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ROLES OF VARIETIES AND FUNGICIDES IN MANAGING LIGHT LEAF SPOT AND CANKER IN WINTER OILSEED RAPE

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ROLES OF VARIETIES AND FUNGICIDES IN MANAGING LIGHT LEAF SPOT AND CANKER IN WINTER OILSEED RAPE

by

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ABSTRACT

The contribution of varietal resistance and fungicides to disease control and yield in winter oilseed rape was investigated at sites in the south west, east and north of England and in the north of Scotland in each of three harvest years, 1995-1997. The varieties, Bristol, susceptible to light leaf spot and resistant to canker, and Nickel or Rocket, resistant to light leaf spot and susceptible to canker, were treated with a range of fungicides at different timings and doses at four sites. The active ingredients used were flusilazole plus carbendazim (as Punch C), carbendazim (as Bavistin or Carbate), tebuconazole (as Folicur) and difenconazole (as Plover). These were applied once at full dose in the autumn and as split half-dose treatments in the autumn and spring. Two full dose sprays of flusilazole plus carbendazim were used as a standard against which to compare the effectiveness of half-dose treatments.

Overall, light leaf spot was the most important disease in these experiments. Some phoma leaf spotting and canker developed at sites in eastern and northern England and white leaf spot was present at sites in Devon.

Nickel or Rocket were consistently higher yielding than Bristol at all sites except for two years in Suffolk. The mean cross-site yields were calculated from 11 sites (excluding one experiment in Cornwall where no autumn sprays were applied because of small plant size) and averaged 3.44 t/ha for cv.Bristol and 3.97 t/ha for cvs Nickel or Rocket. The mean response to all fungicide treatments was 0.28 t/ha on cv. Bristol and 0.17 t/ha on cvs Nickel or Rocket. Significant treatment differences for yield were recorded in 9 out of 12 experiments, all eight showed differences between varieties and 7 showed differences between fungicides. A number of treatments yielded less than the untreated control and whilst not statistically significant effects, these represented 22% of site x variety x fungicide combinations.

Two sprays of flusilazole plus carbendazim at full dose gave the largest yield response of 0.52 t/ha on cv. Bristol and 0.35 t/ha on cvs Nickel or Rocket and this was just profitable. The most profitable treatments were a full dose of flusilazole plus carbendazim in autumn for Bristol (£32/ha) and a full dose of difenoconazole in autumn on cvs Nickel or Rocket (£12.5/ha). Caution is needed in extrapolating from these results as phoma disease

pressure was generally low and light leaf spot infection was severe in the autumn at some sites.

Light leaf spot infection was most severe in Scotland and in the south west, resulting in an estimated yield loss of 3 t/ha in Aberdeen in 1995/96. In contrast, there was no yield response to fungicide treatment at Aberdeen in 1997, despite light leaf spot affecting 13% leaf area in April. These experiments demonstrated that light leaf spot control in the spring can be worthwhile (0.74 t/ha response on cv. Bristol in Cornwall in 1995) but the most damaging attacks occur when symptoms are apparent in the autumn and severe frosts lead to substantial loss of plants.

The project provided comparative data on fungicide efficacy. Flusilazole plus carbendazim and tebuconazole were highly effective against light leaf spot. Difenoconazole and flusilazole plus carbendazim showed good activity against white leaf spot and phoma leaf spot, though epidemics of the latter were limited. Convincing control of canker was not achieved. Carbendazim treatments were inconsistent and the presence of MBC resistant strains of light leaf spot in Scotland is thought to have contributed to this.

Routine treatment of winter oilseed rape with fungicides is unlikely to be cost-effective. At individual sites losses approaching 1 t/ha have been recovered with fungicides, so careful targeting of sprays is required. There are significant advantages in using resistant varieties and, in the case of light leaf spot resistance, this equated to 0.53 t/ha (£79/ha). The untreated yield of the resistant variety (Nickel/Rocket) was higher than the fungicide treated yield of the susceptible variety (Bristol). Single spray treatments may be adequate for control of light leaf spot, provided disease pressure is not high. Further work to optimise fungicide inputs and to forecast disease epidemics is recommended.

INTRODUCTION

This is the final report on work which started in the autumn of 1994. The concept of integrated disease risk (IDR) is being developed for cereals (Paveley, 1995). Studies on diseases of oilseed rape have concentrated on the aetiology and epidemiology of individual diseases (Sansford *et al.*, 1995, 1996). This experiment is aimed at investigating the interaction of location, variety, fungicide product and dose on the incidence and severity of light leaf spot (*Pyrenopeziza brassicae*) and canker (*Leptosphaeria maculans*).

Annual monitoring of diseases in winter oilseed rape since autumn 1976 by ADAS and CSL has provided a quantitative record of their incidence and severity. This database has only been partially exploited to date and there are clearly regional and seasonal differences which, with further understnding of the critical factors responsible for this variation, will be of value in improving decision making on farms. There is no doubt that a high degree of disease control can be achieved with fungicides (Sansford *et al.*, 1996).

It is of concern that disease severity in 1994 and 1995 was comparable to that recorded in the late 1970's. This is in spite of improvements in varieties and more widespread use of fungicides. A range of new fungicides have been introduced for use on oilseed rape, but fundamental understanding of their properties together with that of the pathogen biology is required to optimise their performance. These components form part of this investigation.

Disease-yield loss relationships have recently been derived for both light leaf spot and canker (Sansford *et al.*, 1996). It is now possible to produce estimates of national yield losses for all the major individual diseases using these and published data for stem rot (*Sclerotinia sclerotiorum*) and dark pod spot (*Alternaria brassicae*) (Fitt *et al.*, 1997). Canker and light leaf spot were the most important diseases and together they have caused yield losses of up to £80 million/annum in recent years. Losses from *Sclerotinia* were up to £1.5 million. These losses occurred in commercial crops, many of which had been sprayed with fungicides. Fungicide use has increased in recent years and expenditure on them is about £9 million/annum. However, there is little evidence that increased fungicide use has led to improved disease control. In order to optimise fungicide use, detailed knowledge of product efficacy in relation to dose and timing is required. Priority for research was given to the two most important pathogens in oilseed rape, light leaf spot and canker in this project. Sites were completed in the south west, east and north of England and in Aberdeenshire, Scotland in harvest years 1995, 1996 and 1997.

OBJECTIVES

To determine the effect of canker (*Leptosphaeria maculans*) and light leaf *spot (Pyrenopeziza brassicae*) on the yield of winter oilseed rape.

Detailed objectives

To develop a scheme for the management of light leaf spot and canker in winter oilseed rape.

To investigate the interaction of fungicide programmes, meteorological variables and geographical area within Great Britain on the expression of disease resistance in contrasting varieties.

To identify the most appropriate fungicide(s) for the control of light leaf spot and canker.

MATERIALS AND METHODS

Sites

Sites were selected to represent the range of geographic and climatic environments where winter oilseed rape is commonly grown. Rape straw was scatttered over plots at some sites to ensure diseases developed to moderate or severe levels.

Table 1. Location of experiments

Harvest year	South-west England	Eastern England	Northern England	Scotland
1995	Trerulefoot, Cornwall	Stonham, Suffolk	Darrington, S. Yorkshire	Tillycorthie, Aberdeenshire
1996	Kingston, Devon	Otley, Suffolk	Darrington, S. Yorkshire	Udny Station, Aberdeenshire
1997	Kingston, Devon	Otley, Suffolk	High Mowthorpe, N. Yorkshire	Tillycorthie, Aberdeenshire

Varieties

Two varieties, which showed different resistance characteristics to light leaf spot and canker, were initially selected from the NIAB Recommended and Descriptive Lists of Oilseed Crops 1995 (Anon. 1995). The variety Nickel was selected as a replacement for Rocket at Darrington, Kingston and Otley sites in 1995/96 and at Kingston and Otley in 196/97 following departure of Rocket from the Recommended List and a shortage of certified seed of that variety.

