CARROTS: THE MANAGEMENT OF *ALTERNARIA* BLIGHT ON CARROTS

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The results and conclusions in this report are based on an investigation conducted over one year. The conditons under which the experiment was carried out and the results obtained have been reported with detail and accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore care must be taken with interpretation of the results especially of they are used as the basis for commercial product recommendations.

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This project has investigated the potential of *Alternaria* forecasting systems to reduce the number of sprays applied to control the disease while maintaining the same level of control and yield benefit as routine prophylactic sprays. The relative efficacy of different fungicide treatments and sequences of treatments has been compared and the effects of the disease on carrot yield and quality evaluated. In addition, the level of susceptibility of carrot varieties has been investigated. The results indicate that forecasting systems can reduce spray frequency on average by 2.6 in a season where *Alternaria* infection pressure was moderate to low. Overall, forecast sprays in fungicide trials improved yield to a greater extent than sprays applied after the forecast risk. There were large differences in the levels of disease developing on different varieties which were generally consistent with those observed in 2000. These findings provide the basis for growers to save on fungicide costs, optimise product choice, and implement an integrated approach for the management of *Alternaria*.

Background and objectives

Foliar diseases of carrots have become of increasing concern in recent seasons, principally due to the occurrence of *Alternaria* blight, caused by the fungus *Alternaria dauci,* which has occurred progressively earlier in the life of the crop, and in a wide range of growing regions. Early infections in maincrop carrots are probably associated in some areas with disease originating from crops under cover. Yield and root quality losses have been attributed to *Alternaria* blight, and it may sometimes create harvesting difficulties due to weakened foliage. The extent of yield loss in the UK is not fully understood, and probably depends to a large extent on the time of appearance of the disease. A 5% yield loss would be worth £2.25 million to growers in the UK. Foliar fungicides can be applied to carrots for *Alternaria* control, but there is little information available which can identify high risk situations where yield and quality losses might be expected. Given the increasing pressure for appropriate use of fungicide, and the needs of the industry for economically justified inputs, there is now a need for a robust and practical system which can identify situations where control of *Alternaria* blight is warranted. This project is aimed at evaluating and validating a developed forecasting system for *A dauci,* identifying varieties which are at risk of developing high levels of *A dauci*, assessing the effectiveness of new and existing products against *Alternaria*, and estimating the effects of the disease on yield and quality.

The project also provides an opportunity to monitor other foliar diseases of carrot, in particular *Sclerotinia sclerotiorum* which has caused problems in several growing areas including some severe internal rotting.

Summary of results and conclusions

1. Disease forecasting

Eighteen fields of mainseason carrots representative of typical commercial crops in the principal growing areas were selected for the second year of study. Weather data for each field or cluster of fields was collected using an Adcon Telemetry weather station with sensors for rain, temperature, humidity, windspeed and wind direction. At each site fields were paired. One of each pair was treated with a fungicide program designed to control the main foliar diseases of carrots in accordance with normal practice. The other member of the pair was treated in accordance with the advice generated by the PLANT-Plus system for Alternaria risk together with the interpretation of a Plantsystems Ltd adviser. The results from the field observation trials showed that, overall, *Alternaria* infection was light in the untreated plots. Little or no infection occurred in either the normal practice treatments or the PLANT-Plus treatments, and there was a reduction in treatment number using PLANT-Plus forecasts. *Sclerotinia* infections in carrot crops were locally severe in 2001. Neither standard practice fungicide treatments, or PLANT-Plus Alternaria forecast treatments, gave control of *Sclerotinia* compared to untreated plots.

With the use of PLANT Plus the average number of fungicide treatments applied to the commercial crops in this study was reduced from 5.1 to 2.5, while maintaining the same level of control of *Alternaria*. Disease in the untreated control areas was at relatively low levels and it was clearly possible to achieve a significant reduction in fungicide application under these conditions with the use of PLANT-Plus.

2. Variety susceptibility

Varieties were inoculated with *Alternaria* spores and the trial irrigated as necessary to promote infection. This produced a uniform and relatively high “infection pressure”. There were substantial differences in the levels of *Alternaria* developing on the varieties included in the trial, and these differences were maintained over the growing season, with little evidence of changes in variety ranking order as the season progressed. Results generally correlated well with those obtained in 2000 and partial resistance appears to be a stable and significant factor which could be incorporated into forecasting systems. Based on both years’ results, varieties have been classified as follows:

Highly resistant – none
Good partial resistance – Nepal, Bristol, Bolero, Riga, Indiana, Maestro, Gladiator
Moderate partial resistance – Narbonne, Narman
Poor resistance - Nerac, Senior, Victor, Leonor, Redco, Nebula, Nairobi, Nigel, Atlantis, Furore, NUN 6710, NUN 6717, Nantucket, Kamaran, Pampa, RX 4420046
Very susceptible – Navarre, Primo, EX962005

3. Fungicide efficacy

Three products, alone and in various alternating sequences, were tested on the variety Nairobi for protectant and curative activity in field experiments. One experiment used deliberate introduction of *Alternaria* infection by inoculating plants with spores and a second used plots in a commercial carrot crop at a site where previous natural infections of *Alternaria* had occurred. Fungicide applications were made according to PLANT-Plus forecast risk (protectant) and 4-5 days after the forecast risk (curative). The introduction of infection was used as the first forecast risk in the inoculated trial. In each trial, two prophylactic spray sequences were also used. The products were Amistar (azoxystrobin, experimental approval) applied at 0.8l/ha, Folicur (tebuconazole), SOLA, applied at 0.5l/ha, and Compass (iprodione and thiophanate methyl), SOLA, applied at 2 l/ha. Corbel (fenpropimorph) SOLA applied at 1l/ha was used as the last spray in the prophylactic sequences for the inoculated trial. Untreated control plots showed 25% foliage infection on 18th October in the inoculated trial, but only 13% on the same date in the naturally infected trial. There were relatively small differences in the degree of disease control between fungicide treatments, and relatively small differences between sequences applied as protectant and curative.

4. Effects of *Alternaria* on yield

Controlling *Alternaria* with fungicides produced yield benefits in the weight of marketable roots per hectare. The mean yield of untreated plots in the inoculated trial was 115.6t/ha, and the mean yield improvement for all fungicide programmes, including those applied prophylactically, was 5.8 t/ha, or 4.9 % at the first harvest in November and 4.7 t/ha or 4% excluding prophylactic treatments. In the naturally infected trial, only prophylactic programmes were applied, and these increased yield by up to 6.9%, using a total of 5 sprays.

Action points for growers

- Moderate levels of *Alternaria* which develop by the end of September can have substantial effects on the yield of marketable produce, and action should be taken to reduce infection
- Forecasting systems offer the potential to reduce prophylactic sprays while still retaining control of the disease
- Varieties appear to differ in levels of resistance to the disease, and though none is completely resistant, some may require fewer sprays than others to minimise the disease
- A comparison of available and new products indicated there was little difference in disease control between single products and alternating sequences of those products. In the 2001 season, protectant and curative timings also gave equivalent control, regardless of product. This is in contrast to the 2000 season, where disease pressure was more intense, and protectant sprays of Amistar were the most effective treatments.

Anticipated practical and financial benefits

The results illustrate the benefits which arise from controlling moderate *Alternaria* infections, and also the savings which can be made by responding to forecast risks rather than prophylactic sprays. Findings from the second year year indicate that failure to control moderate *Alternaria* infection could result in losses of 4.9 % worth about £2 million on the current UK acreage, but also that a forecasting system could reduce spray costs by approximately £80 - £100/ha, depending on product used. Varieties differed substantially and consistently in susceptibility to *Alternaria*, offering the opportunity to exploit partial resistance in ICM systems.

Science section

Introduction

Alternaria blight of carrots, caused by *Alternaria dauci*, has recently increased in importance in the UK crop with growers applying frequent sprays to maintain disease free foliage. Infections are tending to appear earlier in the season than has previously been experienced, and the disease is found in all of the major carrot growing regions of the country. Disease which develops earlier in the season is more likely to have an effect on yield, though late season disease may also be significant, both in terms of direct yield loss and harvesting losses due to foliage breakdown. The disease is seed-borne, and can survive on carrot debris. Once introduced on seed, the disease probably becomes established in intensive carrot growing areas. Movement of inoculum from crops grown under covers to main season crops is also possible.

Though growers apply fungicides to control *Alternaria*, there is very little information available on the losses which the disease can cause, and therefore on the cost effectiveness of sprays applied. Disease forecasting systems are increasingly being used in the field vegetable sector in order to satisfy the drive towards justification of inputs, and reduce costs of production to the grower (eg Carrot Country, 2001) Though systems are available for prediction of *Alternaria* risks, there has been no independent evaluation of these in terms of their ability to reduce sprays compared to prophylactic approaches, and maintain disease control at acceptable levels. The use of resistant varieties has been advocated as part of integrated control systems for *Alternaria* elsewhere (Davis *et al*, 1993), but information on the relative susceptibilities of varieties used, or likely to be used, in the UK is extremely limited. This work was undertaken with four main objectives. Firstly, to evaluate and validate *Alternaria* blight forecasting systems; secondly, to investigate the range of susceptibility to *Alternaria* in varieties; thirdly to investigate the effectiveness of different fungicides for *Alternaria* control, and finally to establish the effects of the disease on carrot yield and quality.

Materials and Methods

Evaluation and validation of forecasting systems

The PLANT-Plus *Alternaria* forecasting system was used in 2001 following initial comparisons with the DSV model in 2000. The principle benefit of the PLANT-Plus system is its ability to incorporate local weather forecasts as part of the risk prediction system in contrast to the accumulated, and retrospective, risk periods used by the DSV model. The validity of the PLANT-Plus system was tested by comparison between the

degree of disease control obtained in crops sprayed according to forecast, and those sprayed according to normal practice.

Eighteen fields of main season carrots representative of typical commercial crops in the main growing areas were selected for the second year of study. Weather data for each field or cluster of fields was collected using an Adcon Telemetry weather station with sensors for rain, temperature, humidity, wind speed and wind direction.

The data from each site were transmitted each 15 minutes to a receiver base station and each 6 hours data was automatically extracted by land line link to the Dacom Databank server. It was then allocated to an appropriate local 5-day weather forecast and made available for collection by accredited users.

Each day Plantsystems advisers collected the site weather data via Internet from the Dacom server and processed the data and the crop information together through the PLANT-Plus *Alternaria* model.The resultant advice was interpreted and when a treatment was necessary the adviser communicated with the field manager who arranged to apply an appropriate treatment.

At each site fields were paired. One of each pair was treated with a fungicide program designed to control the main foliar diseases of carrots in accordance with normal practice. The other member of the pair was treated in accordance with the advice generated by the PLANT-Plus system together with the interpretation of a Plantsystems adviser.

Each site was recorded for crop characteristics including growth, density, senescence and the presence of *Alternaria* and *Sclerotinia*. Each field also contained an area that was untreated with fungicides. This was located towards the centre of each field to avoid any edge effects. All sites were finally recorded in October prior to winter straw covering.

Evaluation of variety susceptibility

Varieties of carrot were drilled on 19th May on a gravelly clay site at NIAB, Cambridge. Plots were 4m long and 4 rows wide on 1.8 m beds. Fertiliser (60:60:60 N:P:K) was applied to beds just before drilling. Linuron was applied on 20th May. Each variety was replicated three times in a randomised block design. Four pathogenic isolates of *Alternaria dauci*, obtained from seed samples submitted to the Official Seed Testing Station, UK culture collections and plant infections collected during 2000, were increased on malt agar plates at 22 °C, under 12h nuv light and 12h dark. Spores were removed

from the plates by soaking in distilled water, scraping, and filtering the resulting suspension through a kitchen plastic mesh sieve, and then a single layer of muslin. The plots were inoculated with 250ml of an aqueous suspension containing 1 x 10^4 spores per ml on 27th July when foliage was meeting in the rows and again on 17th August. The trial was irrigated just prior to inoculation and the suspension was directed downwards at the mid point of the foliage to ensure that the inoculum was protected by the upper leaf canopy. The trial was irrigated during rain-free periods to promote cycles of infection, and scored at approximately weekly intervals through the season. Scores were made of the % foliage and petiole area infected with *Alternaria* on a per plot basis (ie taking all the foliage area in a plot into account) using the area diagrams shown in Appendix I.

