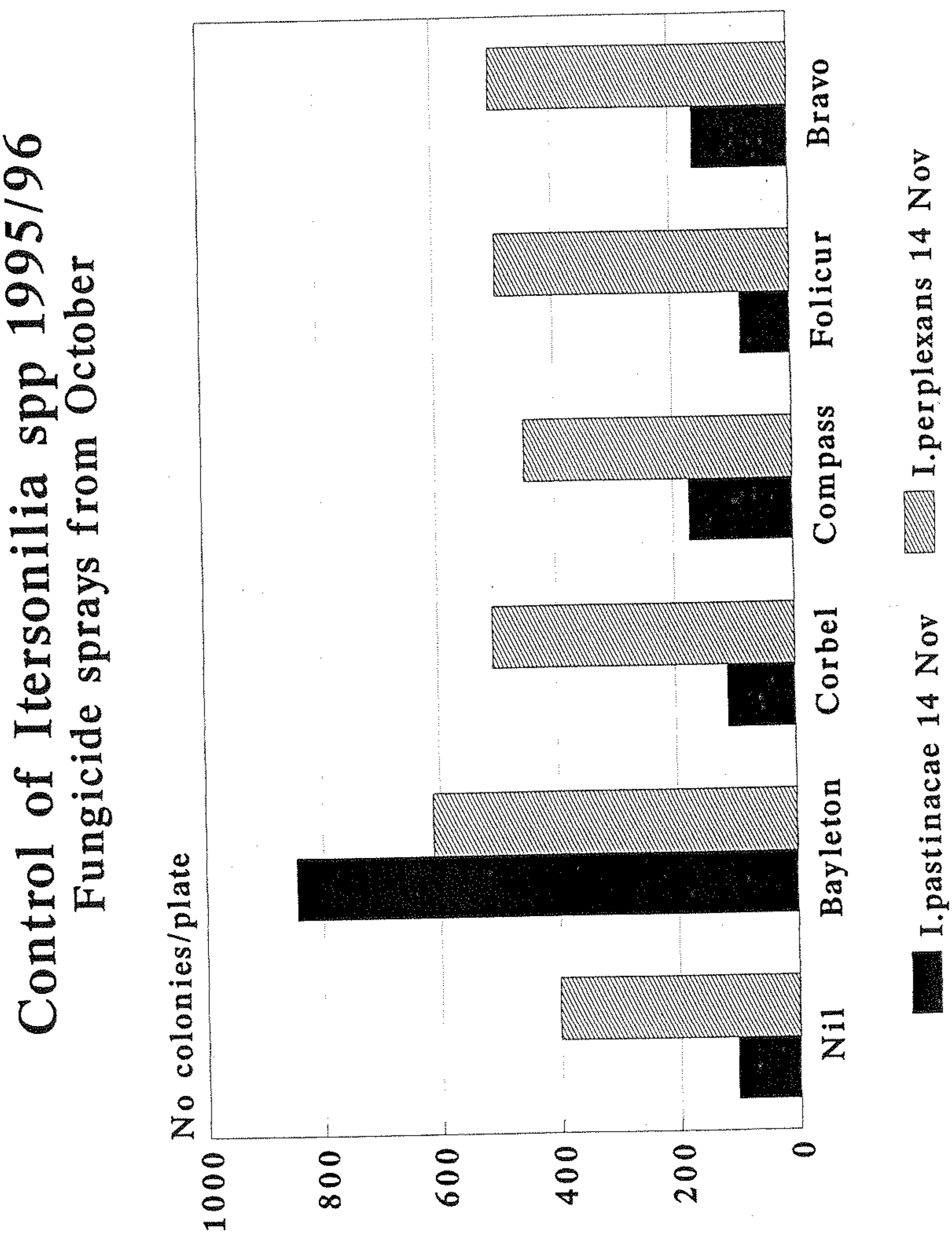
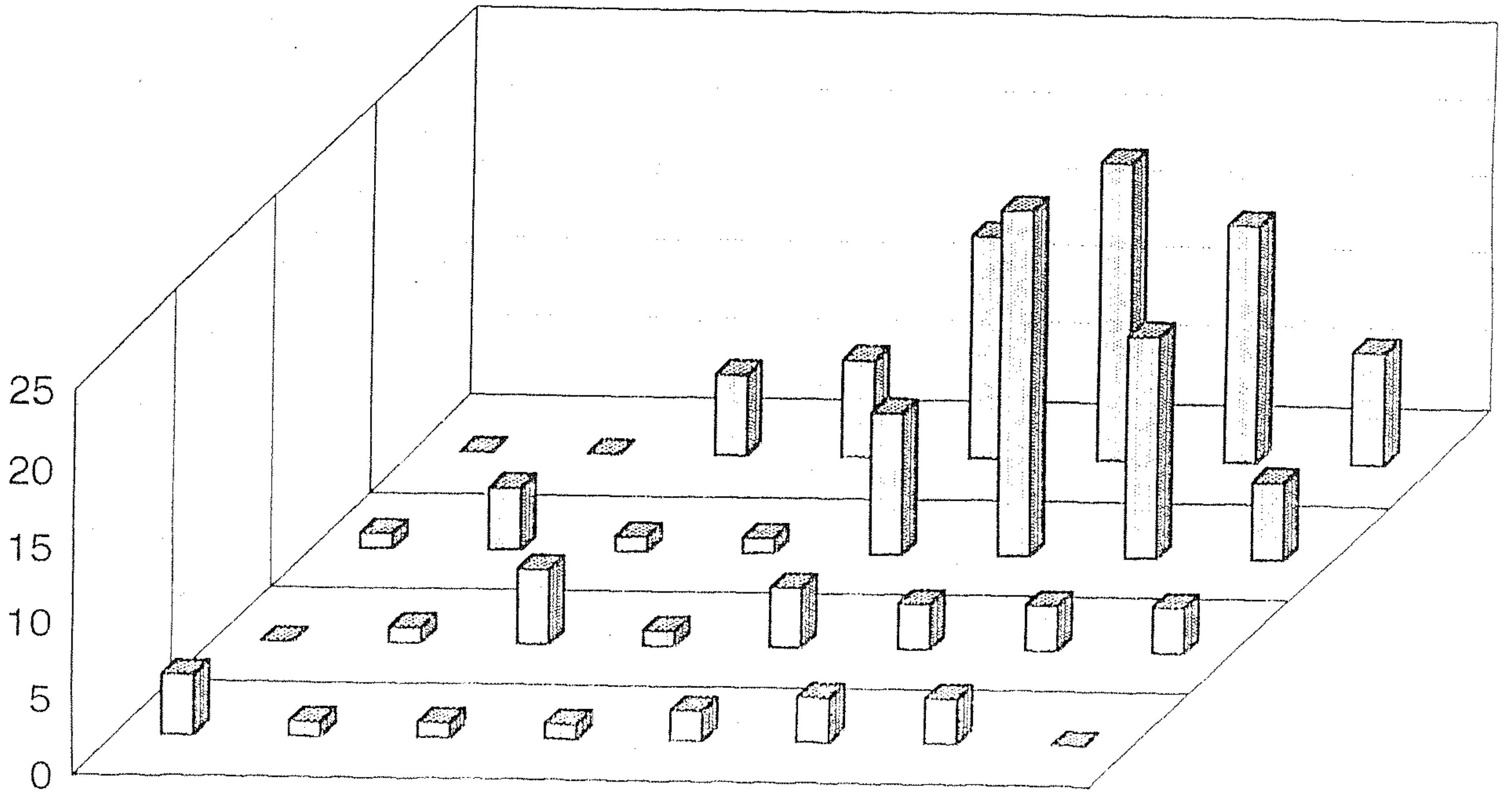

Control of Itersonilia spp 1995/96
Fungicide sprays from October
No colonies/plate
1000
800
600
400
200
0
Nil
Bayleton
Corbel
Compass
Folicur
Bravo
I.pastinacae 14 Nov
I.perplexans 14 Nov

Fig. 5

Beck Row Parnip Ridging 1995-96

Distribution of fanged root over trial area (% roots affected)



Experiment 3: Soil ridging 1994/95

The soil ridging experiment was carried out in uniformly established crop and there were no effects of treatment on the total number of roots or the number of fanged roots (Table 37). Treatments had no effect on the weight of roots harvested on 14 February 1995.