Table 2. Disease resistance ratings (NIAB, 1995)

	Variety	Light leaf spot	Canker
1.	Bristol	3	5
2.	Rocket	7	4
3.	Nickel	9	4

Fungicides

The fungicides selected were from those new or recently introduced active ingredients which would control the two diseases and provide data on the efficacy of different active ingredients at two doses (Table 3a). Carbendazim treatments were re-evaluated following concerns about resistance to MBC fungicides in light leaf spot in Scotland. In 1994/95, autumn treatments were not applied at the site in Cornwall because seedling establishment was late and treatments were modified to extend the range of spring treatments (Table 3b).

Table 3a. Fungicide treatments

	Fungicide treatments	Timing	
		autumn	spring
1.	nil	-	-
2.	flusilazole plus carbendazim	1*	1
3.	flusilazole plus carbendazim	1	-
4.	flusilazole plus carbendazim	½	½
5.	carbendazim	1	-
6.	carbendazim	½	½
7.	tebuconazole	1	-
8.	tebuconazole	½	½
9.	difenoconazole	1	-
10.	difenoconazole	½	½

Table 3b. Treatments at Trerulefoot 1994/95

	Fungicide treatments	Timing spring
1.	nil	-
2.	flusilazole plus carbendazim	1*
3.	flusilazole plus carbendazim	½
4.	flusilazole plus carbendazim	¼
5.	carbendazim	1
6.	carbendazim	½
7.	tebuconazole	1
8.	tebuconazole	½
9.	difenoconazole	1
10.	difenoconazole	½

* 1, ½ and ¼ indicate full, half and quarter the manufacturers recommended application rate for the product. * signifies full dose. (See Table 4 for rates of application)

Fungicides were applied to a calendar date in the autumn (generally mid-November) and to a development stage in the spring (early stem extension, GS 2.2).

Table 4. Fungicides, products and application dose

Common name	Commercial product	Concentration (g ai/l or kg)	Manufacturers recommended application dose(l or kg/ha)
carbendazim	Bavistin DF/FL*	500	0.5
difenoconazole	Plover	250	0.5
flusilazole plus carbendazim	Punch C	250 + 125	0.8
tebuconazole	Folicur	250	1.0

* Carbate Flowable was used at Udny Station

Disease assessment

Foliar disease

Ten plants per plot were assessed in December, at early stem extension and pod ripening. Diseases were assessed on a whole plant basis. The percentage area infected for a given disease on an individual plant was recorded. Prior to stem extension, the samples were incubated in polyethylene bags at room temperature for 24 h to encourage the development of symptoms of light leaf spot before laboratory assessment.

Pod disease

Ten plants per plot were assessed on one occasion only, at pod ripening (GS 6,3-6,5). The main raceme was selected and the presence of each disease as a estimated percentage area of the whole raceme affected recorded.

Stem disease

Ten plants per plot between end of flowering and pod ripening (GS 6,1-6,5) were assessed.

(i) Light leaf spot - the estimated percent area of the stem affected was recorded.

(ii) Canker - aerial lesions, as for light leaf spot, but cankers were recorded on a 0-4 scale where:

0	- no disease
1	- less than half stem girdled by a lesion (± penetration)
2	- more than half stem girdled by a lesion (± penetration)
3	- whole stem girdled by a lesion (± penetration)
4	- plant dead

Penetration was assessed by splitting stem at the centre of a lesion.

Crop physiology measurements

The height to the top of the main raceme and internode lengths on the main stem and raceme were recorded to the nearest 1 cm from 10 plants per plot at flowering to pod ripening when full height had developed.

Premature ripening

Prior to desiccation/harvest each plot was scored for any colour difference on a 1-5 scale as follows:-

a) the brightest/cleanest plot was scored as 1.
b) the darkest/dirtiest plot was scored as 5.
c) other plots were scored by interpolating between the two as necessary.

Design and analysis

A two-way factorial with added controls in a split-plot design in three or four replicate blocks: cultivars completely randomised in main plots; fungicides completely randomised on sub-plots. Data were analysed using the most appropriate methods with transformation of disease data where a skewed distribution was identified. A cross-site analysis was carried out for yield using 11 of the 12 experiment sites (excluding Cornwall 1995 which had no autumn sprays) using each site/year combination as a separate 'site' in the analysis. Because of the large variation between sites (crops) even on the same farm, it is not possible to distinguish between 'site' and 'year' effects. The varieties have been considered as 'light leaf spot susceptible' (all Bristol) or 'canker susceptible' (Nickel or Rocket) without differentiating between Nickel and Rocket in the cross-site analysis.

RESULTS

Yield

1994/95 (Table 5)

The untreated yields were higher in Rocket at Trerulefoot (1.14 t/ha), Darrington (0.27 t/ha) and Tillycorthie (0.53 t/ha) than Bristol. At Stonham the yield of Bristol was higher than Rocket (0.63 t/ha) (Table 5). When comparing the highest treated yields, Rocket out-yielded Bristol at Trerulefoot (0.55 t/ha), Darrington (0.18 t/ha) and at Tillycorthie (1.01 t/ha). Bristol out-yielded Rocket at Stonham (0.10 t/ha).

Significant differences between varieties and fungicide treatments were observed at Treulefoot, Stonham and Tillycorthie but there were no differences at Darrington. Interactions between fungicide and variety were detected at Treulefoot and Tillycorthie.

1995/96 (Table 6)

The mean yields of were higher in Nickel than Bristol at Kingston (0.21 t/ha), and Otley (0.37 t/ha), but at Darrington the yield of Bristol was marginally higher (0.05 t/ha) (Table 6). At Udny Station Rocket had a substantially higher mean yield (2.07 t/ha) than Bristol and its maximum yield was 1.62 t/ha higher than Bristol. When comparing the highest treated yield in Bristol, Nickel out-yielded Bristol at Kingston (0.26 t/ha), Darrington (0.12 t/ha) and at Otley (0.45 t/ha). Bristol out-yielded Nickel at Darrington (0.10 t/ha).

At Kingston, there were no significant effects of variety or differences between treatments on Nickel. On Bristol, however, yield increases were obtained with all the spray programmes except carbendazim. The split dose programmes were higher yielding than the single full dose in the autumn by up to 0.46 t/ha (tebuconazole) on Bristol (Table 6).

There were no significant effects on yield at Otley, which averaged 4.25 t/ha on Bristol and 4.62 t.ha on Nickel at this low disease site (Table 6). There were no significant effects on yield at the Darrington site. There appeared to be larger variations in yield between full and split dose treatments on Bristol than on Nickel (Table 6).

There were significant effects of treatment ($\underline{P}$ = 0.001) and variety ($\underline{P}$ = 0.05) yield at Udny Station. Rocket average 3.65 t/ha overall compared with 1.58 t/ha for Bristol. The highest yield on each cultivar was given by two full doses of flusilazole + carbendazim and the lowest yields by carbendazim alone (Table 6).

1996/97 (Table 7)

Kingston

There were large yield responses to fungicide of up to 0.98 t/ha on Bristol and equally large yield differences between varieties with Nickel producing a site mean yield of 4.39 t/ha, 1.09 t/ha more than Bristol. Carbendazim failed to produce a yield benefit on either variety. In general, a split dose approach gave higher yield than a single full dose in the autumn. Splitting a full dose gave an average benefit of 0.2 t/ha for flusilazole plus carbendazim, 0.29 t/ha for tebuconazole and 0.05 t/ha for difenoconazole (Table 7).

Otley

There were no significant effects of treatment on yield at this site.

High Mowthorpe

There were highly significant differences between cultivars and fungicides and an interaction between these factors. Plots treated with two applications of flusilazole plus carbendazim at full rate gave the best yields in both varieties, while the single full-rate and two half-rate treatments gave similar, but lower, yields. On Bristol the largest response was 0.93 t/ha and the advantage of growing Rocket over Bristol was 0. 55 t/ha (Table 7). A single autumn spray of carbendazim gave a slightly increased yield for Bristol, but a slightly depressed yield for Rocket. Two half-rate sprays produced the same, but less marked, effect. All tebuconazole or difenoconazole treatments led to higher yields in

Bristol. Full-rate sprays of tebuconazole or difenoconazole in the autumn had little effect on yield of Rocket while half-rate sprays at stem extension increased yield. These results are closely correlated with levels of light leaf spot in April, the regression equation being: Yield = 4.44 - 0.3 * % LLS which accounted for 66.5% of the variance ($R^2 = 0.665$ with 58 degrees of freedom).