Evaluation of the effectiveness of fungicides

Fifty-one plots of the variety Nairobi were drilled at NIAB trial ground, Cambridge on 8th May in a sandy clay loam soil. Plots were 9m long and 4 rows wide on 1.8m beds, and received fertilise (N:P:K 60:60:60) just before drilling, and herbicide (Linuron) on 20th May, plus Dosaflo and Atlas Brown on 16th July. There were three replicates of seventeen treatments arranged in a randomised block design. Discard plots were included at each end of the trial. An Adcon weather station was erected at Cambridge University Farm, Huntingdon Road, approximately 400m from the trial area. Plots were irrigated to promote establishment, just prior to inoculation with *Alternaria* spores on 27th July and once more to maintain plant growth on 2nd August during a hot, dry period. Plots were inoculated using the same method and inoculum source as described for the variety trial at a rate of 500 ml of inoculum per plot. Forecast, "late" ie several days after the forecast risk, and prophylactic treatments were applied to the trial at various times as summarised in Table 1. The plots were scored at intervals during the season.

A second trial consisting of 51 plots of Nairobi was established on within a commercial crop of the same variety at Isleham Carrot Growers Ltd, Freckenham, Norfolk. The trial was not inoculated and plots were managed according to standard commercial practice with the exception of fungicides, which were omitted. An Adcon weather station at the site was used to detect high risk periods for *Alternaria* infection, and two prophylactic treatment sequences were also applied. There were no forecast applications at the site according to advice generated by the PLANT-Plus system. Details of the prophylactic applications are shown in Table 2, and product information relating to both the inoculated and natural infection trial are summarised in Table 3.

Table 1 Spray sequences, rates and dates of application on inoculated trial, Cambridge

	Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	Spray 6
U 1						
U 2						
T3	Amistar 0.8 l/ha forecast 23.07.01	Folicur 0.5l/ha forecast 27.08.01	Folicur 0.5l/ha forecast 14.09.01			
T4	Amistar 0.8l/ha late 01.08.01	Folicur 0.5l/ha late 31.08.01	Folicur 0.5l/ha late 20.09.01			
T5*	Amistar 0.8 l/ha forecast 23.07.01	Folicur 0.5l/ha forecast 27.08.01	Folicur 0.5l/ha forecast 14.09.01			
T6	Amistar 0.8 l/ha forecast 23.07.01	Amistar 0.8 l/ha forecast 27.08.01	Amistar 0.8l/ha forecast 14.09.01			
T7	Amistar 0.8l/ha late 01.08.01	Amistar 0.8l/ha late 31.08.01	Amistar 0.8l/ha late 20.09.01			
T8	Folicur 0.5l/ha forecast 23.07.01	Folicur 0.5l/ha forecast 27.08.01	Folicur 0.5l/ha forecast 14.09.01			
T9	Folicur 0.5l/ha late 01.08.01	Folicur 0.5l/ha late 31.08.01	Folicur 0.5l/ha late 20.09.01			
T10	Folicur 0.5l/ha forecast 23.07.01	Folicur 0.5l/ha forecast 27.08.01	Amistar 0.8l/ha forecast 14.09.01			
T11	Folicur 0.5l/ha late 01.08.01	Folicur 0.5l/ha late 31.08.01	Amistar 0.8l/ha late 20.09.01			
T12	Amistar 0.8 l/ha forecast 23.07.01	Amistar 0.8 l/h forecast 27.08 .01				
T13	Folicur 0.5l/ha forecast 23.07.01	Folicur 0.5l/ha forecast 27.08.01				
T14	Compass 2l/ha forecast 23.07.01	Compass 2l/ha forecast 27.08.01				
T15	Compass 2l/ha late 01.08.01	Compass 2l/ha late 27.08.01	Compass 2l/ha late 20.09.01			
T16	Amistar 0.8l/ha prophylactic 23.07.01	Folicur 0.5 l/ha prophylatic 07.08.01	Folicur 0.5l/ha prophylactic 20.08.01	Amistar 0.8l/ha Prophylactic 03.09.01	Amistar 0.8l/ha prophylactic 20.09.01	Corbel 1.0l/ha prophylactic 04.10.01
T17	Folicur 0.5l/ha prophylactic 23.07.01	Folicur 0.5l/ha prophylactic 07.08.01	Amistar 0.8l/ha prophylactic 20.08.01	Amistar 0.8l/ha Prophylactic 03.09.01	Folicur 0.5l/ha prophylactic 20.09.01	Corbel 1.0 l/ha prophylactic 04.10.01

* T5 sequence intended to have Corbel as 4th forecast spray, but no forecast was made, thus T5 receivd the same overall sequence as T2

Table 2. Spray sequences, rates and dates of application on the natural infection trial, Freckenham

	Spray 1	Spray 2	Spray 3	Spray 4	Spray 5
T16	Amistar	Folicur	Folicur	Amistar	Amistar
	0.8 l/ha	0.5 l/ha	0.5 l/ha	0.8 l/ha	0.8 l/ha
	07.08.01	20.08.01	03.09.01	20.09.01	04.10.01
T17	Folicur	Folicur	Amistar	Amistar	Folicur
	0.5 l/ha	0.5 l/ha	0.8 l/ha	0.8 l/ha	0.5 l/ha
	07.08.01	20.08.01	03.0.01	20.09.01	04.10.01

Table 3. Product details for fungicide trials.

Product	Active ingredient	Current Status	Rate (l product/ha)	Application volume (l water/ha)
Folicur	Tebuconazole	SOLA	0.5	400
Amistar	Azoxystrobin	SOLA*	0.8	400
Compass	Iprodione/ thiophanate methyl	SOLA	2	400
Corbel	Fenpropimorph	SOLA	1	400

* used under Automatic Experimental Approval for the trial

Effects of disease on yield

Plots in the fungicide trials were harvested in the autumn on 5th November (Cambridge) and 22nd October (Freckenham) by taking a 1m section across 4 rows, and recording total weight, root number (>19mm diameter), unmarketable roots (classified as undersized, ie < 19 mm, and/or affected by cavity spot, wet rots, black surface rots and crown rot) and then calculating weight of marketable roots per hectare. The trials were then protected against frost using straw and a second harvest taken on 22nd February (Cambridge) and 14th February (Freckenham)

Results and Discussion

Evaluation and validation of forecasting systems

Alternaria infection levels were lower on the whole than in 2000, but the results from the field observation trials show a similar pattern to that recorded in 2000. Over all sites, there was a light to moderate level of *Alternaria* foliage infection in the untreated plots,

little or no infection in the normal practice treatments, little or no infection in the PLANT-Plus treatments and a reduction in treatment number using PLANT-Plus.

Infections of *Sclerotinia* in carrot crops were less widespread in 2001 but were locally severe. There was also no evidence of significant control of the disease with the fungicide programs used compared to untreated plots.

With the use of PLANT - Plus the average number of fungicide treatments applied to the commercial crops in this study was reduced from 5.1 to 2.5. Control of *Alternaria* was similar in both cases and was of a commercially acceptable standard.

Alternaria was still present in untreated control plots at levels greater than in treated crops but in 2001 the disease progression started late in the season and many crops were straw covered before significant infections occurred. Crops were therefore generally less affected than might be the case in an early season and disease did not reach epidemic levels except in the controlled conditions of the inoculated trial in Cambridge and in the occasional favourable site.

For the second year in this study the correct implementation of the Plant-Plus *Alternaria* model has been shown to reduce the fungicide input compared to normal practice. This has proved possible whilst maintaining good control of the disease. With the generally lower disease pressure seen in 2001, well over two sprays on average could be saved without compromising disease control.

The Plant-Plus system provides the opportunity to gauge when risk periods are approaching and gives a rational use of protectant materials which can be applied just ahead of an infection event. As with all Decision Support Systems (DSS), the user must ensure that the crop recordings upon which the system is operating, together with the weather data, are kept fully up-to-date. In addition the user must carefully interpret the advice output to achieve the correct choice of fungicide material. The advised spray must be applied in good time to achieve crop protection.

If conditions are favourable PLANT-Plus will continue to generate risk assessments and spray warnings until well into the autumn period. At this time many crops are approaching full maturity and it may not be necessary to continue to treat for *Alternaria* The user must therefore continue to carefully interpret warnings in relation to the individual crop maturity and must decide when to cease treatments. At the same time the

user may well want to continue to protect against crown rot organisms. This is a matter of judgement that can only be decided by the individual, depending on site history and previous experience.

A selection of tabulated output and PLANT-Plus graphics is presented in Appendix II and a summary of data collected from all commercial sites in Appendix III

Although the main subject of this study is *Alternaria*, levels of other diseases are of interest to the project team. The most significant disease to affect the foliage of commercial crops in year 2000 was *Sclerotinia* but in 2001 this was less apparent. However again in Norfolk the disease was severe and also caused concern in some crops in Scotland. On specific sites, often those where oilseed rape has been grown, *Sclerotinia* can be a severe problem in carrots. In wet conditions a varieties such as Nairobi which is widely grown, will develop heavy foliage that is inclined to senesce through shading, providing apparently good conditions for infection by *Sclerotinia*. Serious infection can completely or partially defoliate the crop leading to severe losses of yield and the potential for core rot.

Attempting to control *Sclerotinia* when symptoms have been recognised has proved unsuccessful. In the past this has been due to act of suitable eradicant fungicide and to the difficulty of penetrating dense lodged foliage with a treatment. In the autumn of 2000 Dacom introduced a *Sclerotinia* prediction model for carrots for evaluation and the opportunity was taken in 2001 to process the collected raw crop and weather data through the new model and observe the output.

The arrival of a predictive model together with a new fungicide (Amistar) leads us to consider new approaches to control of this disease in carrots and other crops. The forward-looking Plant Plus Model for *Sclerotinia* should enable the application of a protective treatment ahead of infection, and therefore achieve good control. Early treatment will also enable more effective penetration of foliage before it becomes lodged.

For the Norfolk sites, which were affected by Sclerotinia in 2001, the model output showed that severe infection opportunities (ie long duration of suitable environmental conditions) for the disease occurred throughout the growing period. There were significant infection opportunities during the early stages of the carrot crops' life cycle when no fungicides were applied. Advice graphics generated from the Plant Plus Model for *Sclerotinia* and a photograph of infected carrots are shown at the back of Appendix II.

Evaluation of variety susceptibility to Alternaria

There were large and significant differences in the level of *Alternaria* developing on varieties, and in general the ranking order was maintained over the season (Table 4). There was a significant correlation between the results seen in 2001 and 2000 ($r = 0.46$, $p=0.05$) for scores taken in early October in both years, though some varieties had variable results between the two years. However, the susceptibility of popular varieties such as Nairobi and Nerac was confirmed, as was the partial resistance in some which are gaining in popularity such as Maestro, Bristol and Indiana. Other varieties included as controls based on previous observations again reacted as expected, and would provide useful markers for future screening work (eg Victor, susceptible control, and Riga, moderately resistant).