Canker incidence and severity was assessed on all roots harvested from each plot on 14 February 1995. Soil ridging in July gave reductions in both black and brown crown canker and in lateral brown canker (Table 38). There were no effects of soil amendment with crab shell on canker incidence. Further analysis of the number of brown canker lesions on affected roots and lesion diameter (expressed as % of root circumference affected) suggested that soil ridging had affected lesion size. Brown crown lesions were smaller on ridged than unridged treatments, whereas soil ridging appeared to have increased the size of brown lateral cankers (Table 39).

Table 37. Experiment 3: Effect of ridging and soil amendment on the number of roots, fanging and harvested weight, Wilby, 14 February 1995.

Treatment	Number of roots /m row	Harvested weight kg/m row	Number of fanged roots / m row
Ridging treatment			
Unridged	13.3	2.8	1.1
Ridged	14.2	2.8	1.0
SED (25 df)	0.82	0.07	0.08
F test	NS	NS	NS
Soil amendment			
Nil	13.8	2.8	1.1
Crab shell x 1 (July)	13.7	2.8	0.9
Crab shell x 2 (July + Aug)	13.9	2.8	1.1
SED (25 df)	1.00	0.09	0.10
CV(%)	17.8	8.2	24.4
F test	NS	NS	NS

NS - No significant differences

Table 38. Experiment 3: Effect of ridging and soil amendment on the incidence of various types of crown and root cankers, Wilby 14 February 1995

Treatment	% Roots affected by canker Crown black	Crown brown	Lateral black	Lateral brown
Ridging treatment				
Unridged	1.46	28.7	0.19	7.67
Ridged	0.33	19.1	0.50	3.72
SED (25 df)	0.510	2.64	0.390	1.715
F Test	5%	0.1%	NS	5%
Soil amendment				
Nil	0.40	22.2	0.64	5.29
Crab shell x 1 (July)	0.94	28.0	0.29	5.78
Crab shell x 2 (July + Aug)	1.33	21.5	0.12	6.02
SED (25 df)	0.625	3.23	0.477	2.100
F test	NS	NS	NS	NS

NS - No significant differences

Table 39. Experiment 3: Effect of ridging and soil amendment on the number and severity of brown canker lesions, Wilby 1994/95

Treatment	Number of lesions /affected roots		Mean % root circumference affected	
	Crown	Lateral	Crown	Lateral
Ridging treatment				
Unridged	1.4	0.9	18.6	3.8
Ridged	1.4	1.2	10.6	6.9
SED (25 df)	0.076	0.19	2.51	1.45
F test	NS	NS	1%	5%
Soil amendment				
Nil	1.5	1.0	14.9	4.2
Crab shell x 1 (July)	1.4	1.1	13.5	7.5
Crab shell x 2 (July + Aug)	1.4	1.1	15.4	4.4
SED (25df)	0.093	0.24	3.08	1.78
F test	NS	NS	NS	NS

NS - No significant differences

Table 40. **Depth of soil cover over parsnips at Ridging Sites at harvest 1995/96**

Site	Unridged	Ridged early	Ridged late	Ridged early + late
Wilby 1	4.0 cm	7.5 cm	7.5 cm	7.5 cm
Wilby 2	NA	NA	NA	NA
Wilby 3	1.0 cm	-	3.5cm	-
Bodney	5.0 cm	8.0 cm	-	-
Saracens Head	4.0 cm	5.0 cm	8.0 cm	7.0 cm
Beck Row	5.6 cm	8.0 cm	8.0 cm	8.0 cm

NA - Not assessed

\- - No treatment

Table 41. Experiment 3: Effect of soil ridging treatments on % healthy roots, fanged roots and crown disease symptoms, Wilby 1, 5 March 1996

Treatment	% roots affected			
	Healthy	Fanged	Brown Spots	Cavity Spot
Unridged	63.5	5.5	7.0	5.5
Ridged early	77.0	5.5	5.5	5.0
Ridged late	75.5	3.0	3.5	3.0
Ridged early + late	73.0	7.5	3.5	2.0
Significant differences	NS	NS	NS	NS

NS - No significant differences

Table 42. Experiment 3: Effect of soil ridging treatments on lateral root symptoms, Wilby 1, 5 March 1996

Treatment	% roots affected				
	Brown Spots	Cavity Spot	Splits	Black Scurf	Carrot fly
Unridged	5.5	7.0	5.5	3.5	0
Ridged early	2.0	2.5	4.5	0.5	1.0
Ridged late	2.5	3.5	8.0	0	2.0
Ridged early + late	6.5	6.0	1.5	0.5	0
Significant differences	NS	NS	NS	0.1%	5%

NS - No significant differences

Table 43. Effect of soil ridging treatments on root weight, root diameter at Wilby 1, 5 March 1996

Treatment	Weight of 25 root (kg)	Root diameter (cm)
Unridged	2.2	4.3
Ridged early	2.4	4.3
Ridged late	2.6	4.6
Ridged early + late	2.2	4.2
Significant differences	NS	NS

NS - No significant differences

Table 44. Experiment 3: Effect of late soil ridging on the incidence of healthy, fanged and symptoms on the crown of the root, Wilby (Site 3), 7 March 1996

Treatment	% roots affected		
	Healthy	Fanged	Brown spots
Ridged late	79.5	11.5	7.5
Unridged	82.0	10.5	7.0
Significant differences	NS	NS	NS

NS - No significant differences

Table 45. Experiment 3: Effect of late soil ridging treatments on the incidence of lateral root symptoms and root weight, Wilby (Site 3), 7 March 1996

Treatment	% roots affected				
	Brown Spots	Black Scurf	Splits	Weight of 25 roots (kg)	Root diameter (cm)
Ridged late	3.5	0	2.5	2.6	4.2
Unridged	3.5	1.0	3.0	2.8	4.3
Significant differences	NS	NS	NS	NS	NS

NS - No significant differences

1995/96

The soil ridging study involved six sites in 1995/96 within the main production areas of Norfolk, Suffolk and Lincolnshire. Details of soil analyses and soil textures determined by laboratory analysis at these sites are provided in Appendix 2. Soil types ranged from loamy sand to silty clay loam. One site (Wilby 2) was harvested early and no canker symptoms were observed. A nearby site (Wilby 3) was used to provide a test of a late ridging treatment. Two assessments were made at the site at Bodney where only an early ridging treatment was used because the crop proved unmarketable by December. Table 40 summarises the depth of soil which was covering the crowns of the parsnips at harvest. The sites at Wilby and Bodney were prepared with farm equipment, those at Saracen's Head and Beck Row by hand.

The site at Wilby 1 had a low incidence of small brown spots and cavity spots in all treatments. There were 10% more healthy roots in all the ridged treatments (Table 41) but differences were not significant. These appeared to be less black scurf and more carrot fly damage following ridging treatments (Table 42) but as affected roots occurred in only a few replicates, the results should be treated cautiously. The late ridging treatment gave 3% roots with 'mechanical' damage, this was not recorded in other treatments. There were no effects on root size or harvest weights (Table 43).

The late ridging treatment at Wilby 3 was carried out in mid December, just prior to a prolonged period of cold frosty weather. The site gave a high proportion of blemish-free roots and there was no benefit from soil ridging (Tables 44 & 45).

At Bodney, severe root blemishes rendered the crop unmarketable in the late autumn. There appeared to be relatively small changes in disease incidence between assessments on 15 December and 29 February (Table 46) except for an increase in cavity spot symptoms. There was no Itersonilia canker and only a low incidence of phoma canker (*Phoma complanata*) which gave large brown lesions on the crown and lateral roots. Cavity spot symptoms were encountered for the first time in the project. These were typically small brown elliptical lesions, slightly sunken with evidence of a slight cavity 1-2mm below the epidermis. Such lesions were frequently penetrating several millimetres into the root. Diagnosis was made by sectioning individual lesions to check for tissue collapse and deep penetration. Cavity spot lesions were recorded on both the crown and lateral root surfaces (Table 46).

Soil ridging during the summer gave significantly higher numbers of healthy roots at both assessments. This was associated with reductions in small brown spots and dark brown rots associated with splitting of roots 15-17.5cm down the root. Ridging also appeared to have reduced cavity spot on lateral root surface at the second assessment (Table 46).

Table 46. Effect of early soil ridging on the incidence of healthy root, root weight and symptoms on the crown and lateral root on two assessment dates, Bodney, 1996.