Tillycorthie

Rocket yielded significantly higher than Bristol (0.77 t/ha). There were no effects of fungicide treatment or interactions between variety and fungicide on yield.

Cross -site analyses (Table 8)

Mean yield for the 11 sites was 3.70 t/ha with Rocket/Nickel crops producing 0.63 t/ha in untreated plots than Bristol and 0.53 t/ha more when averaged over all treatments. There were highly significant effects ($P < 0.001$) of site, site x variety interaction, fungicide, fungicide x site interactions and weaker differences ($P = 0.05$) for interactions at the level of site x variety x fungicide. There were no overall interactions between variety and fungicide. Significant differences for variety were found at 8 sites and 7 of these showed responses to fungicide. Two sites in Suffolk and two sites in Yorkshire did not show any significant yield differences.

Margins over fungicides have been calculated using seed valued at £150/tonne and azole treatments (difenoconazole, flusilazole plus carbendazim, tebuconazole) costed at £25/ full dose and carbendazim at £10/full dose. Margins were modest, reaching only £32/ha for an autumn full dose spray of flusilazole plus carbendazim on Bristol and £12.5/ha for a full dose of difenoconazole in autumn on Nickel/Rocket (Table 8). Differences were apparent between products and varieties reflecting disease control efficacy and disease susceptibility. Tebuconazole gave better margins over fungicide cost on Bristol than Nickel/Rocket whilst difenoconazole appeared to give better margins on Nickel/Rocket than Bristol only when used as a single full dose in autumn. Both these fungicides gave better margins when applied as autumn + spring programmes. For flusilazole plus carbendazim the optimum strategy varied with variety - a single full dose in autumn was optimal for Bristol, but a split dose was more beneficial on Nickel/Rocket (Table 8). Carbendazim sprays performed poorly and gave very small positive (£0.5- 2) or negative margins.

At a number of indivdual sites yield responses of 0.5 to 1 t/ha were obtained, these would provide margins of £50 to £125/ha from a single full dose treatment of an azole fungicide. For break-even response, treatments need to produce a yield response of at least 0.2 t/ha; preferably 0.3 t/ha if application costs are included. Excluding the treatment with two full doses of flusilazole plus carbendazim which is not a commercial recommendation, responses of at least 0.3 t/ha were obtained with 10 out of 12 crops of Bristol and 8 out of 12 crops of Nickel/Rocket. Of course not all fungicides gave a response at these sites, fungicide choice therefore remains a key issue.

The largest yield response came from two full doses of flusilazole plus carbendazim and this was similar on both varieties. For Bristol, a single full dose of flusilazole plus carbendazim in the autumn was the most effective strategy whilst a half dose split autumn and spring was more effective on Rocket/Nickel. Carbendazim treatments gave very small responses both positive and negative. Both difenoconazole and tebuconazole gave rather larger responses on Bristol than Nickel/Rocket when used as a split dose programme whereas they showed greater benefits on Nickel/Rocket when applied at full dose in autumn (Table 8).

Table 5. Yield (t/ha at 91% DM), 1994/95

Treatment	Timing aut	Timing spring	Site: Trerulefoot (spring only) Bristol	Trerulefoot Rocket	Stonham Bristol	Stonham Rocket	Darrington Bristol	Darrington Rocket	Tillycorthie Bristol	Tillycorthie Rocket
1. nil			1.13	2.27	4.98	4.35	4.35	4.62	2.70	4.23
2. flusilazole plus carbendazim	1	1	1.87	2.42	5.19	4.68	5.01	4.83	3.68	4.39
3. flusilazole plus carbendazim	1	-	1.57	2.24	5.22	4.71	4.86	4.66	3.24	4.46
4. flusilazole plus carbendazim	½	½	1.55	2.37	5.18	5.01	4.59	4.93	3.53	4.15
5. carbendazim	1	-	1.62	2.47	4.81	4.71	4.63	4.95	2.77	4.24
6. carbendazim	½	½	1.49	2.10	4.97	4.50	4.39	4.60	2.74	4.23
7. tebuconazole	1	-	1.84	2.37	5.19	4.58	4.37	4.77	3.15	4.53
8. tebuconazole	½	½	1.80	1.81	5.10	4.66	4.43	4.83	3.59	4.51
9. difenconazole	1	-	1.51	2.21	5.32	5.22	4.26	4.94	3.11	4.62
10. difenconazole	½	½	1.54	2.15	4.99	4.99	4.71	4.97	3.41	4.69
Mean			1.45	2.24	5.10	4.74	4.56	4.81	3.19	4.40
SED (36 df) Variety (44 df Otley and Udny Station)			0.099		0.005		0.118		0.074	
Fungicide			0.036		0.144		0.203		0.148	
Variety x Fungicide			0.140		0.203		0.297		0.212	
CV(%)			8.8		5.1		7.5		6.7	

Table 6. Yield (t/ha at 91% DM), 1995/96

Treatment	Timing aut	Timing spring	Site: Kingston Bristol	Kingston Nickel	Otley Bristol	Otley Nickel	Darrington Bristol	Darrington Nickel	Udny Station Bristol	Udny Station Rocket
1. nil			2.65	3.27	4.31	4.56	2.96	3.04	1.04	3.50
2. flusilazole plus carbendazim	1	1	3.25	2.85	4.11	4.80	3.92	3.80	2.44	4.06
3. flusilazole plus carbendazim	1	-	3.12	2.92	4.30	4.76	3.58	3.46	1.68	3.78
4. flusilazole plus carbendazim	½	½	3.39	3.18	4.29	4.67	3.09	3.48	1.36	3.73
5. carbendazim	1	-	2.78	3.16	4.25	4.50	3.61	3.02	1.08	3.48
6. carbendazim	½	½	2.93	2.95	4.27	4.66	3.71	3.45	1.24	3.47
7. tebuconazole	1	-	2.86	3.65	4.27	4.63	3.09	3.35	2.19	3.75
8. tebuconazole	½	½	3.32	3.62	4.11	4.57	3.35	3.48	1.74	3.84
9. difenconazole	1	-	2.96	3.32	4.32	4.74	3.31	3.42	1.70	3.50
10. difenconazole	½	½	3.16	3.56	4.35	4.67	3.83	3.37	1.30	3.39
Mean			3.04	3.25	4.25	4.62	3.44	3.39	1.58	3.65
SED (36 df) Variety (44 df Otley and Udny Station)			0.085		0.119		0.219		0.323	
Fungicide			0.116		0.270		0.255		0.179	
Variety x Fungicide			0.164		0.208		0.360		0.403	
CV(%)			6.4		5.7		12.9		11.8	

Table 7. Yield (t/ha at 91% DM), 1996/97

Treatment	Timing aut	Timing spring	Kingston Bristol	Kingston Nickel	Otley Bristol	Otley Nickel	High Mowthorpe Bristol	High Mowthorpe Rocket	Tillycorthie Bristol	Tillycorthie Rocket
1. nil			2.98	4.31	3.10	2.84	3.48	4.54	1.90	2.81
2. flusilazole plus carbendazim	1	1	3.96	4.73	3.15	3.34	4.41	4.64	2.22	3.14
3. flusilazole plus carbendazim	1	-	3.50	4.43	3.34	3.09	4.18	4.48	2.11	2.79
4. flusilazole plus carbendazim	½	½	3.72	4.61	3.18	3.26	4.18	4.55	2.11	3.09
5. carbendazim	1	-	2.77	4.06	3.15	3.10	3.83	4.42	1.88	2.67
6. carbendazim	½	½	2.82	4.30	3.15	3.17	3.69	4.44	1.98	2.98
7. tebuconazole	1	-	3.38	4.19	3.17	3.25	4.03	4.49	2.08	2.97
8. tebuconazole	½	½	3.55	4.61	3.71	3.25	4.34	4.62	2.11	2.33
9. difenconazole	1	-	3.24	4.36	3.29	3.11	3.88	4.51	1.98	2.93
10. difenconazole	½	½	3.38	4.32	3.33	3.18	3.83	4.65	2.11	2.50
Mean			3.33	4.39	3.26	3.16	3.98	4.53	2.05	2.82
SED (36 df) Variety (44 df Otley and Udny Station)			0.110		0.441		0.042		0.093	
Fungicide			0.041		0.288		0.088		0.167	
Variety x Fungicide			0.155		0.400		0.124		0.242	
CV(%)			4.9		7.7		3.6		11.9	