Table 4 Severity of *Alternaria* infection (% foliage area infected) in 30 carrot varieties

	6th Sept	14th Sept	21st Sept	27th Sept	5th Oct	12th Oct
Nairobi	3.4	5.7	9.7	16.7	36.7	46.7
Narbonne	0.2	2.6	5.7	9.0	20.0	28.3
Narman	0.8	3.0	6.7	11.3	26.7	38.3
Navarre	5.0	7.6	16.7	25.0	43.3	65.0
Nerac	1.3	4.3	9.0	15.0	26.7	40.0
Gladiator	0.0	1.0	4.0	8.3	23.3	31.7
Bolero	0.7	0.7	5.0	6.3	11.7	20.0
Senior	2.0	2.7	7.3	15.0	25.0	38.3
Victor	0.7	3.8	9.0	12.7	29.0	41.7
Maestro	0.0	0.2	2.7	6.3	11.7	23.3
Leonor	3.3	6.0	11.3	21.7	33.3	40.0
Riga	0.8	3.0	6.7	10.7	28.3	35.0
Nigel	3.4	8.3	15.0	23.3	36.7	60.0
Atlantis	4.3	6.7	11.7	13.3	31.7	41.7
Furore	5.7	6.7	14.0	22.3	38.3	43.3
NUN 6710	0.7	3.7	6.7	10.7	30.0	40.0
Nepal	0.2	1.7	5.7	7.3	17.3	28.3
Bristol	1.7	5.0	11.3	16.7	25.0	33.3
NUN 6717	5.0	9.7	18.3	20.0	33.3	45.0
EX 942060	3.3	7.7	18.3	26.7	45.0	46.7
Nantucket	3.0	4.7	7.3	14.0	25.0	30.0
Primo	5.7	9.0	18.3	30.0	61.7	71.7
Kamaran	9.0	15.0	25.0	35.0	55.0	65.0
Redco	4.3	7.3	13.0	15.7	26.7	33.3
Indiana	0.0	0.1	2.0	4.7	10.0	20.0
PX 942114	0.4	1.7	5.7	10.0	21.7	33.3
EX 962005	3.7	9.0	20.0	21.7	41.7	50.0
RX 4420046	1.3	4.3	9.0	15.0	33.3	43.3
VAC 33	3.7	6.7	12.3	18.3	43.3	56.7
VAC 35	1.7	7.3	15.0	30.0	40.0	46.7
lsd (p=0.05)	3.10	4.69	7.91	12.59	18.60	18.56

Evaluation of the effectiveness of fungicides

All treatments significantly reduced the level of *Alternaria* throughout the season (Table 5). However, there were no significant differences between the fungicide programmes used, and no significant differences in disease control whether the programmes were applied as protectants before the risk period, or as curatives several days after the forecast risk. The prophylactic spray sequences, consisting of a total of six sprays, did not give any significantly greater disease control than just two sprays of any product applied according to two PLANT-Plus forecasts in the early part of the season, indicating good protection was persisting through subsequent disease risk periods. Similarly, there was no significant difference in disease control between the application of sprays applied in response to all the forecasts, and applications which had stopped after the first two forecasts.

Table 5 Progress of *Alternaria* (% foliage infected) under different fungicide regimes, inoculated trial, Cambridge.

Treatment	27.09.01	03.10.01	10.10.01	18.10.01	23.11.01
U (1)	2.83	5.81	12.00	24.00	28.33
U (2)	3.67	7.33	13.33	25.00	33.33
AF forecast sequence	0.87	3.00	5.33	11.33	20.00
AF late sequence	1.50	2.67	6.00	12.33	18.33
AF forecast sequence (2)	2.33	3.67	5.67	9.0	13.33
A forecast sequence	0.67	3.00	6.67	11.67	21.67
A late sequence	0.10	0.83	2.33	5.67	12.33
F forecast sequence	2.33	2.67	6.00	12.33	18.33
F late sequence	1.20	3.33	5.67	9.00	25.00
FA forecast sequence	2.83	4.67	7.33	13.33	16.67
FA late sequence	1.83	2.67	5.00	9.67	15.67
AA forecast	0.83	2.00	3.67	6.33	15.00
FF forecast	2.33	3.67	8.33	16.67	26.67
CmCm forecast	2.00	4.00	5.67	10.67	19.00
CmCmCm late	2.33	4.33	6.67	12.33	20.00
AFFAACo prophylactic	0.83	1.67	3.67	8.33	19.00
FFAAFCo prophylactic	0.53	0.83	3.00	5.67	14.00
lsd (p=0.05)	1.70	3.06	6.72	9.21	15.80

A= Amistar, F=Folicur, Cm =Compass, Co = Corbel. AF, FA etc refer to the sequences specified in Table1.

There were no forecast sprays at the Freckenham trial. *Alternaria* developed relatively late in the season, reaching only 3% leaf area cover on untreated plots by early October. Prophylactic sprays reduced the disease to very low levels (Table 6).

Table 6 Progress of *Alternaria* (% foliage infected) under different fungicide regimes, natural infection trial, Freckenham.

Treatment	27.09.01	04.10.01	10.10.01	18.10.01
U (1)	1.33	3.67	6.67	15.00
U (2)	1.33	3.0	4.67	10.67
AFFAA prophylactic	0.10	0.1	0.1	0.83
FFAAF prophylactic	0.07	0.1	0.1	1.17
lsd (p=0.05)	0.89	1.99	2.11	6.43

Effects of disease on yield

Effects of *Alternaria* on yield were measured in the fungicide trials.There were significant effects (p=0.05) of treatment on the yields of marketable roots in the Cambridge inoculated trial at the first harvest (Table 7). Sequences of Amistar/Folicur/Folicur, or Folicur/Folicur/Amistar applied according to the PLANT-Plus forecast, gave some of the largest yield improvements in the range of 8 to 10 t/ha of marketable roots over untreated controls. Two forecast sprays of Compass gave a comparable response. However, only one of the prophylactic sequences, comprising a total of 6 sprays, gave a statistically significant yield benefit over untreated controls of 18 t/ha. There was no clear relationship between differences in yield due to treatments and the degree of disease control achieved by them. However, the average yield of all the forecast combinations was 122.9 t/ha, or a benefit of 6.3% over untreated controls, while the average yield of all the late combinations was only 0.4 % greater than controls. The reason for the advantage of the forecast sprays is not clear, though possibly the initial establishment of infection which took place when sprays were late did reduce plant growth to some extent. The overall benefit of fungicide treatments, including those applied prophylactically, was 4.9%, or 5.8t/ha of marketable roots, associated with an average reduction in *Alternaria* from 12% to 5% leaf area cover in early October. Most fungicide treatments also improved yields at the second harvest (Table 8), but differences were not significant (p=0.05) and there were considerable weights of unmarketable roots, which did not appear to be affected by treatment. There were only low levels of unmarketable categories at the first harvest, and no clear treatment effects.

Table 7 Effects of fungicide treatment on yield (t/ha) of marketable and unmarketable root categories, Cambridge inoculated trial, first harvest

Treatment	Marketable	Cavity spot	Crown rot	other rots	Undersize
U (1)	116.8	3.1	0	0.4	0.2
U (2)	114.4	0.4	0	0.1	0.3
AF forecast sequence	124.3	0.0	0	0.1	0.0
AF late sequence	107.7	1.0	0	0.0	0.2
AF forecast sequence (2)	127.9	0.0	0	0.1	0.2
A forecast sequence	122.3	0.3	0	0.0	0.2
A late sequence	119.0	0.6	0	0.1	0.3
F forecast sequence	118.5	0.3	0	0.3	0.0
F late sequence	120.3	4.1	0	0.0	0.2
FA forecast sequence	127.4	1.4	0	0.0	0.0
FA late sequence	117.9	4.0	0	0.4	0.3
AA forecast	120.3	0.4	0	0.7	0.1
FF forecast	115.6	1.0	0	0.2	0.2
CmCm forecast	126.9	2.7	0	0.3	0.2
CmCmCm late	115.6	1.5	0	0.0	0.2
AFFAACo prophylactic	133.8	4.5	0	1.3	0.1
FFAAFCo prophylactic	122.9	1.3	0	0.9	0.1
lsd (p=0.05)	17.21	4.28	-	1.13	0.32

Table 8. Effects of fungicide treatment on yield (t/ha) of marketable and unmarketable root categories, Cambridge inoculated trial, second harvest

Treatment	marketable	cavity	crown	other rots	undersize

		spot	rot		
U (1)	93.7	2.3	0.9	5.8	0.0
U (2)	90.6	3.0	1.2	3.9	0.1
AF forecast sequence	100.0	4.2	0.1	3.6	0.4
AF late sequence	99.1	4.6	0.7	2.5	0.1
AF forecast sequence (2)	110.4	2.1	1.9	4.4	0.1
A forecast sequence	98.1	0.9	2.2	4.5	0.0
A late sequence	121.2	3.7	1.0	2.0	0.3
F forecast sequence	103.8	2.9	0.3	8.1	0.5
F late sequence	110.9	0.6	0.7	0.4	0.1
FA forecast sequence	93.0	4.6	1.2	6.5	0.3
FA late sequence	112.2	4.0	1.8	1.8	0.2
AA forecast	113.8	4.7	1.6	3.9	0.2
FF forecast	106.2	3.7	0.9	2.6	0.1
CmCm forecast	113.8	1.1	1.4	0.4	0.0
CmCmCm late	97.8	4.8	1.1	4.9	0.2
AFFAACo prophylactic	100.2	2.4	2.6	2.6	0.2
FFAAFCo prophylactic	114.0	2.5	0.0	0.4	0.3
lsd (p=0.05)	28.65	4.83	2.48	6.23	0.38

.

In the natural infection trial, no forecast sprays were applied. All plots were harvested however, and data are shown for the highest and lowest yielding untreated plots in the trial and the prophylactic treatments (Table 9). There was considerable variation across the trial, and treatment differences were not significant, but both prophylactic treatments did show an increase over the highest untreated yield. However, it should be noted that this was achieved with a total of 5 sprays compared to a similar benefit achieved with 3 sprays in the inoculated trial which had higher disease. At the second harvest, many roots were found to be unmarketable due to extensive rotting which was attributed to secondary organisms possibly infecting primary cavity spot lesions. It was not possible to confirm the presence of cavity spot, and though symptoms were typical of lesions with secondary rots, there may have been some frost damage. However, both of the prophylactic treatments greatly decreased the yield of affected roots (Table 10). This observation may merit further investigation, though from the data available here it is not possible to draw any firm conclusions about the effect observed.

Table 9 Effects of fungicide treatment on yield (t/ha) of marketable and unmarketable root categories, Freckenham natural infection trial, first harvest

Treatment	marketable	cavity spot	crown rot	other rots	undersize
U (highest yield)	105.9	0	0	0.1	2.6
U (lowest yield)	88.9	0	0	0.0	2.7
AFFAA prophylactic	110.4	0	0	0.0	3.8
FFAAF prophylactic	113.3	0	0	0.0	4.9
lsd (p=0.05)	16.21	-	-	0.68	2.25

Table 10 Effects of fungicide treatment on yield (t/ha) of marketable and unmarketable root categories, Freckenham natural infection trial, second harvest

Treatment	Marketable	"soft rots"	crown rot	other rots	Undersize
U (highest yield)	50.4	40.1	1.0	0.0	1.4
U (lowest yield)	35.7	43.1	1.2	0.0	1.8
AFFAA prophylactic	64.6	34.5	0.6	0.0	1.2
FFAAF prophylactic	65.3	37.3	1.4	0.0	4.4
lsd (p=0.05)	10.29	15.79	1.63	-	2.8

Conclusions

Based on this year's results, and those from 2000, the following conclusions can be made:

- PLANT Plus forecasting systems can significantly reduce the number of sprays applied for *Alternaria* while retaining acceptable levels of control, offering growers the opportunity to reduce production costs. In 2001, with overall lower disease pressure than 2000, an average of 2.6 sprays over a number of growing regions could be omitted without affecting disease levels.
- Varieties differ substantially and consistently in resistance to *Alternaria*. This information can be incorporated into the PLANT-Plus forecasting system enabling further reductions in spray frequency on some varieties
- Amistar, Folicur, and Compass gave effective control of *Alternaria*, whether applied as protectants or curatives in the 2001 season. Alternating sequences of Folicur and Amistar controlled *Alternaria* as effectively as the same product used throughout the season, thus confirming that anti-resistance strategies should not compromise disease control
- Forecast fungicide treatments increased the yield of marketable roots in a trial where infection was deliberately introduced by 6.3% on average. This compares to 8% in

2000, reflecting less favourable conditions for disease development in 2001. Sprays applied after the forecast risk gave much lower yield benefits.

