CONTROL OF LEEK WHITE TIP:

Alternative fungicides to metalaxyl-based products 1995-1996

(Project No. FV 172)

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CONTENTS

APPLICATION

These trials were designed to evaluate a range of fungicides for their efficacy in controlling white tip in leeks. The twelve fungicides tested included the standard white tip product Folio, some older products such as Cuprokylt L, Filex and Rover and a range of new potato blight products including Invader, Tattoo and Shirlan.

SUMMARY OF RESULTS

The evaluation of fungicides showed that the best candidate to pursue for specific off-label approval was Invader. The performance of Folio was much poorer at one of the two trials and this was related to the overwhelming presence of metalaxyl-resistant strains of *Phytophthora porri* at that site.

The addition of an adjuvant to the fungicides under test gave no consistent benefit in terms of enhanced disease control.

The use of a straw mulch as a physical barrier to prevent leaf infection from soil-borne insculum proved ineffective.

A study of disease development in unsprayed plots showed that new infections occurred throughout the Autumn, Winter and early Spring. It is likely that the latent period between infection and symptom expression was considerably longer at lower temperatures.

ACTION POINTS FOR GROWERS

White tip is a very damaging disease and every effort should be made to minimise infection. As problems with control may in part be due to resistance to metalaxyl, growers should avoid the production of leeks in fields where this fungicide has been extensively used. An HDC funded survey in the Autumn/Winter of 1996/97 should reveal the extent of any resistance problem.

Growers should support the use of HDC funds in obtaining residue data for the product Invader as this appears to be the most useful fungicide of those tested and an application for specific off-label approval has been submitted.

INTRODUCTION

White tip, caused by the soil-borne fungus *Phytophthora porri*, is a major disease problem in leek production. Fungicidal control is now mainly dependent upon one active ingredient, metalaxyl, available in conjunction with chlorothalonil as 'Folio 575 SC' or mancozeb as 'Fubol 58 WP' and 'Fubol 75 WP'. Growers have recently reported poor control of white tip following the use of metalaxyl-containing products. As resistance to this chemical is known to occur in other fungi, e.g. *Bremia lactucae* (lettuce downy mildew), *Phytophthora infestans* (potato blight) and *Pythium* spp (root rot of bedding plants), it was considered possibly that metalaxyl-resistant strains of *P. porri* may have been contributing to the poor control observed. It was therefore of prime importance to examine alternative fungicides for the control of white tip. A wide range of products was examined with a view to selecting the best material to put forward for specific off-label approval.

Other aspects of white tip control that were examined in this work included the possible benefit of adding an adjuvant to the fungicides tested, the value of applying a straw mulch as a physical barrier to leaf infection, an examination of weather data in relation to infection and a check on metalaxyl sensitivity of *P. porri* isolates from the trial sites.

MATERIALS AND METHODS

Sites: WCF Farm Produce Ltd
Burscough
Lancs

W Emmett
Sheeplands Farm
Wargrave
Berks

Varieties: Lancs: **?**
Berks: **?**

Sowing/Planting Dates: Lancs: **?**
Berks: **?**

Plot size and replication: Lancs: **?** x 1 bed approximately
Berks: **?** x 1 bed approximately

Treatment application: All applied by ADAS staff using knapsack sprayers on the following dates:

Lancs: **?** Berks: **?**
? **?**

Fungicide treatments:

	Product	Active ingredients	Product rate/ha (in 300 l water)
1	Untreated	-	-
2	Filex	propamocarb	1.5 l
3	Invader	dimethomorph + mancozeb	2.0 kg
4	Shirlan	fluazinam	0.3 l
5	Tattoo	propamocarb + mancozeb	4.0 l
6	Trustan WDG	cymoxanil + oxadixyl + mancozeb	2.5 kg
7	Folio	metalaxyl + chlorothalonil	2.0 l
8	Trimanzone	ferbam + maneb + zineb	3.0 kg
9	Cuprokylt L	copper oxychloride	2.8 l
10	Guardian	cymoxanil + chlorothalonil	1.5 kg
11	Aliette	fosetyl-aluminium	1.68 kg
12	Rover	chlorothalonil	2.0 l
13	Curzate M	cymoxanil + mancozeb	2.0 kg

At the Lancashire site an additional treatment was a straw mulch applied to the plots.