Table 8. Cross-site yield analysis(t/ha at 91% DM) for 11 sites, 1995/97

Treatment	Timing		Cross-Site Means						
	aut	spring	Variety Means		Fungicide Mean	Yield response		Margin over fungicide cost (£/ha)*	
			Bristol	Nickel /Rocket		Bristol	Nickel /Rocket	Bristol	Nickel /Rocket
1. nil			3.19	3.82	3.50	0	0	-	-
2. flusilazole plus carbendazim	1	1	3.71	4.17	3.94	0.52	0.35	28.0	2.5
3. flusilazole plus carbendazim	1	-	3.57	3.98	3.77	0.38	0.16	32.0	-1.0
4. flusilazole plus carbendazim	½	½	3.47	4.05	3.76	0.28	0.23	17.0	9.5
5. carbendazim	1	-	3.26	3.82	3.54	0.07	0.00	0.5	-10.0
6. carbendazim	½	½	3.27	3.89	3.58	0.08	0.08	2.0	2.0
7. tebuconazole	1	-	3.43	3.97	3.70	0.24	0.20	11.0	5.0
8. tebuconazole	½	½	3.54	3.94	3.74	0.35	0.12	27.5	-7.0
9. difenconazole	1	-	3.41	4.07	3.74	0.22	0.25	8.0	12.5
10. difenconazole	½	½	3.50	4.01	3.75	0.31	0.19	21.5	3.5
Mean			3.44	3.97	3.70				
SED (396 df) Variety			0.129						
Fungicide					0.043				
Variety x Fungicide			0.080						
CV(%)			7.8						

*** Seed valued at £150/tonne. Azole fungicides at £25/ha at full dose, MBC fungicides at £10/ha at full dose.**

Disease

"tr" in the tables signifies that the disease was present at less than 0.1%.

1994/95

Trerulefoot

An assessment for light leaf spot and the phoma leaf spot was made at the time of the spring application (Table 9). Light leaf spot affected 14.5% of the plant area on Bristol and 0.7% on Rocket. Canker was not recorded in the untreated plots of Bristol or Rocket.

Table 9. Leaf area affected (%) with light leaf spot and phoma leaf spot, 4 April 1995 (GS 2,5) at Trerulefoot

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	14.7	0.7	0	0.0
2. flusilazole plus carbendazim 1	16.7	0.3	0	0.0
3. flusilazole plus carbendazim ½	16.3	0.0	0	0.7
4. flusilazole plus carbendazim ¼	16.0	0.7	0	0.0
5. carbendazim 1	16.7	0.0	0	0.3
6. carbendazim ½	14.0	1.0	0	0.0
7. tebuconazole 1	14.7	0.3	0	0.7
8. tebuconazole ½	15.7	0.7	0	0.7
9. difenoconazole 1	14.7	0.0	0	0.3
10. difenoconazole ½	14.7	0.7	0	0.7
Mean	15.4	0.4	0	0.3
SED (18 df)	1.25	0.36		0.36

At GS 4.1 the phoma leaf spot was not recorded on Rocket. Light leaf spot was recorded at only 0.1% leaf area on Rocket (Table 10). On Bristol, light leaf spot affected 16.8% of the leaf area. Carbendazim, tebuconazole, difenoconazole and the quarter rate of flusilazole had little effect on disease levels. The full and half dose of flusilazole plus carbendazim gave some control of light leaf spot.

Table 10. Leaf area affected (%) with light leaf spot and phoma leaf spot, 25 April 1995 (GS 4,1) at Trerulefoot

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	16.8	0.1	0	0
2. flusilazole plus carbendazim 1	7.5	tr	0	0
3. flusilazole plus carbendazim ½	8.7	tr	0	0
4. flusilazole plus carbendazim ¼	12.2	0	0	0
5. carbendazim 1	10.3	0.1	0	0
6. carbendazim ½	11.3	0.1	0	0
7. tebuconazole 1	10.2	0.1	0	0
8. tebuconazole ½	10.3	0	0	0
9. difenoconazole 1	9.7	tr	0	0
10. difenoconazole ½	9.3	tr	0	0
Mean	10.6	0.1	0	0
SED (18 df)	1.84	0.06		

At GS 5,5, only trace levels of light leaf spot and canker were recorded on Rocket. Phoma leaf spot was absent on Bristol. Light leaf spot was controlled by all doses of flusilazole plus carbendazim, tebuconazole and the full rate of tebuconazole on Bristol (Table 11).

Table 11. Leaf area affected (%) with light leaf spot and phoma leaf spot, 10 May 1995(GS 5.5-5.7) at Trerulefoot

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	19.0	tr	0	tr
2. flusilazole plus carbendazim 1	4.9	0	0	0
3. flusilazole plus carbendazim ½	7.2	0	0	0
4. flusilazole plus carbendazim ¼	9.3	0	0	0
5. carbendazim 1	11.8	0	0	0
6. carbendazim ½	13.7	0	0	0
7. tebuconazole 1	5.6	0	0	0
8. tebuconazole ½	7.0	0	0	0
9. difenoconazole 1	9.0	0	0	0
10. difenoconazole ½	13.3	0	0	0
Mean	10.1	tr	0	tr
SED (18 df)	1.55			

At GS 6,1, canker was absent on the stems of both cultivars. Light leaf spot was not recorded on the stems of Rocket. The stem area affected by light leaf spot was reduced by all the treatments, but the full dose of flusilazole plus carbendazim gave the greatest reduction in disease severity (Table 12).

Table 12. Light leaf spot on stems (% area), 22 June 1995 (GS 6,1) Trerulefoot

Treatment	Area stems affected (%)	
	Bristol	Rocket
1. nil	6.4	0
2. flusilazole plus carbendazim 1	1.7	0
3. flusilazole plus carbendazim ½	2.5	0
4. flusilazole plus carbendazim ¼	3.6	0
5. carbendazim 1	3.1	0
6. carbendazim ½	3.8	0
7. tebuconazole 1	2.5	0
8. tebuconazole ½	2.4	0
9. difenoconazole 1	2.8	0
10. difenoconazole ½	3.2	0
Mean	3.2	0
SED (18 df)	0.55	

Stonham

In the autumn, shortly after the first spray application, only trace levels of light leaf spot were recorded. The area of plants affected by the leaf spot phase of phoma was less than 1.5% for both Bristol and Rocket (Table 13).

Table 13. Leaf area affected (%) with light leaf spot and phoma leaf spot, 14 December 1994 at Stonham

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	tr	tr	1.4	1.1
2. flusilazole plus carbendazim 1+1	tr	tr	0.7	0.8
3. flusilazole plus carbendazim 1	tr	tr	0.7	0.5
4. flusilazole plus carbendazim ½+½	tr	tr	0.8	0.6
5. carbendazim 1	tr	tr	1.1	0.6
6. carbendazim ½+½	tr	tr	1.1	0.9
7. tebuconazole 1	tr	tr	0.8	0.7
8. tebuconazole ½+½	tr	tr	0.9	0.7
9. difenoconazole 1	tr	tr	0.8	0.5
10. difenoconazole ½+½	tr	tr	0.6	0.6
Mean	tr	tr	0.9	0.7
SED (36 df)			0.181	

At the beginning of stem extension the phoma leaf spot was present at 0.2% area affected on both Bristol and Rocket. Light leaf spot was not recorded on Rocket. The leaf area affected on Bristol was less than 5%, but there was evidence of control by all treatments (Table 14).