- Prophylactic spray sequences applied in a situation where disease did not develop significantly until mid-October gave yield benefits, but these were unlikely to be cost effective compared to forecast sprays in a situation where significant disease development had occurred by early October.

Technology transfer

This work was presented to British Carrot Growers Association seminar meetings in 2001 and 2002. A poster describing the first year's results was demonstrated at the UK Carrot and Onion Conference, Spalding, 2001. A fact sheet based on the results of the first two years will be prepared for HDC members during April 2002.

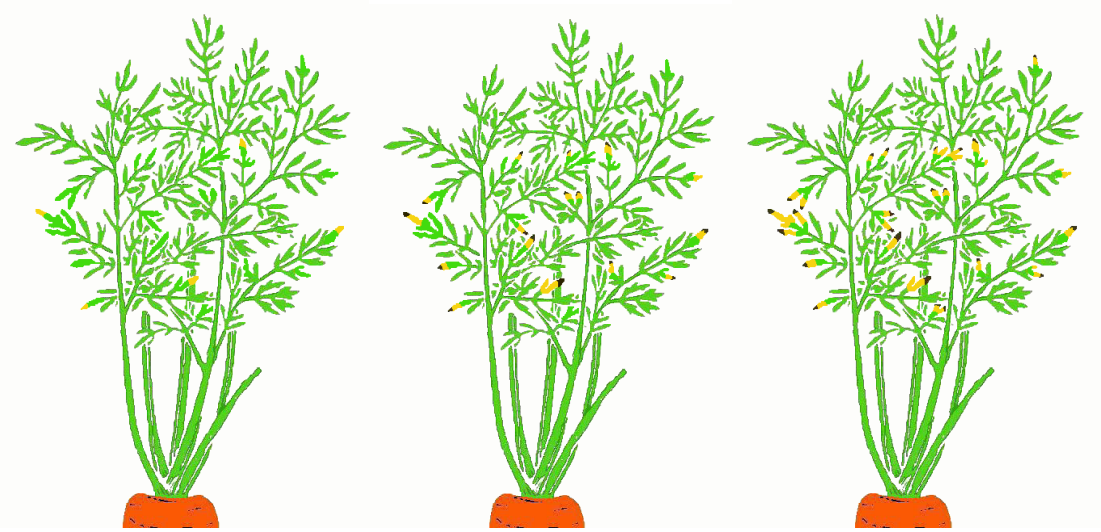
References

Anon 2001 "Leaf blight was a focus in New York" in Carrot Country, pp 10-14, Summer 2001.

Davis M; Gilbertson B; Nunez J; Pryor B; Strandberg J. 1993 *Alternaria* disease of carrots. Bulletin of the University of California-Davis, December 1993

APPENDIX I

Scale for Alternaria assessment



1% 5% 10%

15% 20% 40%

- Interpolate between % points
- Score all yellowing and blackening confirmed as *Alternaria*
- Include petiole area
- Examine the whole of the plot, and assign mean score

APPENDIX II

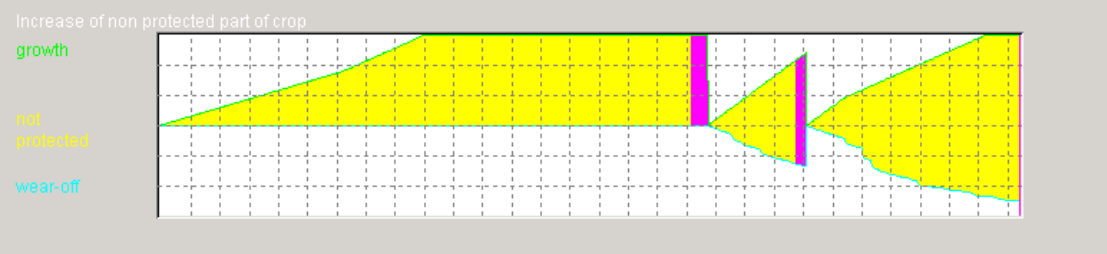
PLANT Plus output and graphics from representative sites

Trial Site and Field Site Season Reviews – Alternaria advice graphics

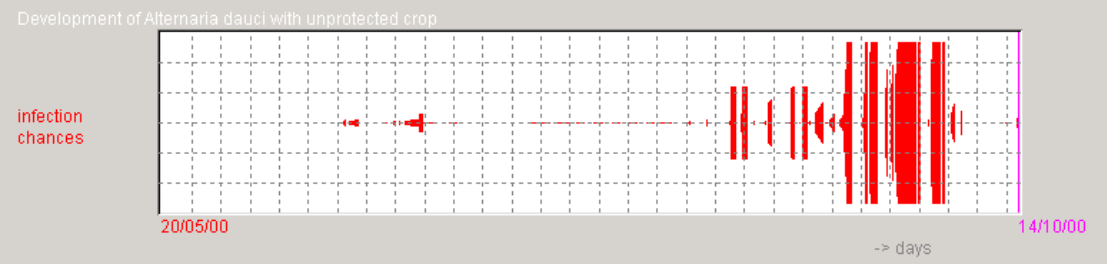
Interpretation of PP Advice Graphics

PP graphics are presented in pairs and represent changes in crop status and in disease risk over a specific time period. The graphics presented in this report are season reviews, which cover the time period between early June and mid October.

The top graphic of the pair illustrates the rate of growth of the crop foliage together with the wear off of the fungicide treatments applied to control disease.



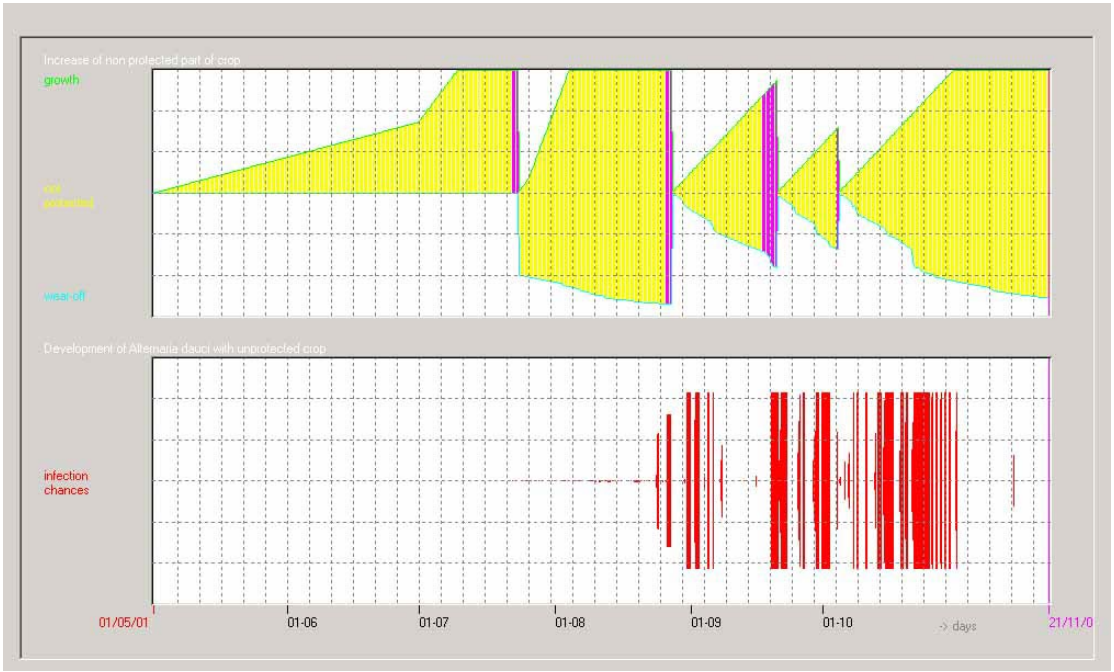
The bottom graphic illustrates the infection events, which have been identified by the PP system assuming the crop is unprotected.



Optimum crop protection is achieved when the treatments (top graphic, vertical bars) are timed just in advance of or to coincide with the most significant infection events.