	First assessment (15 December 1995)			Second assessment (29 February 1996)		
Assessment	Unridged	Ridged early	Significance level	Unridged	Ridged early	Significance level
% Healthy roots	1.5	28.0	<0.1%	3.2	39.2	<0.1%
% Fanged roots	4.5	4.0	NS	7.6	9.6	NS
Wt. of 25 roots (kg)	NA	NA		3.6	2.9	NS
Root diameter (cm)	NA	NA		5.8	5.0	1%
Crown symptoms						
Large brown	4.5	2.0	NS	2.0	0	NS
Brown spots	24.5	10.5	0.1%	18.0	4.0	<0.1%
Cavity spot	0	0	NS	5.2	2.0	NS
Lateral root symptoms						
Large brown	0	0	NS	2.0	0	NS
Brown spots	98.0	60.5	<0.1%	85.2	40.0	<0.1%
Cavity spot	5.5	4.5	NS	42.0	17.6	<0.1%
Dark split	19.5	8.0	0.1%	16.0	4.4	0.1%
Black scurf	5.5	11.0	NS	0.5	0.6	NS

NA - Not recorded
NS - No significant difference

Table 47. Experiment 3: Effect of soil ridging on the % healthy roots, fangs and crown disease symptoms and frost damage, Saracens Head, 26 March 1996

Treatment	% roots affected				
	Healthy	Fanged	Brown spot	Cavity spot	Frost damage
Unridged	62.5	8.5	13.0	2.0	1.0
Ridged early	64.5	11.5	9.5	1.5	0.0
Ridged late	63.5	7.0	17.5	5.0	0.5
Ridged early + late	62.5	10.0	13.0	4.0	2.5
Significant differences	NS	NS	NS	NS	NS

NS - No significant differences

Table 48. Experiment 3: Effect of soil ridging on the incidence of lateral root symptoms, Saracens Head, 26 March 1996

Treatment	% roots affected				
	Large brown	Brown spot	Cavity spot	Splits	Carrot fly
Unridged	0.0	4.5	0.5	10.5	2.0
Ridged early	0.5	1.5	1.0	7.5	3.5
Ridged late	0.0	1.5	1.0	6.0	3.0
Ridged early + late	0.0	2.0	1.0	8.0	0.0
Significant differences	NS	NS	NS	NS	NS

NS - No significant differences

Table 49. Experiment 3: Effect of soil ridging on root weight and root diameter, Saracens Head, 25 March 1996.

Treatment	Wt of 25 roots (kg)	Root diameter (cm)
Unridged	5.0	5.2
Ridged early	4.8	5.2
Ridged late	5.0	5.3
Ridged early + late	5.6	5.6
Significant differences	NS	NS

NS - No significant differences

At Saracens Head, brown spotting of the crown and lateral root surfaces was the most common blemish (Tables 47 and 48). Cavity spot, skin splitting and carrot fly damage were also present. There were no significant effects of soil ridging on root weight or root diameter (Table 49). Ridging aided the control of annual nettle weeds.

Beck Row, Suffolk was a high disease site where some Itersonilia black canker developed (Tables 50 and 51), only 20% of roots were healthy. Fanging was a major problem at this site but it showed a patchy distribution in the trial area. Samples were taken approximately 4 metres intervals along each of 4 four-row beds and this enabled the distribution of the fanging to be plotted (Fig. 5). The main patch occurred within 2 beds (c 4m) and over a distance of 12-20m within each bed. Peak incidence was 88% roots affected. Soil ridging had no effect on either large black or brown canker or brown spotting. Cavity spot appeared to be higher after a single early ridging treatment (Table 50). Although there appeared to be some effect of ridging on black canker (Table 50), the disease was very variable with individual samples ranging from 0 to 48% roots affected in the unridged control and differences were not significant. The additional soil cover did not affect carrot fly damage (Table 52). There was no effect on root size (Table 52).

Table 50 **Experiment 3: Effect of Soil Ridging on incidence of healthy, fanged and crown disease symptoms, Beck Row, 1 February 1996**

Treatment	% roots affected					
	Healthy	Fanged	Black canker	Brown canker	Brown spot	Cavity spot
Unridged	20.5	6.5	9.0	3.0	7.0	0.5
Ridged early	14.5	34.0	6.0	1.5	11.0	6.0
Ridged late	19.0	18.5	4.0	3.5	7.5	1.5
Ridged early + late	22.0	20.0	2.5	3.0	9.0	1.0
Significant differences	NS	NS	NS	NS	NS	5%

NS - No significant differences

Table 51 **Experiment 3: Effect of soil ridging treatments on the incidence of lateral root symptoms, Beck Row, 1 February 1996**

Treatment	% roots affected				
	Black lesions	Large brown lesions	Brown spots	Cavity spot	Dark spots
Unridged	1.5	1.5	52.5	14.5	6.0
Ridged early	3.5	4.0	47.0	20.5	1.5
Ridged late	0.5	4.5	48.5	13.5	1.0
Ridged early + late	1.0	2.0	45.0	15.0	1.0
Significant differences	NS	NS	NS	NS	NS

NS - No significant differences

Table 52. Experiment 3: Effect of soil ridging treatments on root diameter and carrot fly damage, Beck Row, February 1996.

Treatment	Root diameter (cm)	% roots with carrot fly damage
Unridged	5.6	21.0
Ridged early	5.5	25.0
Ridged late	5.4	26.0
Ridged early + late	5.7	22.0
Significant differences	NS	NS

NS - No significant differences

1996/97

The early ridging treatment was carried when there was full ground cover in late July and the late ridging had to be carried out by hand because of the large root size and vigorous growth of the foliage. The late and early + late ridging treatments gave 12-15% more healthy roots, some of which was associated with a lower incidence of fanging (Table 53). There appeared to be a localised patch of brown canker (Phoma) in part of the bed assigned to the early ridged treatment and this treatment had a substantially higher incidence of large brown crown canker (though not lateral root infection) and black scurf. There were no effects of ridging on cavity spot or carrot fly incidence. Brown spotting was lower in all the ridged treatments on both crowns and lateral roots than in the untreated control (Table 53 and 54). The late ridged treatment gave the lowest yield (Table 55).

At ADAS Arthur Rickwood, the crop was sown later and plants remained much smaller than at East Harling (Table 56). There were also fewer healthy roots (Table 57), primarily because of carrot fly damage which affected 51% of unridged roots at harvest in early March (Table 58). The late ridging treatment appeared to have given a useful reduction in the incidence of carrot fly damage which was found on only 26% (lateral) roots (Table 58). Ridging also appeared to reduce cavity spot which affected 10.5% in unridged plots and 2.5% roots in early + late ridged treatment. Ridging had no effect on small brown spotting or brown banded symptoms (Table 58).

Table 53. **Experiment 3: Effect of Soil Ridging on incidence of healthy, fanged and crown disease and pest damage symptoms, East Harling 4 March 1997**

Treatment	% roots affected					
	Healthy	Fanged	Black canker	Brown canker	Brown spot	Cavity spot
Unridged	45.0	11.5	0.5	1.5	30.5	0.0
Ridged early	45.0	9.0	5.5	10.5	20.5	0.5
Ridged late	60.0	5.0	0.5	1.5	22.0	0.5
Ridged early + late	57.0	3.5	0.0	2.0	19.0	0.5
Significant differences	5%	5%	NS	0.1%	5%	NS

NS - No significant differences

Table 54. **Experiment 3: Effect of soil ridging treatments on the incidence of lateral root symptoms, East Harling 4 March 1997**

Treatment	% roots affected				
	Black scurf	Large brown lesions	Brown spots	Cavity spot	Carrot fly damage
Unridged	6.5	0.0	10.0	1.0	2.5
Ridged early	12.5	6.5	7.0	1.0	1.0
Ridged late	4.5	5.5	5.5	1.0	1.0
Ridged early + late	5.0	6.0	6.0	1.5	1.5
Significant differences	NS	NS	NS	NS	NS

NS - No significant differences

Table 55. Experiment 3: Effect of soil ridging treatments on root diameter and carrot fly damage, East Harling 4 March 1997

Treatment	Root diameter (cm)	Root yield (kg/m row)
Unridged	7.8	2.1
Ridged early	7.9	2.4
Ridged late	7.4	1.7
Ridged early + late	7.5	2.0
Significant differences	5%	0.1%

NS - No significant differences

Table 56. Experiment 3: Effect of soil ridging treatments on root diameter and yield at ADAS Arthur Rickwood, 19 March 1997

Treatment	Root diameter (cm)	Root yield (kg/m row)
Unridged	3.4	0.32
Ridged early	3.7	0.36
Ridged late	3.4	0.30
Ridged early + late	3.6	0.34
Significant differences	5%	5%

NS - No significant differences

Table 57. Experiment 3: Effect of Soil Ridging on incidence of healthy, fanged and crown disease and pest symptoms at ADAS Arthur Rickwood, 19 March 1997