Table 14. Leaf area affected (%) with light leaf spot and phoma leaf spot, 4 April 1995 at Stonham

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	4.6	0	0.2	0.2
2. flusilazole plus carbendazim 1+1	0.5	0	0	0
3. flusilazole plus carbendazim 1	1.1	0	0	0.1
4. flusilazole plus carbendazim ½+½	1.1	0	tr	0
5. carbendazim 1	2.7	0	0.2	tr
6. carbendazim ½+½	2.4	0	tr	tr
7. tebuconazole 1	1.1	0	0.1	0.1
8. tebuconazole ½+½	0.9	0	tr	0
9. difenoconazole 1	2.5	0	0	0
10. difenoconazole ½+½	3.9	0	0	0
Mean	1.9	0	0.1	tr
SED (36df)	0.902 (22 df)		0.077	

Canker was evident on the stems at pod ripening, with no difference apparent between the untreated of either cultivar. There was little reduction in canker levels, but carbendazim appeared to have little effect. Where reduction in disease did occur there appeared to little benefit from the spilt dose (Table 15).

Light leaf spot was absent on the stems of Rocket and at low levels on Bristol. Splitting the dose had little effect on the effectiveness of disease control, except for the half dose of flusilazole plus carbendazim. Carbendazim had no effect on diseases levels (Table 15).

Table 15. Stem area affected (%) with light leaf spot and canker, 20 July at Stonham

Treatment	Light leaf spot		Canker	
	Bristol	Rocket	Bristol	Rocket
1. nil	6.9	0	8.0	9.1
2. flusilazole plus carbendazim 1+1	1.9	0	3.7	5.0
3. flusilazole plus carbendazim 1	1.8	0	3.1	7.7
4. flusilazole plus carbendazim ½+½	4.8	0	6.0	7.6
5. carbendazim 1	6.9	0	5.8	10.8
6. carbendazim ½+½	6.9	0	7.2	10.8
7. tebuconazole 1	3.3	0	6.3	8.6
8. tebuconazole ½+½	3.4	0	7.5	8.1
9. difenoconazole 1	3.2	0	4.3	7.0
10. difenoconazole ½+½	3.8	0	3.6	7.3
Mean	4.3	0	5.6	8.2
SED (36 df)	1.177 (22 df)		1.178	

Treatment had little effect on the canker index on Rocket. Splitting the dose had little effect on the canker index were disease was reduced. Carbendazim was not effective in reducing the canker index (Table 16).

Table 16. Canker index, 20 July 1995 at Stonham

Treatment	Canker index	
	Bristol	Rocket
1. nil	61.1	54.4
2. flusilazole plus carbendazim 1+1	11.1	31.1
3. flusilazole plus carbendazim 1	12.8	31.1
4. flusilazole plus carbendazim ½+½	29.4	42.8
5. carbendazim 1	46.1	43.9
6. carbendazim ½+½	50.0	53.3
7. tebuconazole 1	36.7	40.0
8. tebuconazole ½+½	46.7	52.2
9. difenoconazole 1	7.8	31.7
10. difenoconazole ½+½	13.9	38.9
Mean	31.6	41.9
SED (36 df)	7.73	

Darrington

In the untreated plots on 13 January, light leaf spot was only present at 0.1% leaf area affected on Bristol and not recorded on Rocket. Phoma leaf spot was not recorded in either the untreated plots of Bristol or Rocket (Table 17).

Table 17. Leaf area affected (%) with light leaf spot and phoma leaf spot, 13 January 1995 at Darrington

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	0.1	0	0	0
2. flusilazole plus carbendazim 1+1	0.5	0	0	0
3. flusilazole plus carbendazim 1	0	0	0	0
4. flusilazole plus carbendazim ½+½	0.1	0.1	0	0
5. carbendazim 1	0.1	0	0	0.1
6. carbendazim ½+½	0.1	0	0	0
7. tebuconazole 1	0.1	0	0	0
8. tebuconazole ½+½	0.1	0	0	0
9. difenoconazole 1	0.5	0	0	0
10. difenoconazole ½+½	0.2	0	0	0.1
Mean	0.2	tr	0	tr
SED (36 df)				

At stem extension disease severity in both cultivars was low, with phoma leaf spot present at only trace levels and light leaf spot on the untreated at 1.2% leaf area affected on Bristol and 0.2% on Rocket (Table 18).

Table 18. Leaf area affected (%) with light leaf spot and phoma leaf spot, 21 March 1995 at Darrington

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	1.2	0.2	tr	tr
2. flusilazole plus carbendazim 1+1	0.4	0.1	tr	tr
3. flusilazole plus carbendazim 1	0.4	0.1	tr	tr
4. flusilazole plus carbendazim ½+½	0.5	0.1	tr	tr
5. carbendazim 1	0.6	0.2	tr	tr
6. carbendazim ½+½	1.9	0.2	tr	tr
7. tebuconazole 1	0.4	tr	0	tr
8. tebuconazole ½+½	0.5	0.1	tr	tr
9. difenoconazole 1	0.9	tr	tr	tr
10. difenoconazole ½+½	1.0	0.1	0	tr
Mean	0.78	0.1	tr	tr
SED (36 df)	0.32			

On 5 June, light leaf spot on the stems reached 6.9% on Bristol and 0.1% on Rocket. Only the two full dose applications gave a significant reduction of the disease. Stem infection in Rocket was only at 0.1%. Low levels of canker were present in both Bristol and Rocket (Table 19).

Table 19. Stem area affected (%) with light leaf spot and canker on 5 June 1995 at Darrington

Treatment	Light leaf spot		Canker	
	Bristol	Rocket	Bristol	Rocket
1. nil	6.9	0.1	tr	0.2
2. flusilazole plus carbendazim 1+1	2.3	0	0	0.1
3. flusilazole plus carbendazim 1	3.9	0.1	0	0.3
4. flusilazole plus carbendazim ½+½	5.3	tr	0.1	0.1
5. carbendazim 1	7.1	0.1	0	0.3
6. carbendazim ½+½	5.2	0.1	0	0.2
7. tebuconazole 1	3.0	0	0	0.3
8. tebuconazole ½+½	4.1	0.1	0	0.3
9. difenoconazole 1	4.3	0.2	0	0
10. difenoconazole ½+½	3.9	0	0	0.1
Mean	4.6	0.1	tr	0.2
SED (36 df)	0.549	0.549		0.118

A full dose of all treatments except carbendazim in the autumn reduced the canker index. Carbendazim, either at the full of the split dose increased the canker index (Table 20).

Table 20. Canker index on 5 June1995 at Darrington

Treatment	Canker index	
	Bristol	Rocket
1. nil	0.3	2.7
2. flusilazole plus carbendazim 1+1	0	0.7
3. flusilazole plus carbendazim 1	0	0.5
4. flusilazole plus carbendazim ½+½	0	1.3
5. carbendazim 1	0.5	4.2
6. carbendazim ½+½	0	3.7
7. tebuconazole 1	0	1.2
8. tebuconazole ½+½	0	1.3
9. difenoconazole 1	0	0.7
10. difenoconazole ½+½	0	1.2
Mean	0.1	1.7
SED (36 df)	0.634	

At the final assessment light leaf spot covered 18.5% area of the stems. Control was only maintained by the two full doses of flusilazole plus carbendazim. The full dose of each fungicide was slightly better at reducing the canker index (Table 21).

Table 21. Light leaf spot on the stems of Bristol and canker index on Rocket on 6 July 1995 at Darrington

Treatment	Light leaf spot on stems (% area) Bristol	Canker index Rocket
1. nil	18.5	4.7
2. flusilazole plus carbendazim 1+1	5.7	1.5
3. flusilazole plus carbendazim 1	12.2	2.5
4. flusilazole plus carbendazim ½+½	11.8	3.0
5. carbendazim 1	9.8	2.2
6. carbendazim ½+½	15.0	3.3
7. tebuconazole 1	8.0	2.3
8. tebuconazole ½+½	10.0	2.7
9. difenoconazole 1	14.5	2.0
10. difenoconazole ½+½	10.3	2.5
Mean	11.6	2.7
SED (36 df)	1.814	0.67

Tillycorthie

On 16 November light leaf spot was recorded only on Bristol reaching 0.2 % area affected. Phoma leaf spot was not present (Table 22).