NIAB Trial Site Cambridge

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 14:23
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB
      Crop reference + size       :  NIAB m/c trial 2001          1.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  PSL Cambridge
      Weather forecast            :  HWS UK Wyton
--- Year survey ------------------------------------------------------------
      # 23/07/01 12:00 curative unnecessary contact too early
      ! 02/08/01 18:00 - 03/08/01 10:00   27 small infection chances not treated
      ! 05/08/01 00:00 - 05/08/01 11:00   19 small infection chances not treated
      ! 06/08/01 07:00 - 07/08/01 10:00   47 small infection chances not treated
      ! 08/08/01 19:00 - 10/08/01 05:00   61 small infection chances not treated
      ! 11/08/01 01:00 - 11/08/01 10:00   16 small infection chances not treated
      ! 12/08/01 08:00 - 13/08/01 13:00   52 small infection chances not treated
      ! 14/08/01 03:00 - 14/08/01 13:00   18 small infection chances not treated
      ! 18/08/01 20:00 - 19/08/01 17:00   38 small infection chances not treated
      ! 19/08/01 23:00 - 20/08/01 10:00   20 small infection chances not treated
      ! 24/08/01 01:00 - 24/08/01 11:00  410 large infection chances not treated
      ! 25/08/01 04:00 - 25/08/01 12:00   15 small infection chances not treated
      # 27/08/01 12:00 curative OK contact too early
      ! 30/08/01 22:00 - 31/08/01 19:00   43 small infection chances not treated
      ! 01/09/01 16:00 - 02/09/01 21:00  192 small infection chances not treated
      ! 04/09/01 18:00 - 05/09/01 01:00  126 small infection chances not treated
      ! 06/09/01 02:00 - 06/09/01 03:00   30 small infection chances not treated
      ! 07/09/01 13:00 - 08/09/01 01:00   76 small infection chances not treated
      ! 15/09/01 17:00 - 15/09/01 19:00   12 small infection chances not treated
      # 20/09/01 12:00 curative OK contact OK
      ! 25/09/01 04:00 - 25/09/01 21:00   56 small infection chances not treated
      ! 26/09/01 14:00 - 26/09/01 16:00   16 small infection chances not treated
      ! 28/09/01 19:00 - 29/09/01 04:00   68 small infection chances not treated
      ! 29/09/01 09:00 - 30/09/01 03:00  540 large infection chances not treated
      ! 30/09/01 19:00 - 02/10/01 02:00 1550 large infection chances not treated
      ! 02/10/01 07:00 - 02/10/01 14:00  420 large infection chances not treated
      # 04/10/01 12:00 curative OK contact OK
      ! 08/10/01 18:00 - 09/10/01 03:00   34 small infection chances not treated
```



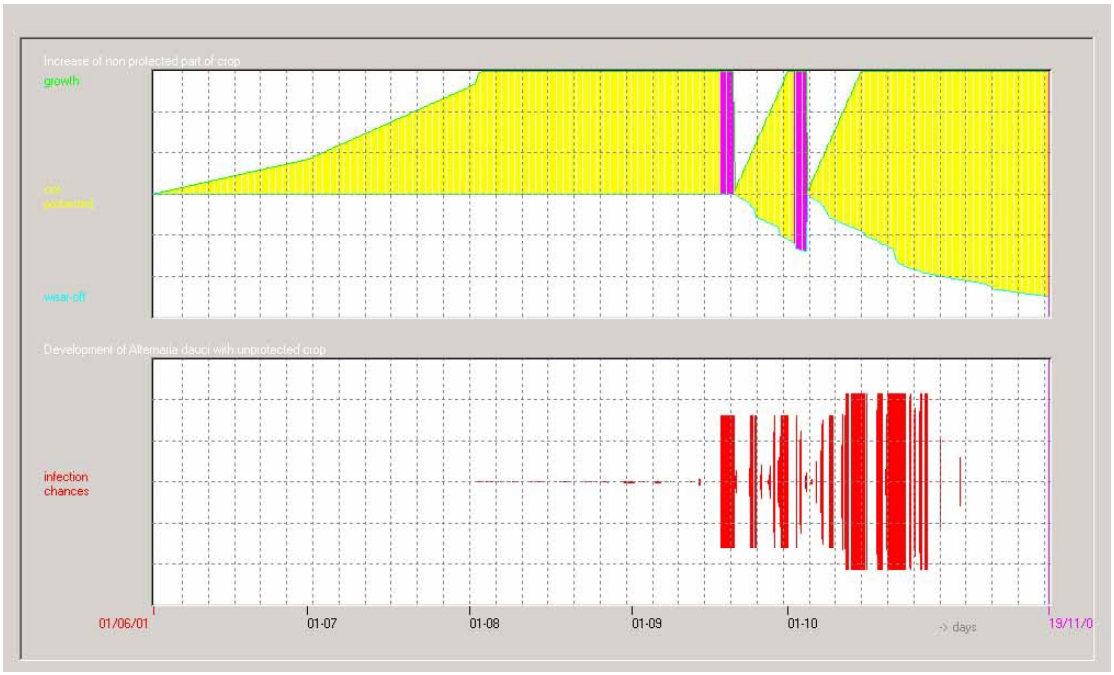
According to the Plant Plus Alternaria model, no infection conditions occurred until 24 August when an infection event triggered the first treatment that was applied on 27 August. The second treatment was applied on 20 September in response to a forecast infection period, which subsequently proved to be significant. The next infection event occurred at the end of September and a further spray was applied on 4 October. There were further significant risks according to the Plant Plus model from the middle of October particularly around the 21st. At this time a spray

was considered but it was decided not to treat, as infections from this period would be unlikely to cause significant yield effect.

By 11 November there was a significant infection of Alternaria in the foliage and 10% of the leaf area had died off.

NIAB Trial Site Freckenham

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 14:28
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Freckenham
      Crop reference + size       :  Freckenham 2001              10.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  PSL Isleham
      Weather forecast            :  HWS UK Wyton
--- Year survey ------------------------------------------------------------
      ! 02/08/01 18:00 - 03/08/01 11:00   17 small infection chances not treated
      ! 05/08/01 00:00 - 05/08/01 12:00   12 small infection chances not treated
      ! 06/08/01 23:00 - 07/08/01 10:00   11 small infection chances not treated
      ! 12/08/01 07:00 - 13/08/01 02:00   19 small infection chances not treated
      ! 19/08/01 01:00 - 20/08/01 11:00   34 small infection chances not treated
      ! 26/08/01 02:00 - 27/08/01 11:00   33 small infection chances not treated
      ! 30/08/01 06:00 - 31/08/01 11:00   29 small infection chances not treated
      ! 31/08/01 17:00 - 01/09/01 14:00   21 small infection chances not treated
      ! 02/09/01 23:00 - 03/09/01 13:00   14 small infection chances not treated
      ! 05/09/01 14:00 - 06/09/01 12:00   22 small infection chances not treated
      # 20/09/01 12:00 curative OK contact OK
      ! 23/09/01 11:00 - 24/09/01 05:00  186 small infection chances not treated
      ! 24/09/01 14:00 - 24/09/01 23:00  173 small infection chances not treated
      ! 25/09/01 16:00 - 25/09/01 20:00   16 small infection chances not treated
      ! 27/09/01 03:00 - 27/09/01 13:00   38 small infection chances not treated
      ! 28/09/01 03:00 - 28/09/01 12:00  344 large infection chances not treated
      ! 29/09/01 02:00 - 30/09/01 23:00 2654 large infection chances not treated
      # 04/10/01 12:00 curative OK contact OK
      ! 07/10/01 06:00 - 07/10/01 14:00   31 small infection chances not treated
      ! 08/10/01 22:00 - 09/10/01 12:00  311 large infection chances not treated
      ! 11/10/01 04:00 - 11/10/01 11:00  195 small infection chances not treated
      ! 11/10/01 21:00 - 12/10/01 14:00  987 large infection chances not treated
      ! 13/10/01 01:00 - 15/10/01 13:00 4748 large infection chances not treated
      ! 15/10/01 22:00 - 16/10/01 01:00  263 large infection chances not treated
      ! 18/10/01 00:00 - 18/10/01 22:00 2204 large infection chances not treated
      ! 19/10/01 15:00 - 23/10/01 12:0010210 large infection chances not treated
      ! 24/10/01 03:00 - 24/10/01 13:00 1080 large infection chances not treated
      ! 25/10/01 02:00 - 25/10/01 05:00  280 large infection chances not treated
```



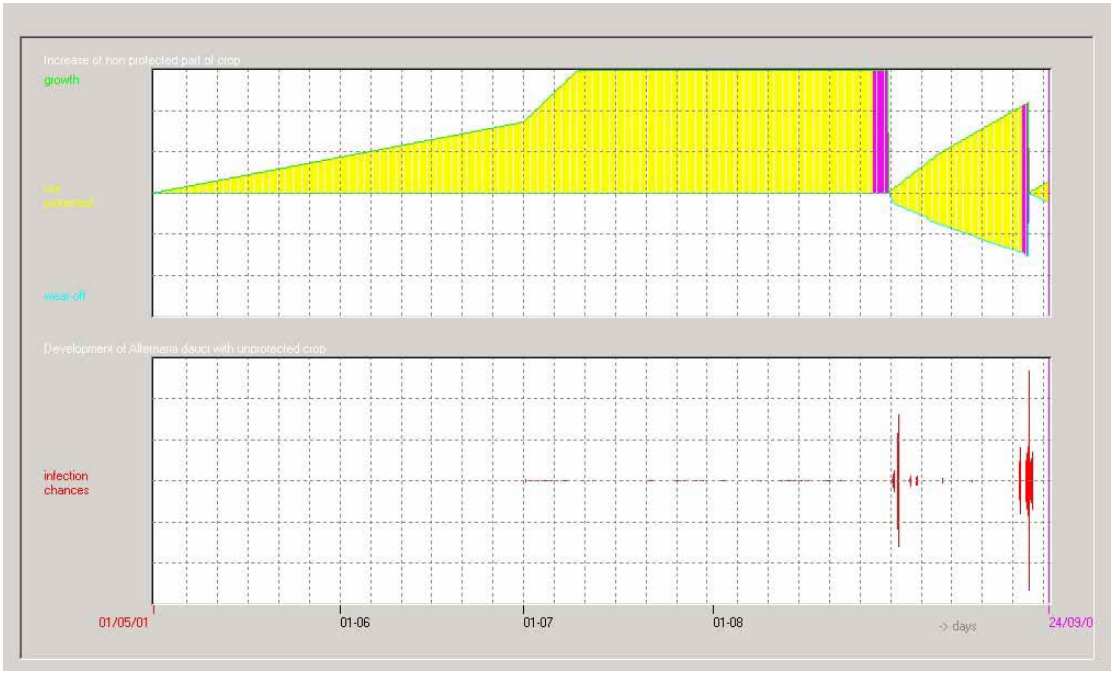
The crop at Freckenham was slow to establish but developed rapidly in the favourable autumn conditions. The crop was judged to be at risk of infection in the third week in

September and a treatment was applied in accordance with the Plant Plus warning on 20 September.

The conditions at the end of September were again very favourable to infection and the second treatment was applied on 4 October. By 11 October the Alternaria infection was becoming more significant with 10% of foliage having died off. October was exceptionally warm and Alternaria development was favoured throughout the month but it was decided not to treat again. No further infection events were recorded after the end of October.