Treatment	% roots affected					
	Healthy	Fanged	Carrot fly damage	Brown banded canker	Brown spot	Cavity spot
Unridged	25.0	7.0	6.0	22.0	4.5	2.5
Ridged early	29.0	12.0	6.5	23.5	4.0	1.0
Ridged late	31.5	6.0	3.0	30.0	2.0	0.0
Ridged early + late	24.0	9.0	9.5	16.0	4.0	0.0
Significant differences	NS	NS	NS	NS	NS	NS

NS - No significant differences

Table 58. Experiment 3: Effect of soil ridging treatments on the incidence of lateral root symptoms at ADAS Arthur Rickwood, 19 March 1997

Treatment	% roots affected				
	Carrot fly damage	Brown banded lesions	Brown spots	Cavity spot	Grey spots
Unridged	51.5	4.0	5.5	10.5	0.0
Ridged early	40.0	3.0	5.0	6.0	0.5
Ridged late	26.5	5.5	4.0	7.0	1.0
Ridged early + late	58.5	4.5	5.5	2.5	0.5
Significant differences	5%	NS	NS	1%	NS

NS - N o significant differences

Table 59. Experiment 3: Date of ridging treatments and depth of soil cover at harvest in soil ridging treatments 1996/97

Treatment	East Harling		ADAS Arthur Rickwood	
	Date ridged	Soil depth over crown (cm)	Date ridged	Soil depth over crown (cm)
Unridged		3.2		3.2
Ridged early	late July	3.8	13 Sept	4.8
Ridged late	20 Dec	5.3	10 Dec	5.5
Ridged early + late	late July + 20 Dec	3.8	13 Sept + 10 Dec	5.8

Disease development

Table 60. Experiment 1: Seed treatment experiment: Incidence (% roots) of root symptoms Wilby 1995/96.

Date assessed	% Healthy	Crown dark brown	Crown brown spot	Lateral brown spot	Black scurf	Cavity spot	Crown rhizoctonia
29/9/95	82	0	8	10	0	0	0
18/10/95	90	0	4	6	0	0	0
14/11/95	86	0	4	14	0	0	0
15/12/95	74	1	5	10	11	0	2

Table 61. Experiment 2: Foliar fungicide experiment: Incidence (% roots) of root symptoms Wilby 1995/96

		Crown					Lateral	
Date assessed	% Healthy	Black-brown	Red-brown	Black scurf	Cavity spot	Crown rhizoctonia	Dk. brown	Brown corky spots
29/9/95	94	2	4	0	0	0	1	0
18/10/95	96	0	2	0	0	0	0	1
14/11/95	88	0	4	0	0	0	2	10
15/12/95	83	0	3	7	2	3	0	0

Table 62. Experiment 3: Disease assessment at Beck Row, 11 December 1995

Symptoms	% Roots affected
Crown brown blotch	10
Crown brown spot	10
Lateral dark brown	8
Black scurf	10
Lateral brown roots	78
Carrot fly damaged	6
Fanged	44

Table 63. Experiment 3: Disease assessment at Saracens Head - 19 December 1995

	Healthy	Crown Brown spot	Fanged	Black scurf	Lat. Brown spot
% roots affected	72	14	4	2	12

Table 64. Experiment 1: Seed treatment experiment: Incidence (% roots) of root symptoms at ADAS Arthur Rickwood 1996/97.

Date assessed	% Healthy	% Fangs	% Crown brown spot	% Crown Carrot fly	% Black scurf	% Lateral brown spot	% Lateral carrot fly damage	% Cavity spot	% Splits
3/12/96	50	8	4	0	0	19	14	5	15
17/1/97	26	7	9	11	1	18	62	9	17

Table 65. Experiment 2: Foliar fungicide experiment: Incidence (% roots) of root symptoms at East Harling, 1996/97.

Date assessed	% Healthy	% Fangs	Crown brown spot	Crown cavity spot	Crown black scurf	Crown dk brown	Lat. lge brown	Lateral brown spot	Lat. black scurf	Cavity spot	Splits
22/7/96	92	4	0	0	1	0	0	0	0	3	0
12/8/96	82	5	4	0	0	0	0	4	1	3	1
3/9/96	85	4	6	2	0	1	0	0	6	0	1
24/9/96	79	5	9	0	5	1	0	1	7	0	1
15/10/96	77	7	11	0	3	0	1	0	5	0	0
5/11/96	64	7	8	0	7	0	2	0	16	1	0
26/11/96	77	7	5	1	5	0	0	2	11	2	0
17/12/96	67	7	8	0	9	3	3	3	15	0	2
14/1/97	53	7	6	0	6	5	6	5	14	0	3

Results

Disease development

Severe root disease were generally slow to develop during the three years of this project. Final harvest assessments were delayed until March in many cases to maximise opportunity to obtain results. Regular assessments were made from autumn onwards when roots had reached an assessable size.

In 1995/96, disease incidence was similar over the period September to December apart from an increase in black scurf incidence from 14 November to 15 December (Table 60). Black scurf also increased in the adjacent foliar fungicide experiment during the same period (Table 6). Black scurf was also common at Beck Row in December (Table 62) but only affected 2% roots at Saracen's Head (Table 63).

Carrot fly damage increased from 14% to 62% roots affected by lateral mines and from 0 to 11% crown symptoms at ADAS Arthur Rickwood between December and January 1996/97..

Cavity spot and crown brown spots also increased to a lesser extent over the same period (Table 64). At East Harling a diversity of root symptoms were found and the general trend was for these to increase steadily from July to January (Table 65). Black scurf, however, appeared to increase quite rapidly from mid October to early November on lateral root surfaces.

Monitoring of *Itersonilia* species

1994/95

Sampling within the crop canopy was carried out using Waksman's agar plates exposed for 15 minutes from 30 June onwards until crops were defoliated mechanically prior to lifting or foliage died down naturally.

The mean results from 10 plates per crop summarised in Table 66 show *Itersonilia* spp. were first found in early September and increased over the following month.

Table 66. Mean number of *Itersonilia* colonies per petri plate in 6 different parsnip crops, Wilby Norfolk 1994.

	Mean number of *Itersonilia* colonies (*Itersonilia pastinacae*)/plate					
Site number	1		2		3	
Crop number	1	2*	3	4	5	6
Date plates exposed						
30.6.94	0	0	0	0	0	0
19.7.94	0	0	0	0	0	0
12.8.94	0	0	0	0	0	0
9.9.94	0.1(0)	0.3(0)	2.6(0.1)	0(0)	0.3(0)	0.1(0)
7.10.94	31.4(21.7)	20.0(18.9)	44.1(1.7)	7.6(0.3)	0.4(0)	0.2(0)
1.11.94	General collapse of foliage, no further tests carried out.					

1995/96

In 1995/96, crops were close to the site used in 1994/95 and also showed first signs of *Itersonilia* activity in September. Subsequent development was slow but moderately high colony counts were obtained in November from the Seed treatment experiment (Table 67).

1996/97

Itersonilia colonies were first detected on 12 August in 1996 (Table 68) and increased to produce the highest number of colonies recorded in September in this project. Dry weather appears to have checked development in September although moderately high counts of *I. pastinacae* were recorded in October and December (Table 68). There was a consistently higher incidence of *I. pastinacae* than *I. perplexans* which contrasted with the previous two years.

Table 67. Plate tests for *Itersonilia* spp. - Mean number of colonies/plate 1995/96

Date assessed	Wilby 1 (farm crop)		Wilby 2		Seed treatment experiment		Fungicide experiment	
	It per	It past	It per	It past	It per	It past	It per	It past
19/7/95	NT	NT	0	0	0	0	0	0
24/8/95	0	0	0	0	0	0	0	0
28/9/95	0	0	0	0.1	0	0	0.1	0
18/10/95	0	0	0	0.3	0.7	0	0	0
14/11/95	50.6	22.6	NT	NT	229.8	116.0	52.9	20.5

NT - Not tested It.per - *Itersonilia perplexans* It.past - *Itersonilia pastinacae*

Table 68. Plate tests for *Itersonilia* spp. - Mean number of colonies/plate 1996/97

Date assessed	East Harling Untreated plots		East Harling (farm crop)		ADAS Arthur Rickwood Soil ridging experiment	
	It per	It past	It per	It past	It per	It past
22/7/96	0	0	-	-		
12/8/96	0.1	0.3	0.2	0		
3/9/96	23.5	146.5	10.0	0.3		
10/9/96	2.6	25.9	-	-	0	0
17/9/96	3.8	0.4	-	-	-	-
24/9/96	7.9	55.9	0.3	3.7	-	-
10/10/96	-	-	-	-	0	0
15/10/96	30.5	274.0	0.9	61.3	-	-
5/11/96	0.5	1.5	0.1	0.6	-	-
6/11/95	-	-	-	-	0.2	0
3/12/96	43.1	461.4	61.0	493.8	1.2	0

NT - Not tested It.per - *Itersonilia perplexans* It.past - *Itersonilia pastinacae*

Laboratory examinations

1994/95

Small pieces of leaf tissue (c.2.5 x 2.5 cm) cut out from leaves showing chlorotic or necrotic spotting were selected from monitoring sites at each visit and tested for the presence of *Itersonilia* species. There was no evidence of *Itersonilia* spp. on such leaf tissue but pink yeast (*Sporobolomyces* sp.) occurred regularly. On 30 June, volunteer plants were present at Site 3 and in a barley crop adjacent to Site 2. Small samples of leaves, stems and umbels were tested for the presence of *Itersonilia*. *Itersonilia* was recovered from a small nectrotic lesion but this isolate was not maintained in culture and was not identified to species level. On subsequent visits, there was no evidence of *Itersonilia* spreading from volunteer plants to the immediately surrounding crop.