Design: Each treatment was replicated 3 times in a randomised block design. Each of the fungicide treated plots was split in two with the fungicide applied alone to one half and applied with the addition of an adjuvant, Nu-Film P, to the other half. The Nu-Film P was applied at 180 ml/ha.

Assessments: The trials were assessed for white tip infection on the following dates:

Lancs:	11 October	Berks:	22 November
	1 November		14 December
	22 November		13 March
	20 December		27 March
	1 March		
	19 March		

The percentage leaf area affected was visually assessed for 10 plants per sub-plot and a mean level calculated.

At the Lancashire site 6 plants were assessed for white tip at regular intervals in each of the 3 unsprayed plots. Each leaf was numbered and the presence or absence of infection was recorded on 14 occasions from late September 1995 to mid-March 1996. Weather records (temperatures and rainfall) were supplied by WCF Farm Produce Ltd from their meteorological station approximately ¼ mile away from the trial. Disease progress was examined in relation to weather factors during the period of the trial.

Other pesticides: Other routine farm treatments were applied by the farm staff when spraying the main field crop. Where leek rust control was required this treatment was fenpropimorph, as Corbel, a product with no known control of white tip.

Harvest: The trial in Berkshire was harvested by ADAS staff on **?** and the leeks were trimmed to marketable specification under the guidance of farm staff. The centre 3 rows x **?** m was lifted and yields calculated. The trial in Lancashire suffered from irregular establishment and was unsuitable for taking to yield.

Fungicide resistance tests: In March samples of white tip infected leaves were taken from the unsprayed and Folio treated plots at both sites and sent to the ADAS Plant Clinic at Wolverhampton. *Phytophthora porri* was isolated and screened for sensitivity to metalaxyl at 2 ppm and 20 ppm initially and at a wider range of concentrations subsequently.

RESULTS

a) Disease Assessments

The assessments for white tip at the Lancashire site on 6 dates are shown in Table 1. The results are shown as mean values of the sub-plots treated and untreated with Nu-Film P as the adjuvant made no significant contribution to disease control.

Table 1. Mean % leaf area affected by white tip - effect of fungicide (Lancs).

Treatment	Assessment dates					
	11/10/95	01/11/95	22/11/95	20/12/95	01/03/95	19/03/96
Unsprayed	0.93 ab	1.72 ab	1.85 a	3.55 ab	3.48 ab	7.48 d
Filex	1.38 ab	2.35 ab	1.70 a	4.23 b	3.42 ab	4.10 ab
Invader	0.73 ab	1.40 ab	1.13 a	2.55 a	2.15 a	3.13 a
Shirlan	0.40 a	1.43 ab	1.80 a	2.97 ab	2.93 ab	3.25 a
Tattoo	0.75 ab	1.67 ab	1.63 a	3.13 ab	2.60 ab	3.15 a
Trustan	1.50 ab	1.60 ab	1.87 a	3.10 ab	3.08 ab	4.82 ab
Folio	1.63 ab	1.68 ab	1.60 a	2.97 ab	2.67 ab	4.95 ab
Trimanzone	1.57 ab	1.85 ab	2.32 a	3.62 ab	3.95 b	4.83 ab
Cuprokylt L	0.92 ab	1.38 ab	1.78 a	4.45 b	3.18 ab	5.93 bcd
Guardian	0.97 ab	1.13 ab	1.50 a	3.02 ab	2.52 ab	7.05 cd
Aliette	1.10 ab	2.73 b	3.00 a	3.33 ab	2.83 ab	5.55 bc
Rover	1.42 ab	1.68 ab	1.70 a	3.15 ab	2.82 ab	5.87 bcd
Curzate M	0.48 a	0.90 a	1.55 a	3.13 ab	2.45 ab	4.20 ab
Straw Mulch	2.12 b	1.37 ab	1.75 a	3.15 ab	3.27 ab	6.88 cd
SE	0.419	0.491	0.550	0.492	0.491	0.583
cv %	90.3	73.5	74.9	36.4	40.8	28.1
df	54	54	54	54	54	54

Duncans multiple range analysis: figures in any column followed by a common letter are not significantly different at P = 0.05.