Perthshire

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 12:45
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Perth
      Crop reference + size       :  Perth m/c 2001              10.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  PSL Almondbank
      Weather forecast            :  HWS UK Strathallan
--- Year survey ------------------------------------------------------------
      ! 04/07/01 02:00 - 05/07/01 16:00   30 small infection chances not treated
      ! 07/07/01 01:00 - 08/07/01 15:00   38 small infection chances not treated
      ! 10/07/01 07:00 - 10/07/01 22:00   15 small infection chances not treated
      ! 21/07/01 07:00 - 22/07/01 10:00   27 small infection chances not treated
      ! 25/07/01 15:00 - 26/07/01 13:00   22 small infection chances not treated
      ! 01/08/01 23:00 - 03/08/01 10:00   35 small infection chances not treated
      ! 13/08/01 01:00 - 13/08/01 13:00   12 small infection chances not treated
      ! 13/08/01 19:00 - 14/08/01 14:00   19 small infection chances not treated
      ! 14/08/01 19:00 - 15/08/01 13:00   18 small infection chances not treated
      ! 16/08/01 03:00 - 16/08/01 15:00   12 small infection chances not treated
      ! 19/08/01 00:00 - 20/08/01 09:00   33 small infection chances not treated
      # 29/08/01 12:00 curative unnecessary contact OK
      ! 20/09/01 00:00 - 20/09/01 04:00   73 small infection chances not treated
      # 21/09/01 12:00 curative OK contact OK
----------------------------------------------------------------------------
```

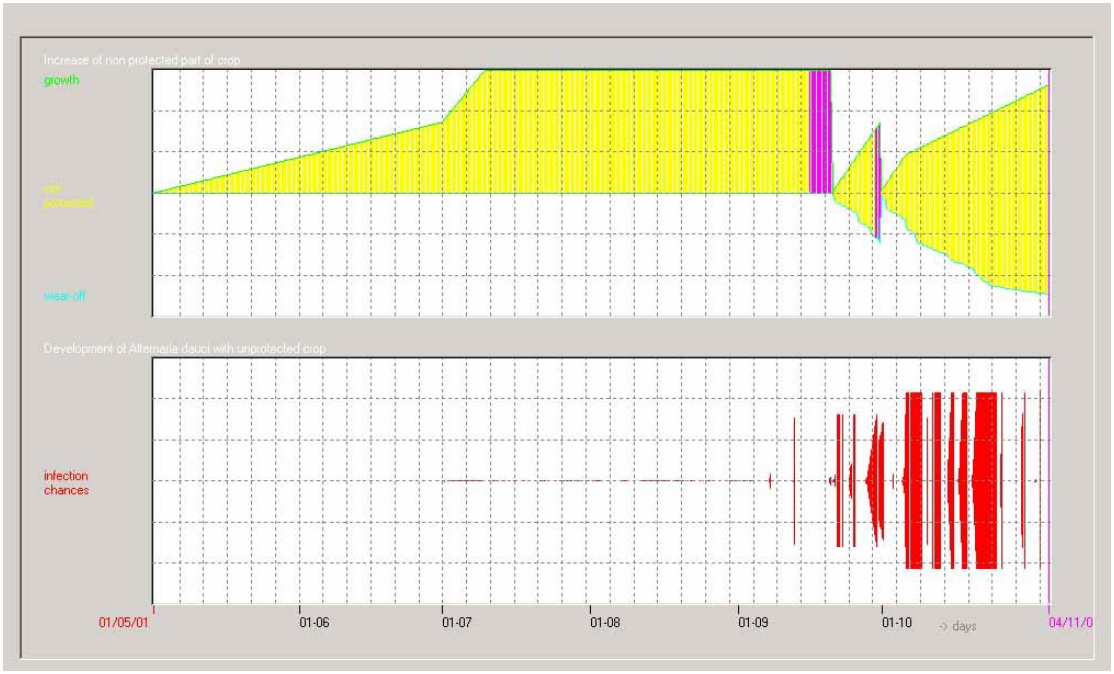


The 2001 season was characterised by cool relatively dry conditions. This gave very few infection events and little or no disease development on any sites. Commercial crops were very clean except right at the very end of the growing period when some Alternaria lesions were observed in the Angus site.

According to the Plant Plus system, two treatments for Alternaria were judged to be necessary in Perthshire and in Angus and three treatments in Fife.

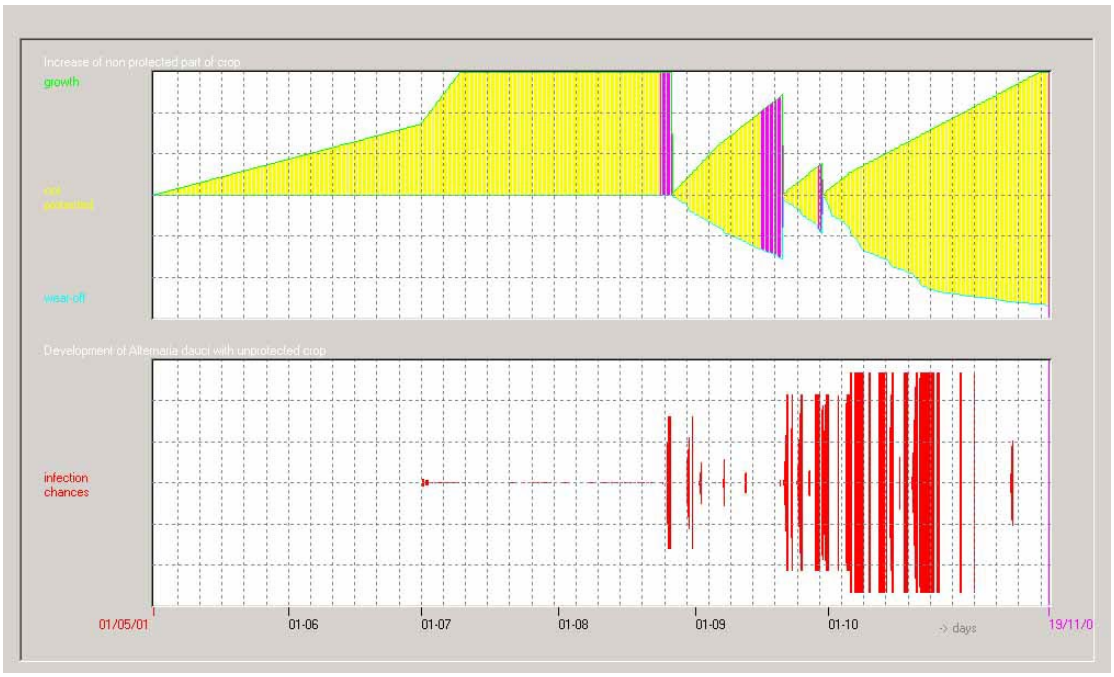
Angus

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 13:11
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Carnoustie
      Crop reference + size       :  Angus m/c 2001              10.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  UK KPL Ravensby
      Weather forecast            :  HWS UK Leuchars
--- Year survey ------------------------------------------------------------
      ! 02/07/01 22:00 - 09/07/01 11:00  138 small infection chances not treated
      ! 21/07/01 06:00 - 22/07/01 11:00   29 small infection chances not treated
      ! 25/07/01 12:00 - 26/07/01 13:00   25 small infection chances not treated
      ! 26/07/01 23:00 - 28/07/01 02:00   27 small infection chances not treated
      ! 28/07/01 22:00 - 29/07/01 09:00   11 small infection chances not treated
      ! 01/08/01 21:00 - 03/08/01 12:00   39 small infection chances not treated
      ! 07/08/01 08:00 - 08/08/01 11:00   27 small infection chances not treated
      ! 11/08/01 13:00 - 12/08/01 11:00   22 small infection chances not treated
      ! 13/08/01 02:00 - 13/08/01 14:00   12 small infection chances not treated
      ! 13/08/01 21:00 - 15/08/01 14:00   41 small infection chances not treated
      ! 15/08/01 23:00 - 17/08/01 11:00   36 small infection chances not treated
      ! 18/08/01 22:00 - 20/08/01 10:00   36 small infection chances not treated
      ! 30/08/01 01:00 - 31/08/01 10:00   33 small infection chances not treated
      ! 01/09/01 22:00 - 02/09/01 10:00   12 small infection chances not treated
      ! 07/09/01 08:00 - 07/09/01 17:00   29 small infection chances not treated
      ! 12/09/01 07:00 - 12/09/01 16:00  171 small infection chances not treated
      # 20/09/01 12:00 curative OK contact OK
      ! 24/09/01 02:00 - 24/09/01 13:00   11 small infection chances not treated
      ! 24/09/01 22:00 - 25/09/01 04:00   33 small infection chances not treated
      ! 27/09/01 13:00 - 29/09/01 13:00  702 large infection chances not treated
      # 30/09/01 12:00 curative OK contact OK
      ! 05/10/01 01:00 - 06/10/01 14:00  449 large infection chances not treated
      ! 07/10/01 00:00 - 09/10/01 04:00 2042 large infection chances not treated
      ! 10/10/01 08:00 - 10/10/01 11:00   98 small infection chances not treated
      ! 11/10/01 10:00 - 11/10/01 15:00   97 small infection chances not treated
      ! 12/10/01 01:00 - 12/10/01 05:00  255 large infection chances not treated
      ! 12/10/01 12:00 - 13/10/01 06:00 1148 large infection chances not treated
      ! 14/10/01 17:00 - 15/10/01 20:00 1435 large infection chances not treated
```



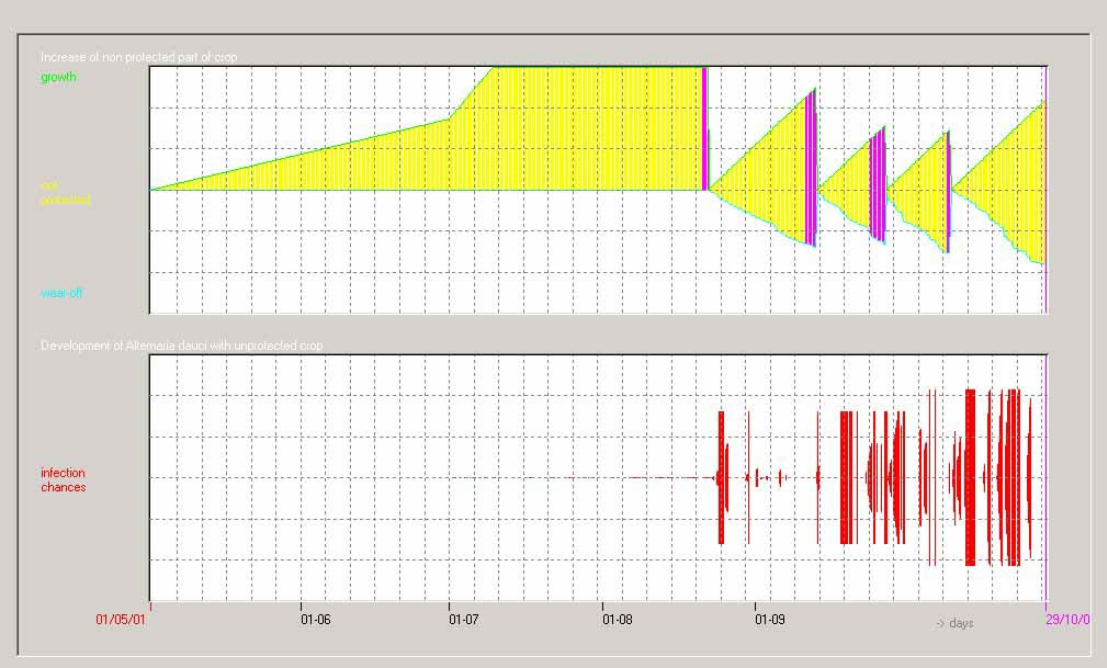
Fife

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 13:18
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Fife
      Crop reference + size       :  Fife m/c 2001                10.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  UK KPL Balmalcom
      Weather forecast            :  HWS UK Edinburgh
--- Year survey ------------------------------------------------------------
      ! 01/07/01 23:00 - 02/07/01 13:00   28 small infection chances not treated
      ! 03/07/01 22:00 - 08/07/01 14:00  100 small infection chances not treated
      ! 08/07/01 22:00 - 09/07/01 10:00   12 small infection chances not treated
      ! 10/07/01 08:00 - 10/07/01 23:00   15 small infection chances not treated
      ! 21/07/01 07:00 - 22/07/01 11:00   28 small infection chances not treated
      ! 27/07/01 02:00 - 27/07/01 14:00   12 small infection chances not treated
      ! 28/07/01 21:00 - 29/07/01 09:00   12 small infection chances not treated
      ! 01/08/01 19:00 - 03/08/01 10:00   39 small infection chances not treated
      ! 07/08/01 14:00 - 08/08/01 13:00   23 small infection chances not treated
      ! 11/08/01 06:00 - 12/08/01 11:00   29 small infection chances not treated
      ! 13/08/01 01:00 - 13/08/01 13:00   12 small infection chances not treated
      ! 13/08/01 20:00 - 14/08/01 12:00   16 small infection chances not treated
      ! 14/08/01 21:00 - 15/08/01 13:00   16 small infection chances not treated
      ! 16/08/01 01:00 - 16/08/01 16:00   15 small infection chances not treated
      ! 18/08/01 22:00 - 20/08/01 09:00   35 small infection chances not treated
      ! 21/08/01 18:00 - 22/08/01 05:00   11 small infection chances not treated
      # 26/08/01 12:00 curative OK contact too early
      ! 30/08/01 03:00 - 30/08/01 17:00   14 small infection chances not treated
      ! 31/08/01 04:00 - 31/08/01 10:00   23 small infection chances not treated
      ! 01/09/01 21:00 - 02/09/01 09:00   12 small infection chances not treated
      ! 07/09/01 05:00 - 07/09/01 14:00   44 small infection chances not treated
      ! 12/09/01 07:00 - 12/09/01 09:00   18 small infection chances not treated
      # 20/09/01 12:00 curative OK contact OK
      ! 23/09/01 18:00 - 25/09/01 03:00   12 small infection chances not treated
      ! 28/09/01 00:00 - 28/09/01 14:00  137 small infection chances not treated
      # 29/09/01 12:00 curative OK contact OK
      ! 05/10/01 02:00 - 06/10/01 07:00  315 large infection chances not treated
      ! 07/10/01 02:00 - 09/10/01 02:00 2021 large infection chances not treated
```



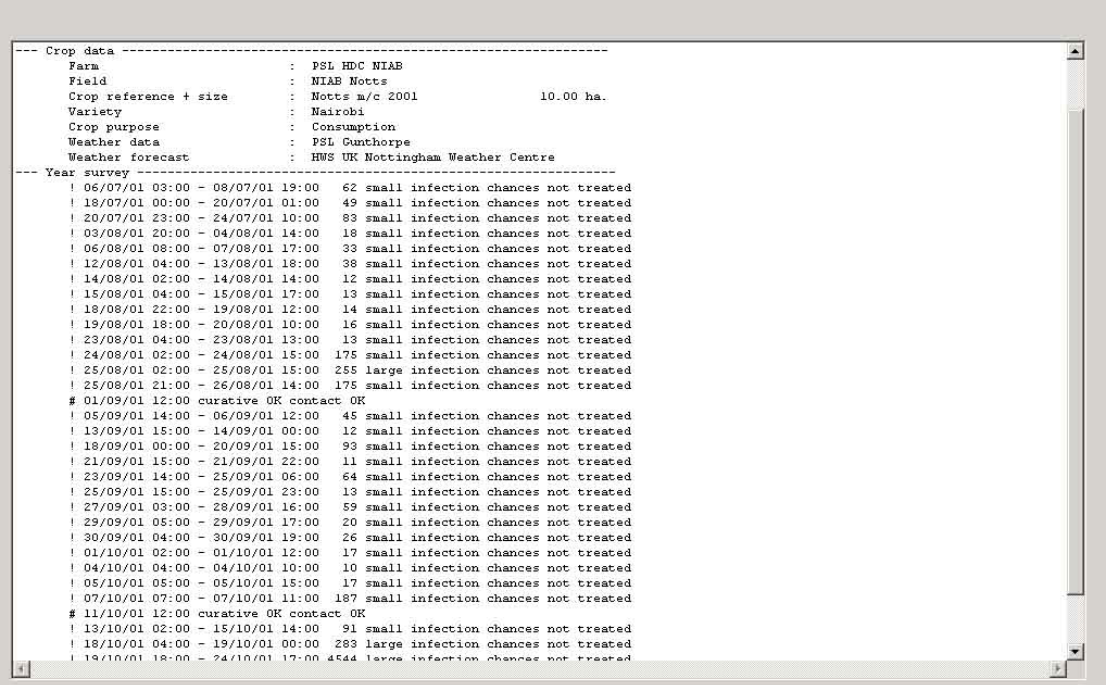
Yorkshire

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 13:50
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Yorks
      Crop reference + size       :  Yorks m/c 2001                1.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  UK HF Naburn
      Weather forecast            :  HWS UK Crosby
--- Year survey ------------------------------------------------------------
      ! 06/08/01 10:00 - 08/08/01 18:00   56 small infection chances not treated
      ! 11/08/01 21:00 - 13/08/01 11:00   38 small infection chances not treated
      ! 16/08/01 01:00 - 16/08/01 12:00   11 small infection chances not treated
      ! 18/08/01 23:00 - 19/08/01 13:00   14 small infection chances not treated
      ! 19/08/01 20:00 - 20/08/01 08:00   12 small infection chances not treated
      # 22/08/01 12:00 curative OK contact OK
      ! 24/08/01 03:00 - 25/08/01 14:00   11 small infection chances not treated
      ! 30/08/01 05:00 - 30/08/01 14:00   20 small infection chances not treated
      ! 05/09/01 19:00 - 06/09/01 03:00   33 small infection chances not treated
      # 13/09/01 12:00 curative unnecessary contact OK
      ! 18/09/01 10:00 - 19/09/01 17:00  167 small infection chances not treated
      ! 20/09/01 03:00 - 20/09/01 12:00   54 small infection chances not treated
      ! 21/09/01 15:00 - 21/09/01 16:00   17 small infection chances not treated
      ! 23/09/01 21:00 - 24/09/01 02:00   45 small infection chances not treated
      # 27/09/01 12:00 curative OK contact OK
      ! 01/10/01 02:00 - 01/10/01 07:00   17 small infection chances not treated
      ! 04/10/01 04:00 - 04/10/01 12:00   58 small infection chances not treated
      ! 05/10/01 03:00 - 05/10/01 14:00  112 small infection chances not treated
      ! 06/10/01 05:00 - 06/10/01 11:00  248 large infection chances not treated
      ! 07/10/01 09:00 - 07/10/01 11:00   98 small infection chances not treated
      # 10/10/01 12:00 curative OK contact OK
      ! 13/10/01 11:00 - 15/10/01 12:00  132 small infection chances not treated
      ! 18/10/01 00:00 - 18/10/01 16:00  200 small infection chances not treated
      ! 19/10/01 18:00 - 21/10/01 01:00  416 large infection chances not treated
      ! 21/10/01 16:00 - 22/10/01 16:00 1095 large infection chances not treated
      ! 23/10/01 01:00 - 23/10/01 14:00  829 large infection chances not treated
      ! 24/10/01 02:00 - 24/10/01 13:00  800 large infection chances not treated
      ! 26/10/01 04:00 - 26/10/01 18:00  775 large infection chances not treated
```