Some leaf spotting attributed to *Phomopsis diachenii* was present at all 3 sites in July 1994, but this did not appear to develop further.

On 9 September, the first signs of ginger-brown spots were noted on few roots at sites 2 and 3 on Javelin raised from natural seed. There were no crown lesions on the Javelin sample (25 roots) from the Experiment 2 which was later sown. *Itersonilia pastinacae* was recovered from the small lesions, but *Phoma complanata* was causing severe black brown canker on occasional plants. *Rhizoctonia solani* was commonly associated with crown lesions.

Itersonilia colonies were detected on the agar plates on 9 September but leaf samples on the same date failed to detect *Itersonilia* spp. By 7 October, the agar plate tests were showing larger numbers of *Itersonilia*, and leaf tests revealed *Itersonilia* in crops 2, 3, 4, 5 and 6 (no leaf tests were done on the Experiment 1 - Crop 1) on dead leaf tissue. *Itersonilia pastinacae* represented an estimated 90% of *Itersonilia* colonies from crop 2 (Experiment 2) and 50% of colonies from crop 5. Crops 3, 4 and 6 gave *Itersonilia perplexans* colonies only.

Canker lesions were present on 8% roots from the untreated crop adjacent to the Foliar Fungicide experiment on 11 December. These ranged from small red-brown spots to dark brown or black lesions affecting up to 70% of the crop. *Itersonilia pastinacae* was confirmed on 5 out of 8 roots, with one root having a mixture of *I. pastinacae* and *I. perplexans*. *Rhizoctonia* was present on two roots, one of which also had *I. pastinacae*. A further sample taken on 24 January and assessed on 27 January showed 39% roots with lesions, mostly of which (26%) were very small brown lesions and only 2% had severe (>50% crown affected) lesions.

Isolations from root samples on 27 January 1995 were as follows:-

	Lesion type	No. lesions tested	Pathogens present	No. confirmed
1.	Severe black crown lesion	3	*Itersonilia pastinacae*	3
			Rhizoctonia solani	3
2.	Moderate lateral black-brown lesions	4	*Itersonilia pastinacae*	4`
			Rhizoctonia solani	2
3.	Moderate orange-brown lesions (associated with split skin)	4	*Itersonilia pastinacae*	4
			Rhizoctonia solani	1
4.	Slight lesions - pale brown spotting	4	*Itersonilia pastinacae*	4
			Rhizoctonia solani	2

Itersonilia pastinacae was much more abundant on severe lesions than moderate lesions, a few spores were discharged from slight lesions.

Culture tests from harvested samples gave the following results.

Experiment 1: Seed treatments (tests on 31 January 1995)

	Lesion type	Pathogens present
1.	Severe black crown canker	*Itersonilia pastinacae, Mycocentrospora acerina, Phoma complanata*
2.	Large dark brown lesions near the crown	*Itersonilia pastinacae, Mycocentrospora acerina*
3.	Small brown crown lesions	*Itersonilia pastinacae, Cylindrocarpon destructans*
4.	Pinkish brown lateral lesions	*Itersonilia pastinacae, Mycocentrospora acerina*

Bacteria and soil saprophytes including species of *Penicillium, Mucor* and *Trichoderma* were also recorded in samples 2 and 3.

Experiment 2: Foliar fungicides (tests on 8 February 1995)

	Lesion type	Pathogen present
1.	Small black-brown lesions on lateral root/shoulders.	*Itersonilia pastinacae* (abundant) *Cylindrocarpon destructans*
2.	Severe black-brown crown lesions (pycnidia present)	*Itersonilia pastinacae* (trace) *Phoma complanata* *Mycocentrospora acerina (1 out of 4 lesions)*
3.	Small pale brown crown lesions	*Phoma* sp
4.	Small lateral brown-black lesions	*Itersonilia pastinacae* (trace) *Cylindrocarpon destructans*

In addition, dead leaf bases still attached to the parsnip crown at sampling on 3 February were tested for *Itersonilia* species and both *I. pastinacae* and *I. perplexans* were confirmed.

Experiment 3: Soil ridging (tests on 15 February 1995)

	Lesion type	Pathogen present
1.	Severe black-brown crown lesions (with pycnidia present)	*Itersonilia pastinacae* *Itersonilia perplexans* *Phoma complanata*
2.	Black lateral lesions	*Itersonilia pastinacae*
3.	Pale brown (water soaked) crown lesions	*Itersonilia pastinacae* *Itersonilia perplexans* (trace) *Cylindrocarpon destructans*

Experiment 1:
Seed Treatment Experiment

Leaf pieces with necrosis sampled on 28 September had *Itersonilia perplexans* (3 out of 4 pieces tested) but no *Itersonilia* spp. were recovered from brown spots on shoulder/side of roots at this stage. Traces of *I. perplexans* were confirmed from crown brown spots. Traces of *I. perplexans* were found on 'scab' lesions on roots but not on other root blemishes or on leaf pieces on 18 October.

On 15 December, *I. perplexans* was recovered from brown spots on the crown. Both *Fusarium* and *Cylindrocarpon destructans* were isolated from lateral brown spots. At harvest in March, *Cylindrocarpon* was recovered from symptoms attributed to cavity spot. *I. pastinacae* was confirmed occasionally on various crown lesions. *Alternaria radicina* was found on a root with ginger skin symptoms.

Experiment 2:
Fungicide Experiment

Leaf samples taken on 28 September showed *Itersonilia perplexans* was present on 3 out of 4 pieces tested but no *Itersonilia* was recovered from brown spots on the shoulder of roots. *I. perplexans* was confirmed on one of 4 pieces of leaf tissue tested, but not on lateral or crown brown spots on 18 October. Samples taken on 16 November showed evidence of *Fusarium* sp. and *Rhizoctonia solani* associated with scab-like lesions on the lateral root surface and crown (respectively).

Samples taken on 15 December gave *Itersonilia perplexans* from a crown lesion with black fibrous appearance. *Fusarium* sp. was isolated from brown spots.

I. pastinacae was confirmed on a brown black canker lesion at harvest on 7 March. *I. perplexans* was found on black-brown crown lesions. Rhizoctonia occurred in association with *Phoma complanata* in large brown lesions in March.

Experiment 3:

Soil ridging

Wilby 1

Both *I. pastinacae* and *I. perplexans* were confirmed in samples from this harvested roots in the Soil Ridging Experiment (5 March) which had brown-black lesions, crown brown spots or crown brown-black spots. *I. pastinacae* predominated in most cases.

Wilby 2

No *Itersonilia* from brown spots or scabs on roots or from dead leaf tissue.

Bodney

At the December assessment, no *Itersonilia* spp were covered from brown spots on the crown. A dark brown rot associated with splitting of the root tissues gave both *Fusarium* and *Phoma medicaginis*. *Fusarium* and *Cylindrocarpon* were isolated from brown spots. *Rhizoctonia* was also present on various crown lesions. *Phoma* was associated with large brown lesions. *Cylindrocarpon* and occasionally *Rhizoctonia* were isolated from brown spots attributed to cavity spot on samples lifted on 29 February. *Cylindrocarpon* was also present in dark brown lesions associated with root splitting 15-20 cm below soil level.

Saracens Head

Dead leaf pieces taken on 19 December, produced large numbers of *Itersonilia* spores, about 10% were *I. pastinacae* and 90% *I. perplexans*. Crown brown spots produced a few spores of *I. perplexans* only.