The mean effect of the Nu-Film P at the Lancashire site is shown in Table 2.

Table 2. Mean % leaf area affected by white tip - effect of Nu-Film P (Lancs).

Treatment	Assessment dates					
	11/10/95	01/11/95	22/11/95	20/12/95	01/03/96	19/03/96
No adjuvant	1.20	1.65	2.35	3.24	2.98	4.90
Nu-Film P	1.07	1.62	1.24	3.38	2.93	5.28

The assessments at the Berkshire site for the effect of the fungicides are shown in Table 3.

Table 3. Mean % leaf area affected by the white tip - effect of fungicide (Berks).

Treatment	Assessment dates			
	22/11/95	14/12/95	13/03/96	27/03/96
Unsprayed	1.03 d	2.27 b	28.33 d	23.78 d
Filex	0.35 ab	0.88 a	13.62 ab	11.07 abc
Invader	0.37 ab	0.70 a	13.28 ab	8.55 a
Shirlan	0.60 abc	1.03 a	13.45 ab	9.60 ab
Tattoo	0.42 abc	0.68 a	12.75 ab	9.20 ab
Trustan	0.35 ab	0.65 a	13.10 ab	8.13 a
Folio	0.65 bc	0.60 a	11.70 a	9.80 ab
Trimanzone	0.35 ab	0.98 a	12.53 ab	9.48 ab
Cuprokylt L	0.77 cd	1.07 a	15.08 b	9.90 ab
Guardian	0.47 abc	0.75 a	18.62 c	14.18 c
Aliette	0.58 abc	1.10 a	13.00 ab	12.78 bc
Rover	0.57 abc	1.00 a	20.68 c	13.28 bc
Curzate M	0.28 a	0.85 a	13.78 ab	9.55 ab
SE	0.110	0.189	0.969	1.269
cv %	51.4	47.8	15.4	27.1
df	50	50	50	50

The effect of the Nu-Film P at the Berkshire site is shown in Table 4.

Table 4. Mean % leaf area affected by white tip - effect of Nu-Film P (Berks).

Treatment	Assessment dates			
	22/11/95	14/12/95	13/03/96	27/03/96
No adjuvant	0.55	0.87	15.82	11.24
Nu-Film P	0.50	1.06	14.93	11.74

The data from the two sites was also analysed comparing the areas occurring under the disease progress curve produced by plotting each assessment date against time (integrated area under the disease progress curve by the trapezoidal rule and split plot analysis of variance). This method of analysis compares the performance of the fungicides over the whole period of the trials. The results for the two sites are presented in Table 5.

Table 5. Comparison of areas under disease progress curves at Lancashire and Berkshire sites.

Treatment	Area under disease progress curves (AUDPC)	
	Lancs site	Berks site
Unsprayed	489 b	
Filex	504 b	
Invader	315 a	
Shirlan	385 ab	
Tattoo	382 ab	
Trustan	429 ab	
Folio	402 ab	
Trimanzone	510 b	
Cuprokylt L	498 b	
Guardian	395 ab	
Aliette	483 b	
Rover	426 ab	
Curzate M	364 ab	
Straw Mulch	457 ab	

b) Yields

The trial in Berkshire was harvested and the results are shown in Table 6.

Table 6. Marketable yield (Berks).