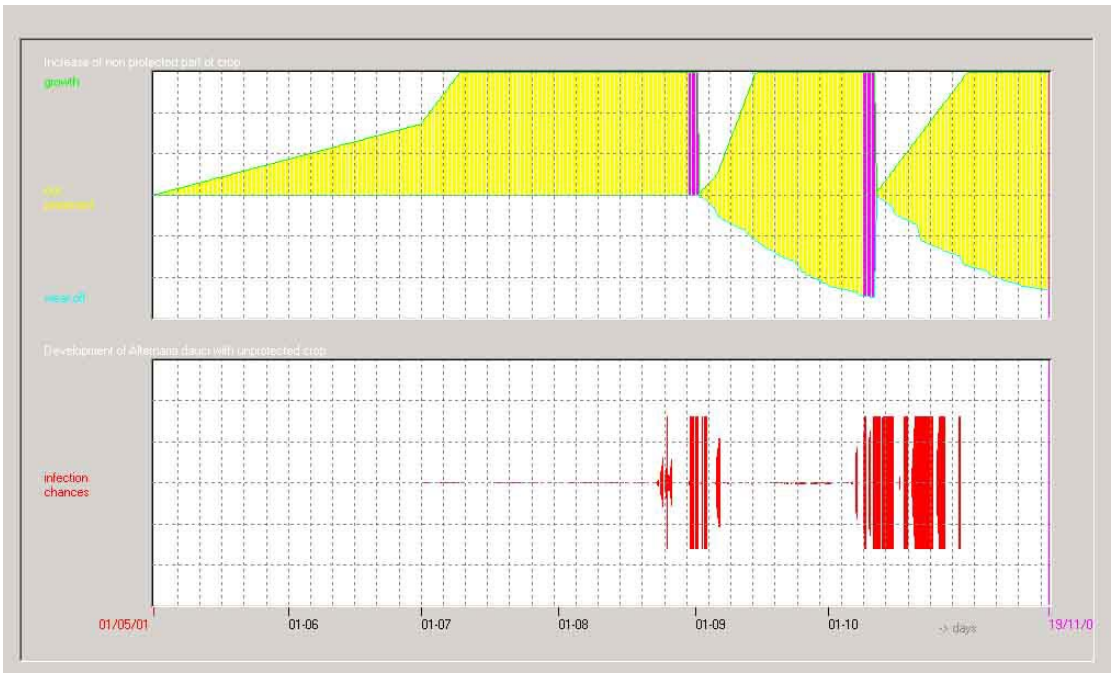


In Yorkshire there were three significant periods favourable to the development Alternaria and a final event was treated for alternaria and crown rot in October. The first event was on the 24 August and a treatment was initiated just before this period. A second treatment was made on the 13 September just before the start of the second significant infection period. A third treatment was recommended at the end of September and a final dual-purpose treatment was applied in October. A few lesions of alternaria developed in the untreated plot.

Nottinghamshire



```
--- Crop data ------------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Notts
      Crop reference + size       :  Notts m/c 2001              10.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  PSL Gunthorpe
      Weather forecast            :  HWS UK Nottingham Weather Centre
--- Year survey ----------------------------------------------------------------
      ! 06/07/01 03:00 - 08/07/01 19:00   62 small infection chances not treated
      ! 18/07/01 00:00 - 20/07/01 01:00   49 small infection chances not treated
      ! 20/07/01 23:00 - 24/07/01 10:00   83 small infection chances not treated
      ! 03/08/01 20:00 - 04/08/01 14:00   18 small infection chances not treated
      ! 06/08/01 08:00 - 07/08/01 17:00   33 small infection chances not treated
      ! 12/08/01 04:00 - 13/08/01 18:00   38 small infection chances not treated
      ! 14/08/01 02:00 - 14/08/01 14:00   12 small infection chances not treated
      ! 15/08/01 04:00 - 15/08/01 17:00   13 small infection chances not treated
      ! 18/08/01 22:00 - 19/08/01 12:00   14 small infection chances not treated
      ! 19/08/01 18:00 - 20/08/01 10:00   16 small infection chances not treated
      ! 23/08/01 04:00 - 23/08/01 13:00   13 small infection chances not treated
      ! 24/08/01 02:00 - 24/08/01 15:00  175 small infection chances not treated
      ! 25/08/01 02:00 - 25/08/01 15:00  255 large infection chances not treated
      ! 25/08/01 21:00 - 26/08/01 14:00  175 small infection chances not treated
      # 01/09/01 12:00 curative OK contact OK
      ! 05/09/01 14:00 - 06/09/01 12:00   45 small infection chances not treated
      ! 13/09/01 15:00 - 14/09/01 00:00   12 small infection chances not treated
      ! 18/09/01 00:00 - 20/09/01 15:00   93 small infection chances not treated
      ! 21/09/01 15:00 - 21/09/01 22:00   11 small infection chances not treated
      ! 23/09/01 14:00 - 25/09/01 06:00   64 small infection chances not treated
      ! 25/09/01 15:00 - 25/09/01 23:00   13 small infection chances not treated
      ! 27/09/01 03:00 - 28/09/01 16:00   59 small infection chances not treated
      ! 29/09/01 05:00 - 29/09/01 17:00   20 small infection chances not treated
      ! 30/09/01 04:00 - 30/09/01 19:00   26 small infection chances not treated
      ! 01/10/01 02:00 - 01/10/01 12:00   17 small infection chances not treated
      ! 04/10/01 04:00 - 04/10/01 10:00   10 small infection chances not treated
      ! 05/10/01 05:00 - 05/10/01 15:00   17 small infection chances not treated
      ! 07/10/01 07:00 - 07/10/01 11:00  187 small infection chances not treated
      # 11/10/01 12:00 curative OK contact OK
      ! 13/10/01 02:00 - 15/10/01 14:00   91 small infection chances not treated
      ! 18/10/01 04:00 - 19/10/01 00:00  283 large infection chances not treated
      ! 19/10/01 18:00 - 24/10/01 17:00 4544 large infection chances not treated
```

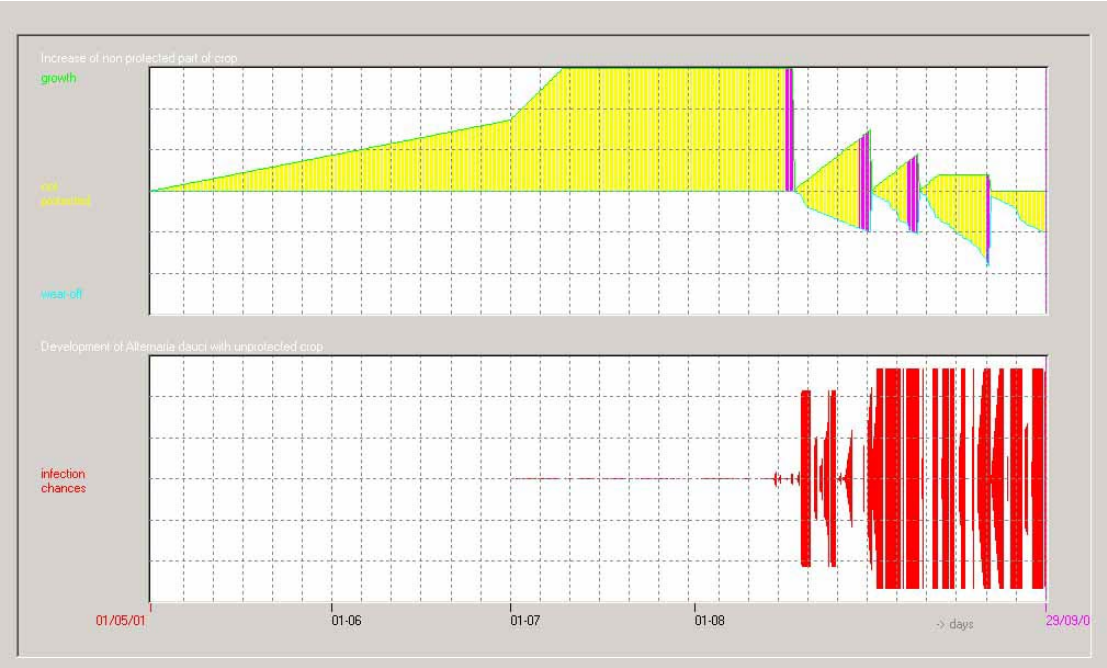


The pattern of infection risk for Nottinghamshire was distinct with two treatments being applied. The first treatment was forecast at the beginning of September and the second in the middle of October.

Commercial crops in Yorkshire and Nottinghamshire were free of significant infections except at the very end of the growing season when minor infections were noted.