Beck Row

Samples taken on 11 December were tested for pathogens. *Itersonilia pastinacae* was only confirmed in a black-brown canker lesion (together with *Rhizoctonia solani*). A range of other symptoms including brown spots and black-brown lesions generally yielded *Cylindrocarpon* but an aggressive rot of the tap root was associated with *Fusarium culmorum*.

At the final assessment on 1 February, *I. pastinacae* was confirmed on large black canker lesions but not on small dead leaf or petiole samples. *Cylindrocarpon* was frequently found in large crown blotches and was associated with ginger skin symptoms.

1996/97

A range of samples with different types of lesions on the roots were tested for the presence of *Itersonilia* spp. to establish if these had reached the crown or contributed to mixed infections. *Itersonilia perplexans* was detected on a small dark brown crown lesion on samples taken on 17 October at East Harling. Pycnidia were frequently seen on large brown lesions and this was regarded as diagnostic for *Phoma complanata. Itersonilia perplexans* and *Rhizoctonia solani* were found to be associated with large crown brown (Phoma) lesions and small black warty growths on the crown from East Harling. Small brown or black-brown lesions failed to produce identifiable pathogens. The conspicuous brown banded lesions which developed as a series of horizontal bands on the lateral root surface occasionally yielded *Rhizoctonia* or *Cylindrocarpon destructans*. Bacterial growth was produced on potato dextrose agar when the banded lesion tissue was sub-cultured. Small grey lesions from crops at ADAS Arthur Rickwood were sub-cultured and in the absence of specific pathogens, their origin remains unknown.

DISCUSSION

1994/95

The seed treatment experiment identified phytotoxicity problems with tebuconazole. The low plant establishment and slow build up of *Itersonilia* on the foliage resulted in a low incidence of Itersonilia canker in this experiment; severe black crown cankers were associated with the fungus *Mycocentrospora acerina*. This pathogen was first documented by Channon (1965) on samples of parsnips from East Anglia fens. Sugar beet had been cropped previously on this site but there was no recent history of carrot, celery or parsnip cropping. The fungus was probably soil-borne and seed treatments are unlikely to give long term protection against such pathogens. As became apparent during the course of this project, a range of fungi is capable of causing canker lesions on parsnips and accurate diagnosis of the problem is essential when problems occur.

Itersonilia pastinacae was isolated from most canker lesions in the harvest assessments (January/February). However, it is by no means certain that it was responsible for all the canker lesions (Channon, 1963a). *Phoma complanata* was apparent on the larger brown-black lesions where pycnidia could be seen (Cerkauskas, 1987). *Itersonilia pastinacae* was also readily detected on these lesions. (Channon, 1963a). Wounding or root damage is thought to favour the development of both *Itersonilia* and *Phoma* cankers (Channon, 1963a). *Cylindrocarpon destructans* was also detected in some small canker lesions and is another component of the canker complex (Channon & Thomson, 1981). It is probable that *Itersonilia* species were spreading from senescent or dead foliage to the root crown from late autumn onwards. At harvest, dry shrivelled petioles were still attached to the crown and a small cavity was present above the root which had previously been occupied by green leaves. Active *Itersonilia* species were detected on the dead petioles and both species were recovered from crown lesions. Previous work by Channon (1963a) suggests that the *Itersonilia perplexans* isolates were unlikely to be pathogenic to parsnip roots and may be present purely as a saprophyte.

The continued activity of *I. pastinacae* on senescent foliage provides a mechanism for late season infection of roots after death of the foliage. Spray treatments in

Experiment 2 were maintained up to dieback of foliage (October) and further work is needed to establish if treatments are effective if maintained up to harvest. There is also the possibility that Phoma cankers develop after a build up of the pathogen on the foliage. Symptoms reported from Canada by Cerkauskas (1987) were not recorded in these experiments but it was interesting to note that chlorthalonil and tebuconazole treatments gave the lowest canker incidence. Chlorothalonil has been shown to control Phoma canker in parsnips (Cerkauskas & McGarvey, 1988).

The foliar disease epidemic produced some evidence that a range of fungicides with potential for canker control, also had activity against mildew and Ramularia leaf spot. Chlorothalonil also showed good activity against downy mildew which was unusually severe in these experiments. The loss of green foliage did not appear to affect yield but earlier attacks have potential to cause large effects on yields.

The development of *Itersonilia* species may be compared directly with previous work by Channon (1963b). Relatively dry conditions during the summer appear to have checked early development of the epidemic and the final epidemic compares with a 'low risk' year such as 1961. The agar plate techniques should provide opportunity to monitor crops and identify high risk sites and high risk years when control measures are needed. The incidence of black canker typical of *Itersonilia pastinacae* was low at all sites monitored during 1994/95 which would be expected given the low counts on the agar plates. There remains, however, a risk that *Itersonilia* species can remain active after dieback of the foliage and still cause canker lesions on late harvested crops. The value of sprays to control this phase of the epidemic will be examined in the second year of this project.

The results of spore monitoring (Table 16) showed a high proportion of *Itersonilia pastinacae* colonies in untreated plots (Site 1). This is similar to previous observations by Channon (1963b). The generally low colony numbers and the predominance of *Itersonilia perplexans* at Site 2 suggests that the commercial spray treatments may have provided control of *Itersonilia pastinacae*. In Year 2, detailed comparisons of treated and untreated plots will be made to establish the effects of fungicides on *Itersonilia* species.

There was no benefit from using crab shell (chitin) treatments which were used to try and stimulate soil micro-organisms which would be antagonistic to the canker pathogens (Khalifa, 1965). In view of the ineffectiveness of these soil amendments, no further work with these treatments will be carried out. Soil ridging in August has been shown to give about 40% control of Itersonilia canker (Channon, 1963b). In this project, this preliminary investigation was carried out with equipment to establish if a practical technique could be developed. The results from the first year are encouraging and suggest there may be benefits for controlling Itersonilia and Phoma canker (Table 38). Treatments were made early in the season to minimise damage to the foliage but there may be additional benefits from soil ridging after foliage has died down in the autumn. This will be investigated in the second year of this project.

1995/96

Although hot dry conditions during the summer curtailed the early development of *Itersonilia* species, substantial populations built up on foliage during late October and early November. Fungicide treatments were successfully monitored with agar plates and it is of concern that some treatments appeared to increase colony counts of *Itersonilia*. Four weeks after treatment there appeared to be little effective control and this has implications for future work. In Year 3, the spray interval will be reduced so that programmes maintain a 3 week interval between applications. Both Folicur and Bravo showed promising activity against *Itersonilia* spp. and these compounds should be included in on-going investigations of carrot crown rot.

Foliar diseases failed to develop in either the seed treatment experiment or the fungicide experiment. In a season when weather conditions appeared favourable for powdery mildew development, later drillings were badly affected by drought and lost much foliage in July/August. Regrowth occurred in September/October but remained disease free. In this situation, regular crop monitoring could provide opportunities to reduce fungicide inputs.

The presence of cavity spot-like symptoms was recorded for the first time in this project. Although the causal agent (*Pythium violae*) was not identified on this project, it was significant that most cavity spot occurred in crops where no Fubol had been applied. A Fubol treatment will be included in the Seed Treatment Experiment in Year 3 to establish if it is effective against parsnip cavity spot. There was no evidence that seed treatments provided effective control of the problem. However, harvest assessments were carried out almost 9 months after drilling and it is perhaps unrealistic to expect control from seed treatments alone to persist for such a long period.

Growers should review their policy of fungicide use and soil testing for cavity spot and be prepared to use fungicide for cavity spot control where there is a risk of attacks.

A dry summer appears to have limited the development of *Itersonilia* canker for a second year. Attention to rainfall during the course of the season may well prove to be a useful criterion for adjusting fungicide spray treatments. Although seed affected by *Itersonilia* was used in the Seed Treatment Experiment, very little canker developed in the crop. The consequences of accepting seed with *Itersonilia* on it may therefore not be detrimental in a dry season. Further experience in a wet year is needed to establish if seed treatments are needed to overcome seed-borne infection.

Seed treatments with Baytan (high rate) and UK226 proved to be phytotoxic - this problem could be overcome by adjusting seed rate based on a germination test. However, the laboratory test tended to underestimate field establishment for the more phytotoxic treatments. Work will continue with seed treatments in Year 3 to establish if there are effects on cavity spot and foliar diseases in addition to canker control.