Treatment	kg/plot	mean leek weight (g)
Unsprayed	6.25 a	157 ab
Filex	8.13 cd	171 abc
Invader	8.08 cd	173 bc
Shirlan	8.33 cd	179 c
Tattoo	9.15 d	178 c
Trustan	8.77 cd	179 c
Folio	8.30 cd	170 abc
Trimanzone	8.07 cd	175 c
Cuprokylt L	8.12 cd	174 bc
Guardian	6.02 a	155 a
Aliette	6.85 ab	162 abc
Rover	6.90 ab	172 bc
Curzate M	7.82 bc	177 c
SE	0.375	5.30
% cv	11.8	7.6
df	50	50

c) Disease progress in unsprayed plots

Eighteen plants in the unsprayed plots at the Lancashire site were regularly assessed for the presence or absence of white tip infection. Each leaf was numbered as it emerged and records were taken of when infection of each leaf occurred. The results of this study are shown in Table 7.

Table 7. Assessment of infection in unsprayed plants (Lancs).

Assessment date	Total no. of infected leaves	No. of newly infected leaves since last assessment	% of all leaves infected
29 Sept	0	-	0
13 Oct	4	4	2.0
23 Oct	6	2	2.5
9 Nov	10	4	4.8
21 Nov	13	3	5.5
28 Nov	18	5	7.2
8 Dec	19	1	7.6
21 Dec	25	6	9.8
9 Jan	27	2	10.3
22 Jan	27	0	9.8
31 Jan	37	10	13.3
13 Feb	54	17	18.3
1 Mar	59	5	19.1
19 Mar	96	37	30.4

Four periods could be identified where disease progress was most significant.

(i) The first records of disease on 13 Oct.

Infection occurred following wet weather on 24 September (15 mm rain) and 9 of the 11 subsequent days with 3 mm or more of rain on 4 of those days. The maximum temperatures during 24 September-13 October were 13°C - 24°C and the minimums were 7°C - 15°C. At these temperatures symptoms were visible approximately 12 days (± 4 days) after the most likely infection period.

(ii) New infections were recorded on 21 December with only one new lesion found on 8 December.

Wet weather occurred on 24 November (8 mm) and on 9 of the subsequent 15 days. The temperature range during 24 November - 21 December was 1°C - 12°C (max) and -2°C - 10°C (min). At these temperatures symptoms were visible approximately 20 days (± 6 days) after the most likely infection period.

(iii) New infections were recorded on 31 January with none having been noted on 22 January.

Wet weather occurred on 4 January (1.6 mm) and on all of the subsequent 9 days with 4 mm on 5 January and 5 mm on 6 January.

The temperatures during 4 - 31 January were 1°C - 11°C (max); -4°C - 9°C (min). At these temperatures symptoms were visible approximately 23 days (± 4 days) after the most likely infection period.

(iv) Many new infections were recorded on 19 March after relatively few were found on 1 March.

There was 2.2 mm of rain on 5 February and on 16 of the following 19 days, with 7 mm on 10 February and 12 mm on 11 February. The temperatures during 5 February - 19 March were -1°C - 11°C (max); and -5°C - 5°C (min). At these temperatures symptoms were visible approximately 34 days (± 9 days) after the most likely infection period.

d) Fungicide sensitivity tests

In March samples of white tip infected leaves were taken from the unsprayed plots and the Folio treated plots at both sites. *P. porri* was successfully isolated from 19 Lancashire samples and 7 Berkshire samples. The material from Berkshire had considerable sooty mould contamination preventing the isolation of clean *P. porri* cultures in many instances.

The *P. porri* isolates were sub-cultured on to unamended agar or agar amended by the addition of metalaxyl at 2 ppm or 20 ppm. The results of this primary screen are shown in Table 8.

Table 8. *P. porri* sensitivity tests for metalaxyl.

Origin of isolate	No. of isolates making growth		
	0 ppm metalaxyl	2 ppm metalaxyl	20 ppm metalaxyl
Berks site:			
Unsprayed plots	3	0	0
Folio plots	4	1	1
Lancs site:			
Unsprayed plots	10	10	10
Folio plots	9	9	9

Isolates growing on metalaxyl amended agar were considered resistant to that fungicide. In a second screen, resistant isolates were plated on to agar amended with 20 ppm, 50 ppm, 200 ppm and 500 ppm metalaxyl. Sensitive isolates were screened at 0.02 ppm, 0.05 ppm, 0.2 ppm, and 0.5 ppm metalaxyl.