Table 22. Plants area affected (%) with light leaf spot and phoma leaf spot, 16 November 1994 (GS 1,5 - 1,6) at Tillycorthie

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	0.2	0	0	0
2. flusilazole plus carbendazim 1+1	0	0	0	0
3. flusilazole plus carbendazim 1	0	0	0	0
4. flusilazole plus carbendazim ½+½	0	0	0	0
5. carbendazim 1	0	0	0	0
6. carbendazim ½+½	0	0	0	0
7. tebuconazole 1	0	0	0	0
8. tebuconazole ½+½	0	0	0	0
9. difenoconazole 1	0	0	0	0
10. difenoconazole ½+½	0	0	0	0
Mean	0	0	0	0

By the 15 December, the levels of light leaf spot on Bristol had risen to 6.7% and to 0.3% on Rocket. The disease was controlled by all treatments except for carbendazim. At this stage dose had little effect. Phoma leaf spot was not recorded on either Bristol or Rocket (Table 23).

Table 23. Area affected (%) with light leaf spot and phoma leaf spot, 15 December 1994 (GS 1,8 - 1,11) at Tillycorthie

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	6.7	0.2	0	0
2. flusilazole plus carbendazim 1+1	2.9	tr	0	0
3. flusilazole plus carbendazim 1	-	-	-	-
4. flusilazole plus carbendazim ½+½	1.6	0.1	0	0
5. carbendazim 1	5.3	0.3	0	0
6. carbendazim ½+½	9.2	tr	0	0
7. tebuconazole 1	0.1	0	0	0
8. tebuconazole ½+½	0.6	0	0	0
9. difenoconazole 1	2.0	tr	0	0
10. difenoconazole ½+½	1.9	0	0	0
Mean	3.0	tr	0	0
SED (16 df)	1.94			

After the winter and prior to stem extension, the level of light leaf spot on Bristol had risen slightly and on Rocket substantially, but levels were still below those on Bristol (Table 24). However, all treatments were effective in controlling the disease on Rocket. On Bristol, carbendazim provided no control at the full dose and marginal control with the split application. At this stage the full single dose of the other treatments in the autumn was providing better control than the spilt half dose.

Table 24. Area affected (%) with light leaf spot and phoma leaf spot, 1 March 1995 (GS 1,12, 3,1) at Tillycorthie

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	8.6	2.4	0	0
2. flusilazole plus carbendazim 1+1	2.6	0	0	0
3. flusilazole plus carbendazim 1	3.7	0	0	0
4. flusilazole plus carbendazim ½+½	6.9	tr	0	0
5. carbendazim 1	10.8	tr	0	0
6. carbendazim ½+½	3.6	0	0	0
7. tebuconazole 1	0.3	0	0	0
8. tebuconazole ½+½	8.9	tr	0	0
9. difenoconazole 1	5.3	0.2	0	0
10. difenoconazole ½+½	10.1	0	0	0
Mean	6.1	0.3	0	0
SED (18 df)	3.07	0.50		

By stem extension the position was less clear, with only the full dose of tebuconazole giving reasonable control of light leaf spot. Light leaf spot on Rocket was essentially only recorded at trace levels. No phoma leaf spot was recorded in either cultivar (Table 25).

Table 25. Leaf area affected (%) with light leaf spot and phoma leaf spot, 11 April 1995 (GS 3,5) at Tillycorthie

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	9.4	0.5	0	0
2. flusilazole plus carbendazim 1+1	10.3	0.1	0	0
3. flusilazole plus carbendazim 1	7.0	0.5	0	0
4. flusilazole plus carbendazim ½+½	7.3	tr	0	0
5. carbendazim 1	11.6	0	0	0
6. carbendazim ½+½	18.3	0.2	0	0
7. tebuconazole 1	4.1	tr	0	0
8. tebuconazole ½+½	11.9	0	0	0
9. difenoconazole 1	10.9	0	0	0
10. difenoconazole ½+½	7.8	0.2	0	0
Mean	10.0	0.2	0	0
SED (18 df)	3.40	0.21		

None of the treatments had a significant effect on the levels of light leaf spot on the stems (Table 26).

Table 26. Light leaf spot on stems (% area), 9 August 1995 (GS 6,8) at Tillycorthie

Treatment	Light leaf spot on stems	
	Bristol	Rocket
1. nil	21.0	1.7
2. flusilazole plus carbendazim 1+1	17.7	1.7
3. flusilazole plus carbendazim 1	17.3	1.7
4. flusilazole plus carbendazim ½+½	19.7	3.0
5. carbendazim 1	18.3	4.0
6. carbendazim ½+½	16.3	3.7
7. tebuconazole 1	22.0	2.3
8. tebuconazole ½+½	21.3	2.0
9. difenoconazole 1	24.0	2.7
10. difenoconazole ½+½	19.3	2.3
Mean	19.7	2.5
SED (36 df)		

Crop height and internode length

Trerulefoot

At Trerulefoot, Rocket was about 10 cm higher than Bristol. Internode lengths were similar at about 8 cm (Table 27). The full dose of flusilazole plus carbendazim, carbendazim and difenconazole increased plant height in Bristol. Tebuconazole reduced crop height in both Bristol and Rocket.

Table 27. Crop height and internode length (mm), 30 May 1995 (GS 5,9) at Trerulefoot

Treatment	Plant height		Internode	
	Bristol	Rocket	Bristol	Rocket
1. nil	1183	1364	8.2	8.1
2. flusilazole plus carbendazim 1	1267	1350	8.2	8.2
3. flusilazole plus carbendazim ½	1197	1320	7.8	7.9
4. flusilazole plus carbendazim ¼	1237	1337	8.1	8.0
5. carbendazim 1	1190	1353	8.2	8.3
6. carbendazim ½	1243	1357	8.1	8.1
7. tebuconazole 1	1163	1270	7.4	7.7
8. tebuconazole ½	1163	1260	7.6	7.7
9. difenoconazole 1	1247	1330	8.5	8.0
10. difenoconazole ½	1223	1333	8.1	8.1
Mean	1211	1327	8.0	8.0
SED				

Stonham

At Stonham, Bristol was about 16 cm taller than Rocket. This was reflected in the differences in the internode length (Table 28). Flusilazole plus carbendazim and difenconazole increased crop height in Bristol. All treatments tended to increase crop height in Rocket.

Table 28. Crop height and internode length (mm), 18 July 1995 at Stonham

Treatment	Plant height (5 June)		1st internode		2nd internode		3rd internode		4th internode	
	Bristol	Rocket	Bristol	Rocket	Bristol	Rocket	Bristol	Rocket	Bristol	Rocket
1. nil	1457	1293	414	431	82	50	74	48	67	46
2. flusilazole plus carbendazim 1+1	1527	1363	380	409	81	51	84	50	76	46
3. flusilazole plus carbendazim 1	1497	1330	411	404	80	54	78	46	79	45
4. flusilazole plus carbendazim ½+½	1503	1357	392	369	78	55	80	52	77	49
5. carbendazim 1	1453	1323	419	370	81	54	75	53	71	55
6. carbendazim ½+½	1437	1327	382	442	83	48	70	50	75	45
7. tebuconazole 1	1460	1307	366	384	78	54	79	49	77	53
8. tebuconazole ½+½	1460	1297	378	388	87	50	81	52	71	46
9. difenoconazole 1	1530	1370	369	411	86	61	78	56	73	54
10. difenoconazole ½+½	1500	1347	398	387	85	53	77	57	80	48
Mean	1482	1331	391	400	82	53	78	51	75	49
SED (36 df)	27.1	27.1	ns	ns	5.2	5.2	ns	ns	ns	ns

Darrington

At Darrington, Rocket was higher than Bristol, reflected also in the internode length. Flusilazole plus carbendazim increased crop height in Bristol. Tebuconazole reduced crop height slightly in Rocket, but not in Bristol (Table 29).