The use of a range of sites for soil ridging observations has revealed a wide range of root symptoms on parsnips. Whilst *Itersonilia* canker and phoma canker were found at a low incidence, brown spotting was very common. Many of these were attributed to cavity spot and it is possible that others included under "brown spots" were variants of cavity spot. Isolations from these lesions at harvest suggested that *Cylindrocarpon* and *Fusarium* colonised or possibly even caused some of the lesions. Growers are therefore faced with a diverse range of pathogens in parsnips and undue attention to canker may not be warranted in some years.

Soil ridging showed significant effects at one high disease site (Bodney) against a wide range of symptoms. Perhaps most surprising was the reduction in root splitting, 15-17.5cm below the root crown. An improvement of 36% extra healthy roots (compared with the unridged control) at Bodney was mostly associated with a reduction in cavity and brown splitting. At other sites with lower disease pressure, soil riding did not produce significant benefits. The treatment appears to have a primary role in controlling canker but in the absence of canker, benefits may be small. Where large roots are present, late ridging with farm equipment may not be practical because of the risk of mechanical damage to roots.

1996/97

The seed treatments experiment confirmed phytotoxicity from UK226 and Baytan (high rate) for a second successive year. Target plant populations were achieved by adjusting seed rates after results of a laboratory germination test were available. A low incidence of cavity spot symptoms developed and these were moderately well controlled by a standard application of

Fubol. There was no evidence that seed treatments had given control of cavity spot. In the absence of foliar diseases it has not been possible to demonstrate that Seed treatments provide control of foliar diseases. Carrot fly damage was prevented from January onwards but was not affected by Seed treatments. Soil ridging in December appeared to reduce carrot fly damage at ADAS Arthur Rickwood although a combined September + December ridging treatment had no effect. There is no obvious explanation for the reduction in carrot fly damage given that egg laying would have taken place in late August/early September and larval damage was already evident in early December.

Powdery mildew was the main foliar disease at East Harling and this was well controlled by all the fungicide evaluated on a three-weekly programme. Some crop damage was apparent after the application of Corbel in July under hot conditions. Such damage can almost certainly be avoided by spraying under cooler conditions. The yield date suggest that powdery mildew may have caused about 10% less of yield. However, it is worth bearing in mind that this estimate was derived from an irrigated crop and large losses may occur in unirrigated crops and with more severe foliar infection. Treatments had the property of extending green leaf retention, particularly Bravo (Table 31). Plots were hand-harvested, and it appeared that the Bravo treated plants had softer stems and were more prone to damage than other treatments. This may reflect continued growth of roots on treatments giving the best green leaf retention.

The effects of fungicides on *Itersonilia* sp.. is complex. Differences were apparent between multiple and single spray applications (Table 32) with a tendency for high colony counts to occur after repeated fungicide applications. Clearly there may by direct and indirect effects of fungicides on *Itersonilia*, with indirect effects on green or senescent leaf tissues affecting the substrate available for multiplication and colonisation by these leaf surface fungi. As judged, three weeks after treatment Folicur and Bravo were the most effective products against *I. pastinacae*.

Although there were apparently benefits from using late soil ridging at both sites in 1996/97, it is not certain that the observed differences can be ascribed solely to ridging treatments. For example at ADAS Arthur Rickwood, carrot fly damage was reduced from 51% in unridged control to 26% in late ridging compared with 58% in early + late ridging. At the time of the late ridging treatment (December) carrot fly damage was already appearing and it seems unlikely that late ridging would have impeded larval activity. There was no evidence of an effect where late ridging was applied after early ridging. At Earl Harling, there was a constant effect from late ridging alone, following early ridging. All ridging treatments reduced brown spotting and there appeared to be an effect on root fanging. This latter effect is surprising as fanging is generally associated with root damage at an early stage of root development and this would normally have occurred before ridging started in September.

The presence of 'cavity spot' type symptoms were primarily small elliptical lesions with a slightly sunken centre. A section through such a lesion revealed a cavity and deeply penetrating brown discoloration. The 'control' of such symptoms with Fubol on a site where cavity spot has also affected carrots provides circumstanted evidence for cavity spot diseases possibly caused by *Pythium violae*. Further work is needed to confirm that *P. violae* and other species affecting carrots can also affect parsnips. Cavity spot assessments should be part of variety trialling.

Overall examination of rainfall records at the main experimental sites (Appendix 3), shows long relatively dry periods (<50 mm/month) each year. First records of *Itersonilia* spp. on agar plates co-incided with periods of high rainfall (c. 100 mm/month), notably September 1994, September 1995 and August 1996. When canker was being investigated by Channon at Wellesbourne during the period 1957-1961, canker epidemics occurred in 1957. 1958 and 1961 but not in 1959 and 1961 (Channon, 1963a, 1963b). Summary rainfall data for the Midlands published annually in Plant Pathology indicate above average rainfall in July-September 1957, June and September1958, December 1959, September- October 1960 and April 1961. Serious outbreaks of canker were detected from early autumn onwards in these studies and was successfully controlled by earthing up plants in early September (Channon, 1963b). Channon (1963b) selected total rainfall over the period July-December as providing an indication of seasonal risk. His published data showed 419 mm ranfall in 1958 and 548 mm in 1960(both seasons with canker problems) compared with 267 mm in 1959 and 319 mm in 1961. I this project rainfall totals for July-December were 330 mm, 244 mm and 407 mm in 194, 1995 and 1996 respectively. The distribution of rainfall is likely to be important and the combination of historic and current records of spore catches suggests that high rainfall during or prior to September is most likely to stimulate *Itersonilia* activity.

Whilst modern varieties are probably contributing significantly to the low incidence of canker in these experiments, further exploration of canker-weather relationships is required. Thresholds for numbers of colonies detected on plates should also be developed in relation to cultivar resistance.

Conclusions

1. Dry weather during the summer provided low risk conditions for *Itersonilia* canker during this project.

2. The progress of *Itersonilia* epidemics was successfully monitored during the growing season with agar plates.

3. A wide range of root symptoms were encountered and these proved difficult to distinguish

4. Foliar fungicides (Bayleton, Bravo, Compass, Corbel and Folicur) applied at 3-4 monthly intervals starting in July provided very good control of powdery mildew in 1996/97.

5. Downy mildew was the main foliar disease in 1994/95 and appeared to be contained by Bravo sprays.

6. Foliar fungicides had little effect on *Itersonilia* spp. 4 weeks after treatment. However, when the intervals between treatments was reduced to 3 weeks in the 1996/97 programmes of Folicur or Bravo gave a reduction in *I. pastinacae* three weeks after treatment. There was tendency for other treatments to increase *Itersonilia* activity.

7. Cavity spot-like symptoms were encountered in this project and symptoms were controlled by a Fubol spray as used for Carrot cavity spot. Growers may need to reconsider use of a cavity spot treatment on parsnips if similar symptoms have occurred in their own (untreated) crops.

8. Soil ridging produced significant benefits at some sites against various symptoms. There were no significant benefits at the other sites. However, treatments require further investigation under high canker pressure. Late ridging treatments require careful management as they may result in mechanical damage to large roots.

9. Some seed treatments were phytotoxic but target plant populations could be achieved by adjusting seed rates in the light of results from a laboratory germination test. Seed treatments had no effect on root diseases or yield under low disease pressure.

10. A wide range of symptoms were distinguished on the crown and lateral root surfaces of parsnips from a range of sites. It is clear that, although canker incidence was low, a range of other disease pose a threat to quality production. Phoma canker (*Phoma complanata*) was frequently encountered and may be confused with black canker as young lesions are usually dark brown (almost black) in colour.

11. Very large roots were severely affected by black canker caused by *Mycocentrospora acerina* in 1994/95.

12. Soil amendment treatments with chitin failed to give control of canker.

References

Cerkauskas, R F (1987). *Phoma canker of parsnips*. Ministry of Agriculture, Fisheries and Food, Ontario, Canada. Leaflet 87-041, 3pp.

Cerkauskas, R F and McGarvey, B D (1988). Fungicidal control of phoma canker of parsnips. *Canadian Journal of Plant Pathology* **10**, 252-258.

Channon, A G (1963a). Studies on parsnip canker. I. The causes of the diseases. *Annals of Applied Biology* **51**, 1-15.

Channon, A G (1963b). Studies on parsnip canker. II. Observations on the occurrence of *Itersonilia pastinacae* and related fungi on the leaves of parsnips and in the air within parsnip crops. *Annals of Applied Biology* **51**, 223-230.

Channon, A G (1965). Studies on parsnip canker IV. *Centrospora acerina* (Hartig) Newhall - a further cause of black canker. *Annals of Applied Biology* **56**, 119-128.