Norfolk

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                        :  Carrot
      Disease                     :  Alternaria dauci
      Date advice calculation     :  10/03/02 / 14:13
--- Crop data --------------------------------------------------------------
      Farm                        :  PSL HDC NIAB
      Field                       :  NIAB Norfolk
      Crop reference + size       :  Norfolk m/c 2001              1.00 ha.
      Variety                     :  Nairobi
      Crop purpose                :  Consumption
      Weather data                :  PSL Woodbastwick
      Weather forecast            :  HWS UK Norwich Weather Centre
--- Year survey ------------------------------------------------------------
      ! 06/07/01 01:00 - 09/07/01 11:00   80 small infection chances not treated
      ! 10/07/01 00:00 - 10/07/01 13:00   13 small infection chances not treated
      ! 10/07/01 19:00 - 11/07/01 09:00   14 small infection chances not treated
      ! 12/07/01 21:00 - 15/07/01 03:00   54 small infection chances not treated
      ! 16/07/01 12:00 - 17/07/01 12:00   24 small infection chances not treated
      ! 17/07/01 23:00 - 20/07/01 12:00   61 small infection chances not treated
      ! 21/07/01 00:00 - 21/07/01 14:00   14 small infection chances not treated
      ! 22/07/01 00:00 - 22/07/01 13:00   13 small infection chances not treated
      ! 23/07/01 00:00 - 23/07/01 14:00   14 small infection chances not treated
      ! 24/07/01 00:00 - 24/07/01 13:00   13 small infection chances not treated
      ! 26/07/01 03:00 - 26/07/01 17:00   14 small infection chances not treated
      ! 27/07/01 00:00 - 27/07/01 12:00   12 small infection chances not treated
      ! 29/07/01 00:00 - 29/07/01 11:00   11 small infection chances not treated
      ! 30/07/01 20:00 - 31/07/01 09:00   13 small infection chances not treated
      ! 02/08/01 05:00 - 03/08/01 13:00   32 small infection chances not treated
      ! 03/08/01 22:00 - 04/08/01 10:00   12 small infection chances not treated
      ! 05/08/01 01:00 - 05/08/01 12:00   11 small infection chances not treated
      ! 05/08/01 21:00 - 07/08/01 13:00   40 small infection chances not treated
      ! 07/08/01 19:00 - 08/08/01 10:00   15 small infection chances not treated
      ! 09/08/01 04:00 - 10/08/01 03:00   23 small infection chances not treated
      ! 12/08/01 00:00 - 14/08/01 15:00   79 small infection chances not treated
      ! 15/08/01 00:00 - 15/08/01 12:00   22 small infection chances not treated
      # 17/08/01 12:00 curative OK contact OK
      ! 22/08/01 00:00 - 22/08/01 13:00   13 small infection chances not treated
      ! 22/08/01 21:00 - 23/08/01 15:00   83 small infection chances not treated
      ! 23/08/01 23:00 - 24/08/01 14:00  123 small infection chances not treated
      ! 25/08/01 22:00 - 27/08/01 12:00  194 small infection chances not treated
      # 30/08/01 12:00 curative OK contact OK
```

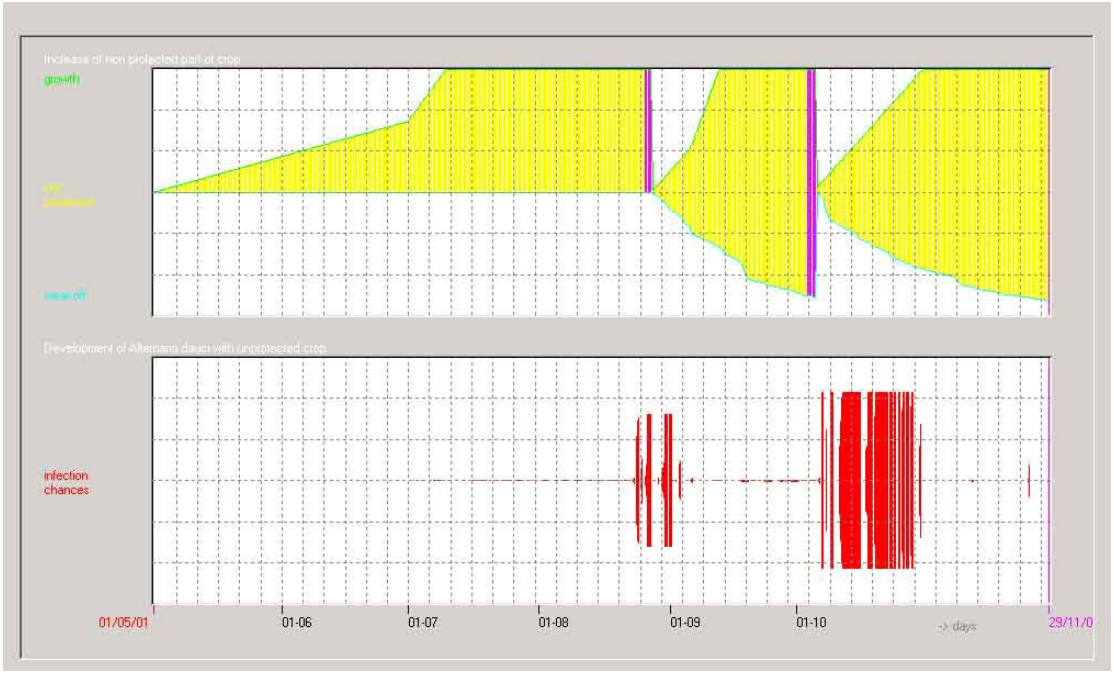


The early part of the growing season in Norfolk in 2001 was cool and wet and whilst this favoured the development of some diseases for example potato blight, it was rather too cold for best development of Alternaria. In mid August however conditions improved and risk events were recorded. The season again proved favourable for of the development and spread of Sclerotinia. In our recorded crops much foliage damage and some root damage occurred from this disease.

Three treatments were applied for alternaria and one dual purpose treatment for alternaria and crown rot. Untreated plots were affected with sclerotinia which made accurate recording of alternaria difficult.

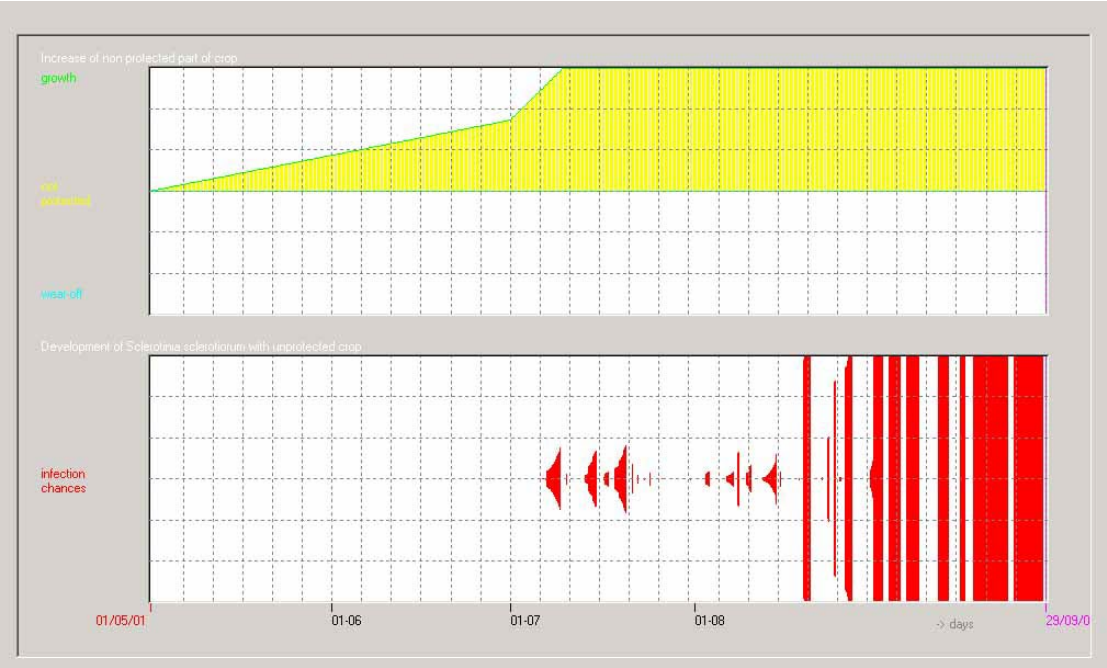
Suffolk Coast

```
--- Dacom PLANT-Plus Advicemodule ------------------------------------------
      Crop                          :  Carrot
      Disease                       :  Alternaria dauci
      Date advice calculation       :  17/03/02 / 11:39
--- Crop data --------------------------------------------------------------
      Farm                          :  PSL HDC NIAB
      Field                         :  NIAB Suffolk
      Crop reference + size         :  Suffolk m/c 2001              1.00 ha.
      Variety                       :  Nairobi
      Crop purpose                  :  Consumption
      Weather data                  :  PSL Nacton
      Weather forecast              :  HWS UK Wittering
--- Year survey ------------------------------------------------------------
      ! 07/07/01 00:00 - 08/07/01 14:00   38 small infection chances not treated
      ! 13/07/01 21:00 - 14/07/01 14:00   17 small infection chances not treated
      ! 17/07/01 22:00 - 18/07/01 11:00   13 small infection chances not treated
      ! 02/08/01 05:00 - 03/08/01 11:00   30 small infection chances not treated
      ! 06/08/01 20:00 - 07/08/01 09:00   13 small infection chances not treated
      ! 07/08/01 19:00 - 08/08/01 08:00   13 small infection chances not treated
      ! 09/08/01 19:00 - 10/08/01 11:00   16 small infection chances not treated
      ! 12/08/01 22:00 - 13/08/01 11:00   13 small infection chances not treated
      ! 15/08/01 00:00 - 15/08/01 11:00   11 small infection chances not treated
      ! 16/08/01 22:00 - 17/08/01 10:00   12 small infection chances not treated
      ! 18/08/01 22:00 - 19/08/01 15:00   17 small infection chances not treated
      ! 23/08/01 00:00 - 23/08/01 12:00   16 small infection chances not treated
      ! 23/08/01 23:00 - 24/08/01 12:00  540 large infection chances not treated
      ! 25/08/01 00:00 - 25/08/01 12:00  144 small infection chances not treated
      # 27/08/01 12:00 curative OK contact OK
      ! 31/08/01 18:00 - 01/09/01 10:00   55 small infection chances not treated
      ! 03/09/01 04:00 - 03/09/01 11:00   11 small infection chances not treated
      ! 05/09/01 21:00 - 06/09/01 11:00   11 small infection chances not treated
      ! 12/09/01 02:00 - 12/09/01 10:00   11 small infection chances not treated
      ! 18/09/01 03:00 - 19/09/01 13:00   55 small infection chances not treated
      ! 20/09/01 03:00 - 20/09/01 11:00   14 small infection chances not treated
      ! 23/09/01 08:00 - 25/09/01 01:00   70 small infection chances not treated
      ! 27/09/01 01:00 - 27/09/01 14:00   22 small infection chances not treated
      ! 28/09/01 00:00 - 28/09/01 14:00   24 small infection chances not treated
      ! 28/09/01 23:00 - 01/10/01 10:00  105 small infection chances not treated
      # 05/10/01 12:00 curative OK contact OK
      ! 09/10/01 04:00 - 09/10/01 13:00   51 small infection chances not treated
      ! 11/10/01 03:00 - 11/10/01 13:00   55 small infection chances not treated
```



Two significant infection events triggered two Plant Plus treatments. From the beginning of October conditions for development of Alternaria were very favourable which allowed infection to build up in untreated plots. The last danger periods were recorded at the end of October. Untreated plots developed significant symptoms during the latter part of October. Thereafter the temperatures dropped away to a point where there was little further development.

Norfolk – Sclerotinia



Advice graphic from Plant plus sclerotinia model for season 2001, Norfolk site. The early infection periods in July which are clearly identified may have led to the observed infection which was first recorded on the 15th of August.

No treatments were applied specifically for control of sclerotinia.

Carrots infected with sclerotinia showing core rot