No growth of the sensitive isolates was found at the lowest concentration of metalaxyl used.

The resistant isolates growth rate was reduced by the higher concentrations of metalaxyl but some growth occurred at 500 ppm. The mean EDSO of the 9 resistant isolates tested was approximately 30 ppm metalaxyl.

The presence of a different proportion of metalaxyl resistant strains at the two trial sites had a direct bearing on the performance of metalaxyl containing products, as shown in Table 9.

Table 9. Efficacy of fungicides in relation to metalaxyl resistant *P. porri* presence.

Site/Treatments	White tip (Mn % leaf area) - final assessment	Disease control (% reduction)
Lancs: (100% resistant strains of *P. porri*)		
Unsprayed	7.48	-
Invader	3.13	58
Folio	4.95	34
Trustan	4.82	36
Berks: (14% resistant strains of *P. porri*)		
Unsprayed	23.78	-
Invader	8.55	64
Folio	9.80	59
Trustan	8.13	66

The performance of Invader was similar at both sites. The efficacy of the metalaxyl-containing fungicide Folio, and oxadixyl-containing fungicide Trustan was markedly reduced where metalaxyl resistance was predominating.

CONCLUSIONS

White tip infection levels at both sites remained low in the Autumn and early Winter periods and no significant differences could be found consistently between fungicides. Consequently both trials were left over winter and a further fungicide treatment was applied in the early Spring. By this time disease levels had increased markedly and the best fungicides could be identified. At the Lancashire site metalaxyl resistance was found in all of the *P. porri* samples tested and this seriously affected the performance of Folio and Trustan. The best disease suppression at this site was given by Invader, Tattoo and Shirlan. By March, at the Berks site disease levels were higher than in Lancashire and all fungicides significantly reduced white tip infection levels. Here, where a low level of metalaxyl resistance was found in the limited testing of the *P. porri* population the best disease control was given by Trustan and Invader. These two fungicides were not significantly better than most of the other tested products. Worst results were obtained with Guardian, Rover, Aliette and Filex.

When the disease levels over the whole season were analysed only Invader was significantly lower than the untreated at the Lancashire site.

At both sites the addition of the adjuvant Nu-Film P had no overall enhancing effect on disease control.

The use of a straw mulch at the Lancashire site proved ineffectual as the material soon decayed and was no longer a physical barrier to infection.

The Lancashire crop was direct sown and emergence was poor so the trial was not taken to harvest. In Berks the transplanted crop was a good stand and yields were taken to ensure that none of the fungicides had any adverse effect on growth. All fungicides apart form Guardian, Aliette and Rover significantly increased yields per plot. The mean weight of the marketable leeks was significantly increased by Shirlan, Tattoo, Trustan, Trimanzone and Curzate M.

Regular assessments of the unsprayed plants were made at the Lancashire site to monitor disease progress in relation to weather conditions. As the exact time of infection could not be recorded and detailed assessments were made at 1-2 week intervals only general conclusions could be made as to the conditions affecting the period between infection and symptom expression. Fresh lesions were found throughout the monitoring period from October to March. There appeared to be a relationship between temperature and latent period. Where mean temperatures were approximately 14°C the latent period was thought to be about 12 days; at 6°C mean temperature the period was extended to 20 days and at 4°C perhaps as long as 30 days. More detailed studies would be required before any conclusions could be drawn and advice given on fungicide use in relation to infection periods and latent periods.

The findings on metalaxyl resistance seem to confirm growers' suspicions that in some cases metalaxyl containing products (Folio; Fubol) are not performing as well as in the past. The extent of the resistance problem needs to be further investigated.

The main objective of this work was to identify a fungicide alternative to Folio and Fubol that would give good control of white tip without any phytotoxicity problems. Specific off-label approval could then be sought following more detailed residue trials. From these two trials the good candidate for such action would be the potato blight fungicide Invader. Should there be problems with this material in the residue trials Tattoo or Shirlan might also be considered.

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