Channon, A G and Thomson, M C (1981). Parsnip canker caused by *Cylindrocarpon destructans*. *Plant Pathology* **30**, 181.

Khalifa, O (1965). Biological control of fusarium wilt of peas by organic soil amendments. *Annals of Applied Biology* **56**, 129-137.

Recommendations

1. A wide range of symptoms can be found on leaves and roots of parsnips. As diseases have caused complete loss of some crops during the course of this project, a diagnostic guide for growers would aid identification of problems.
   This could produced as Fact Sheet with support from HDC.

2. Powdery mildew control with a range of fungicides has been clearly demonstrated together with yield increases related to retention of green leaf tissue. Disease development is variable and regular crop monitoring is advisable to minimise use of fungicides.

3. Downy mildew was the main foliar disease in 1994 and control with chlorothalonil appears to be a practical solution. Chlorothalonil has potential for control of *Itersonilia* and *Phoma complanata* in parsnips and should be considered for further development in parsnips.

4. Tebuconazole has broad-spectrum activity and showed good activity against *Itersonilia* and powdery mildew. It should be evaluated further in carrots for control of foliar diseases and crown rot as well as in parsnips.

5. Cavity spot-like symptoms were found in parsnips and controlled with a standard treatment of metalaxyl and mancozeb. Formal confirmation of the pathogens involved is required.

6. Given the diversity of root diseases and blemishes, many of which are caused by soil-borne fungi, priority should be given to comprehensive screening and selection of resitant varieties.

7. Soil ridging produced some benefits but not consistently so. Early ridging merits evaluation under farm conditions particularly if parsnip crowns have little soil cover and high rainfall is anticipated. Ridging is not advocated in crops with large roots as root damage can occur.

8. Agar plate monitoring gave a useful record of *Itersonilia* activity and could be used to by growers to identify high risk crops and seasons. This should enable crop scheduling to minimise losses from *Itersonila* canker.

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Appendix I 1994/95

Fungicide treatments applied to commercial crops used in *Itersonilia* monitoring studies.

	Site 2	Site 3
Cultivar(s)	Improved Marrow Javelin	Javelin
Previous cropping - 1993	Arable	Parsnips
Sowing date	8-10 March 1994	10-12 March 1994
Fungicide treatments	Spinnaker (0.5 l/ha) 16 July Spinnaker (0.5 l/ha) 26 July Bayleton (0.5 kg/ha) 3 August Corbel (1.0 l/ha) 12 August Bayleton (0.5 kg/ha) 25 August Corbel (1.0 l/ha) 17 September Corbel (1.0 l/ha) 12 October	Spinnaker (0.5 l/ha) 26 July Bayleton (0.5 kg/ha) 3 August Corbel (1.0 l/ha) 12 August Spinnaker (0.5 l/ha) 25 August Corbel (1.0 l/ha) 17 September

Appendix I 1995/96 Site and crop details

Site	Wilby 1, Norfolk	Wilby 2, Norfolk	Wilby 3, Norfolk	Bodney, Norfolk	Saracens Head, Lincs	Beck Row, Suffolk
Cultivar	Javelin	Javelin	Javelin	Javelin	Improved Marrow	Imperial Crown
Seed treatment	Polycote Prime	Polycote Prime	Polycote Prime	Untreated	Untreated	Pelleted Untreated
Sowing date	21 April 1995	21 April 1995	25 April 1995	15 April 1995	May 1995	4 April 1995
Fungicide treatments	Fubol (12 kg/ha) 27 April 1995 Spinnaker (0.5 l/ha) 13 July 1995 Afugan (0.11 l/ha) 28 July 1995 100 Plus (0.5 kg/ha) 7 August 1995 Spinnaker (0.5 l/ha) 31 August 1995 Corbel (1.0 l/ha) 12 September 100 Plus (0.5 kg/ha) 5 October 1995 Corbel (1.0 l/ha) 12 November 1995 Final assessment 5 March 1996	Spinnaker (0.5 l/ha) 13 July 1995 Afugan (0.22 l/ha) 28 July 1995 100 Plus (0.5 kg/ha) 7 August 1995 Spinnaker (0.5 l/ha) 31 August 1995 Corbel (1.0 l/ha) 12 September 1995 Harvested 16 October 1995	Afugan (0.22 l/ha) 31 July 1995 100 Plus (0.5 kg/ha) 4 August 1995 Corbel 1.0 l/ha 9 September 1995 100 Plus (0.5 kg/ha) 12 September 1995 Corbel (1.0 l/ha) + Bayfidan (0.5 l/ha) 13 October 1995 Final assessment 7 March 1996	Copper oxychloride (2 kg/ha) June 1995 / July 1995 Thiovit (10.4 kg/ha) July 1995 Bayfidan (0.5 l/ha) 7+22 August 1995 Corbel (1.0 l/ha) 5+19 September 1995 + 11 October 1995 Final assessment 29 February 1996 Not harvested	100 Plus (0.5 kg/ha) 8 August 1995 Bayfidan (0.5 l/ha) 2 September 1995 Corbel (1.0 l/ha) 14 September 1995 100 Plus (0.5 kg/ha) 12 October 1995 Harvested 20 March 1996	Fubol (12 kg/ha) 4 April 1995 Final assessment 1 February 1996

Appendix I 1996/97 Site and crop details

ADAS Arthur Rickwood, Mepal, Cambs
Seed treatment and soil ridging experiments

Field name : House Ground
Soil type : peaty loam

Previous cropping : 1995 Peas, brussels sprouts, cabbage
1994 Set-aside, potatoes
1993 Carrots, brussels sprouts, lettuce, chinese cabbage, onions

Pre-sowing preparations : Beds (1.8 m, 4 rows/bed, 60 cm apart) made up 13 June 1996

Sowing date : 14 June 1996
Seed rate : 30 seeds/m row (43 seeds/m row for Baytan (high rate) and UK226)

Irrigation : 25mm 15 & 26 June

Fungicide : Fubol 58WP (12 kg/ha) applied to selected plots in seed treatment experiment by OPS sprayer on 26 June

Crop emergence : Start of emergence 2 July

Herbicides : Afalon @ 2.5l/ha in 400l water 19 July
Prometryne @ 1kg/ha in 400l water 31 July
Falcon @ 1.5l/ha in 400l water 3 August
Linuron @0.5l/ha and Dosaflo @ 0.5l/ha in 400l water 15 August
Linuron@0.5l/ha and Dosaflo@0.5l/ha in 400l water 7 September
Hoe/ hand weed meadow grass 18 September

Insecticides : Aphox @280g/ha in 250l water

Crop damage : Severe hailstorm and rain - plants at 2 rough leaf stage 23 July

Fertilisers : Nitrogen 40kg/ha 23 July
Trace elements : Manganse sulphate @ 4kg/ha in 200l water 26 July

Soil ridging treatments : Early ridging 13 September
Late ridging 10 December

Harvest date : 19 March 1997 (all experimental plots)

Appendix I

Site details	-	East Harling, Norfolk
Cultivar	-	Improved Marrow
Seed treatment	-	Polycote Prime
Sowing date	-	3 April 1996
Previous crop	-	W. Barley
Insecticides	-	Temik (15 kg/ha) in seed bed Hostathion (1.25 l/ha) 5 June Ambush (0.25 l/ha) 20 June Cyperhill (0.25 l/ha) 8 July Ambush (0.25 l/ha) +Aphox (0.28 kg/ha) 27 July Aphox (0.28 kg/ha) 8 August Hallmark (0.3 l/ha) 10 August

Fungicides (to adjacent crop)

Corbel (1 l/ha) 8 August
Bayleton (0.5 kg/ha) 25 August

Irrigation 6 mm 9 May, 20 mm 5 August
25 mm 23 June, 20 July, 21 August

Harvest date (commercial crop) - mid September 1996

Appendix 2   Soil analyses at experimental sites 1995/96

Site	Wilby 1+2	Wilby 3	Bodney	Saracens Head	Beck Row
Soil texture	LS	SL	LS	ZCL	SL
pH	8.1	8.2	7.9	8.0	8.1
P index	3	1	2	4	3
K index	1	1	2	2	2
Mg index	1	2	2	2	2
% Organic matter	-	2.2	1.56	2.60	7.66

1996/97

Site	ADAS Arthur Rickwood	East Harling
Soil texture	Pty L	SL
pH	6.4	8.2
P index	3	4
K index	3	1
Mg Index	3	2
% Organic	31.6	1.1

Monthly rainfall at experimental sites, Watton 1994-96