Table 29. Crop height and internode length (mm) at Darrington, 1995

Treatment	Plant height		Internode	
	Bristol	Rocket	Bristol	Rocket
1. nil	1170	1300	94	97
2. flusilazole plus carbendazim 1+1	1360	1320	97	103
3. flusilazole plus carbendazim 1	1330	1330	105	109
4. flusilazole plus carbendazim ½+½	1280	1300	97	109
5. carbendazim 1	1210	1290	89	95
6. carbendazim ½+½	1240	1310	92	95
7. tebuconazole 1	1290	1290	107	103
8. tebuconazole ½+½	1290	1200	80	103
9. difenoconazole 1	1280	1330	100	110
10. difenoconazole ½+½	1250	1310	91	101
Mean	1270	1298	95	103
SED (36 df)	31.21		7.78	

Tillycorthie

At Tillycorthie, Bristol was about 32 cm taller than Rocket. Rocket was most affected by the treatments, with the full dose treatments being about 5-22 cm taller than the untreated. A similar effect was not apparent in Bristol (Table 30).

Table 30. Crop height (mm), 30 May 1995 (GS 5,9) at Tillycorthie

Treatment	Plant height	
	Bristol	Rocket
1. nil	1398	1083
2. flusilazole plus carbendazim 1+1	1408	1334
3. flusilazole plus carbendazim 1	1461	1303
4. flusilazole plus carbendazim ½+½	1451	1282
5. carbendazim 1	1368	1134
6. carbendazim ½+½	1416	1069
7. tebuconazole 1	1437	1393
8. tebuconazole ½+½	1431	1270
9. difenoconazole 1	1393	1169
10. difenoconazole ½+½	1428	1334
Mean	1419	1237
SED (18 df)	33.6	38.9

1995/96

Kingston

White leaf spot affected 0.01% leaf area on Bristol and 0.05% on Nickel when autumn sprays were applied on 4 December. An assessment for light leaf spot and the white leaf spot was made at the time of the spring application (Table 31). Light leaf spot affected 2.83% of the plant area on Bristol and 0.27% on Nickel. Phoma leaf spot was not recorded in the untreated plot of Bristol or Nickel and only traces of white leaf spot were found in control plots.

Table 31. Leaf area affected (%) with light leaf spot and white leaf spot, 27 March 1995 (GS 2,5, 3,1) at Kingston

Treatment	Light leaf spot		White leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	2.83	0.27	0.01	0.01
2. flusilazole plus carbendazim 1 + 1	0.03	0	0	0
3. flusilazole plus carbendazim 1	0.07	0	0	0
4. flusilazole plus carbendazim ½ + ½	0.03	0	0	0
5. carbendazim 1	0.13	0.03	0	0
6. carbendazim ½ + ½	0.27	0.07	0	0
7. tebuconazole 1	0.07	0	0	0
8. tebuconazole ½ + ½	0.13	0.03	0	0
9. difenoconazole 1	0.13	0	0	0
10. difenoconazole ½ + ½	0.27	0.04	0	0
Mean	0.40	0.04	0.001	0.001
SED(36df)Variety	0.092		0.015	
Fungicide	0.163		0.029	
Variety x Fungicide	0.238		0.042	

Just prior to the yellow bud stage (GS 3, 6), sixteen days after the spring spray, there had been little further disease development. Light leaf spot was at only 2.03% leaf area on Bristol and 0.53% on Nickel (Table 32). The full and half dose of flusilazole plus carbendazim and tebuconazole gave good control of light leaf spot as they had in March (Tables 31 and 32).

Table 32. Leaf area affected (%) with light leaf spot and white leaf spot (16 days after treatment), 17 April 1996 (GS 3,6) at Kingston

Treatment	Light leaf spot		White leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	2.03	0.53	0	2.93
2. flusilazole plus carbendazim 1 + 1	0.07	0	0	0.30
3. flusilazole plus carbendazim 1	0.07	0	0	0.20
4. flusilazole plus carbendazim ½ + ½	0.13	0.03	0	0.43
5. carbendazim 1	0.37	0.03	0	0.57
6. carbendazim ½ + ½	0.47	0.13	0	0.87
7. tebuconazole 1	0.10	0	0	0.10
8. tebuconazole ½ + ½	0.03	0.03	0	0.17
9. difenoconazole 1	0.43	0	0	0.23
10. difenoconazole ½ + ½	0.57	0.07	0	0.13
Mean	0.43	0.08	0	0.59
SED(36df)Variety	0.052		0.151	
Fungicide	0.109		0.262	
Variety x Fungicide	0.155		0.383	

On 17 April (GS 3,6), white leaf spot was active on Nickel but no phoma leaf spot was found on either variety. All treatments gave control of white leaf spot and those with an azole component had the lowest disease severity (Table 32).

At GS 5.9, canker was absent on the stems of both cultivars. Light leaf spot was not recorded on the stems of Nickel but affected 21.7% area of untreated Bristol. The stem area affected by light leaf spot was reduced by all the treatments, but the double full dose of flusilazole plus carbendazim had the lowest disease severity (Table 33). Comparison of the single full dose treatments or the split dose treatments suggested that flusilazole + carbendazim and tebuconazole were rather more effective than carbendazim or difenoconazole. The split dose treatments were consistently less severely affected than those receiving the full dose in the autumn. There was no evidence of canker or pod diseases.

Table 33. Light leaf spot on stems (% area), 10 June 1996 (GS 5,9) Kingston

Treatment	Area stems affected (%)	
	Bristol	Nickel
1. nil	21.7	0
2. flusilazole plus carbendazim 1 + 1	0.7	0
3. flusilazole plus carbendazim 1	2.0	0
4. flusilazole plus carbendazim ½ + ½	1.3	0
5. carbendazim 1	7.3	0
6. carbendazim ½ + ½	5.7	0
7. tebuconazole 1	2.0	0
8. tebuconazole ½ + ½	1.3	0
9. difenoconazole 1	10.0	0
10. difenoconazole ½ + ½	7.3	0
Mean	5.93	0
SED(36df)Variety	0.56	
Fungicide	1.02	
Variety x Fungicide	1.48	

Otley

The crop was drilled on 6 September 1995 and established well to produce a population of 48 plants/m^2 on 18 October. Volunteer barley were well controlled but did produce some competition with the crop in early autumn. Rape stubble was spread on the plots shortly after emergence to provide disease inoculum. In the autumn, shortly after the first spray application, only trace levels of light leaf spot were recorded. The area of plants affected by the leaf spot phase of phoma was less than 0.1% for both Bristol and Nickel (Table 34). No treatment differences were significant at this stage (22 days after treatment).

Table 34. Leaf area affected (%) with phoma leaf spot and light leaf spot, 21 December 1995 at Otley.

Treatment	Phoma leaf spot		Light leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	0.04	0.09	0.02	0.02
2. flusilazole plus carbendazim 1+1	0.03	0.01	0.03	0.00
3. flusilazole plus carbendazim 1	0.01	0.01	0.00	0.01
4. flusilazole plus carbendazim ½+½	0.03	0.02	0.00	0.00
5. carbendazim 1	0.03	0.03	0.02	0.02
6. carbendazim ½+½	0.08	0.01	0.02	0.04
7. tebuconazole 1	0.04	0.01	0.01	0.01
8. tebuconazole ½+½	0.04	0.07	0.00	0.00
9. difenoconazole 1	0.05	0.03	0.00	0.01
10. difenoconazole ½+½	0.07	0.01	0.00	0.08
Mean	0.04	0.03	0.01	0.02
SED(44 df) Variety	0.016		0.008	
Fungicide	0.021		0.011	
Variety x Fungicide	0.032		0.016	

Light leaf spot was apparent on both varieties on 21 December. There was little consistent effect of treatments on the total exclusion of light leaf spot and some disease was recorded in plots treated with each of the different fungicides (Table 34).

Table 35. Leaf area affected (%) with phoma leaf spot and light leaf, 24 April 1996 at Otley.

Treatment	Phoma leaf spot		Light leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	0.8	0.7	0.04	0.00
2. flusilazole plus carbendazim 1+1	0.5	0.3	0.00	0.00
3. flusilazole plus carbendazim 1	0.4	0.3	0.01	0.00
4. flusilazole plus carbendazim ½+½	0.3	0.4	0.00	0.00
5. carbendazim 1	0.7	0.4	0.02	0.00
6. carbendazim ½+½	0.5	0.7	0.05	0.01
7. tebuconazole 1	0.4	9.3	0.06	0.00
8. tebuconazole ½+½	0.5	0.4	0.04	0.00
9. difenoconazole 1	0.4	0.4	0.01	0.00
10. difenoconazole ½+½	0.3	0.3	0.00	0.00
Mean	0.5	0.4	0.02	0.001
SED (44 df) Variety	0.06		0.007	
Fungicide	0.08		0.012	
Variety x Fungicide	0.13		0.017	

Phoma leaf spot was recorded in all treatments on 24 April (GS 3, 6) 7 days after application of the spring sprays. Difenoconazole, flusilazole + carbendazim and tebuconazole as single or split dose treatments reduced phoma leaf spot severity (Table 35). There were no treatment differences for light leaf spot which occurred at very low severity.

Subsequent disease development was very limited because of dry weather and only canker reached assessable levels immediately before harvest.

Table36. Incidence (% plants) of canker at Otley, 2 August 1996

Treatment	Canker	
	Bristol	Nickel
1. nil	9.3	9.2
2. flusilazole plus carbendazim 1+1	4.7	3.3
3. flusilazole plus carbendazim 1	6.3	4.3
4. flusilazole plus carbendazim ½+½	5.7	4.0
5. carbendazim 1	8.7	9.3
6. carbendazim ½+½	7.0	7.3
7. tebuconazole 1	7.3	4.7
8. tebuconazole ½+½	5.3	4.0
9. difenoconazole 1	6.3	3.0
10. difenoconazole ½+½	4.0	3.7
Mean	0.55	
SED (44 df) Variety	0.72	
Fungicide	0.72	
Variety x Fungicide	1.07	

Treatments had some effect on the canker incidence which was very low on both varieties. Canker was reduced by difenoconazole, flusilazole + carbendazim and tebuconazole applied as either single or split dose treatments (Table 36).

Darrington

This crop established slowly in the dry autumn and was subject to some competition from chickweed. Disease levels were low in December and spring and traces of diseases were still apparent at the yellow bud stage (GS 3, 7) on 9 May (Table 37).

Table 37. Leaf area affected (%) with light leaf spot and phoma leaf spot, 9 May 1996 at Darrington

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	0.1	0	tr	tr
2. flusilazole plus carbendazim 1+1	0	0	tr	tr
3. flusilazole plus carbendazim 1	0	0	tr	tr
4. flusilazole plus carbendazim ½+½	tr	0	tr	tr
5. carbendazim 1	tr	0	0.1	tr
6. carbendazim ½+½	0	0	tr	tr
7. tebuconazole 1	0	0	0.2	tr
8. tebuconazole ½+½	tr	tr	tr	0.1
9. difenoconazole 1	0	0	tr	tr
10. difenoconazole ½+½	0	0	tr	tr
Mean	tr	tr	0.02	0.02
SED (36 df) Variety	0.006		0.006	
Fungicide	0.010		0.011	
Variety x Fungicide	0.014		0.016	

Table 38. Pod and stem area affected (%) by light leaf spot at pod ripening, (9 July 1996) at Darrington

Treatment	Pods		Stems	
	Bristol	Nickel	Bristol	Nickel
1. nil	0.3	0.4	0.6	0.6
2. flusilazole plus carbendazim 1+1	0.3	0.8	0.2	1.4
3. flusilazole plus carbendazim 1	0	0.2	0.3	0.9
4. flusilazole plus carbendazim ½+½	0.4	0.2	0.5	0.5
5. carbendazim 1	0.1	0.4	0.9	0.8
6. carbendazim ½+½	0	0.5	0.4	0.7
7. tebuconazole 1	0.9	0.5	1.4	0.8
8. tebuconazole ½+½	0.5	0.1	0.5	0.5
9. difenoconazole 1	0.7	0.4	0.1	0.7
10. difenoconazole ½+½	0.2	0.2	0.3	0.3
Mean	0.34	0.37	0.52	0.72
SED (36 df) Variety	0.174		0.378	
Fungicide	0.297		0.378	
Variety x Fungicide	0.420		0.564	

At pod ripening on 9 July, light leaf spot was present in all treatments on stems and pods (Table 38), but severity was low. The split dose treatments were generally as good or better than the single autumn spray at full dose, but differences were not significant. The canker index (0-100 scale) was low and no significant differences were detected (Table 39).

Table 39. Canker index on 9 July 1996 at Darrington

Treatment	Bristol	Nickel
1. nil	2.5	5.8
2. flusilazole plus carbendazim 1+1	5.8	5.8
3. flusilazole plus carbendazim 1	0.8	3.3
4. flusilazole plus carbendazim ½+½	0.8	1.7
5. carbendazim 1	2.5	5.8
6. carbendazim ½+½	2.5	6.7
7. tebuconazole 1	3.3	2.5
8. tebuconazole ½+½	2.5	1.7
9. difenoconazole 1	3.3	0.8
10. difenoconazole ½+½	1.7	3.3
Mean	2.58	3.75
SED (36 df) Variety	0.962	
Fungicide	1.991	
Variety x Fungicide	2.817	

Udny Station

When the first sprays were applied on 20 November (GS 1, 05) light leaf spot was already well established on Bristol (70% plants, 7.2% leaf area affected) and also apparent on Rocket (17% plants, 1.2% leaf area affected). Alternaria affected 30% plants of Bristol and 73% plants of Rocket with 0.2 and 1.0% leaf area affected respectively.

Table 40. Incidence (% plants) and severity of light leaf spot, 15 December 1995 (GS 1, 07) at Udny Station.

Treatment	% Plants		% Leaf area	
	Bristol	Rocket	Bristol	Rocket
1. nil	86.7	23.3	16.90	3.40
2. flusilazole plus carbendazim 1+1	6.7	0.0	0.10	0.00
3. flusilazole plus carbendazim 1	13.3	0.0	0.83	0.00
4. flusilazole plus carbendazim ½+½	56.7	0.0	4.07	0.00
5. carbendazim 1	90.0	13.3	23.47	1.63
6. carbendazim ½+½	50.0	20.0	10.10	2.43
7. tebuconazole 1	16.7	0.0	0.60	0.00
8. tebuconazole ½+½	36.7	0.0	1.60	0.00
9. difenoconazole 1	43.3	0.0	3.63	0.00
10. difenoconazole ½+½	66.7	6.7	8.90	0.17
Mean	46.7	6.3	7.02	0.76
SED (44 df) Variety	10.08		1.401	
Fungicide	9.58		1.698	
Variety x Fungicide	16.43		2.692	

By the 15 December, the % leaf area affected by light leaf spot had risen to 16.9% on Bristol and to 3.4% on Rocket (Table 40). The disease severity was reduced by all treatments except for full dose carbendazim on Bristol, but differences on Rocket were not significant. A number of treatments gave control of light leaf spot on Rocket and this highlighted the good activity of flusilazole + carbendazim and tebuconazole. There were differences in light leaf spot incidence between full and half doses of flusilazole + carbendazim but not for the other fungicides. Phoma leaf spot was not recorded on either Bristol or Rocket but alternaria leaf spotting was common on Rocket (Table 41). Treatment differences were not significant.

Table 41. Incidence (% plants) and severity of alternaria leaf spot, 15 December 1995 (GS 1, 07) at Udny Station

Treatment	% Plants		% Leaf area	
	Bristol	Rocket	Bristol	Rocket
1. nil	0.0	36.7	0.0	0.43
2. flusilazole plus carbendazim 1+1	6.7	23.3	0.07	0.27
3. flusilazole plus carbendazim 1	3.3	40.0	0.03	0.43
4. flusilazole plus carbendazim ½+½	0.0	16.7	0.00	0.20
5. carbendazim 1	0.0	23.3	0.00	0.27
6. carbendazim ½+½	0.0	50.0	0.00	0.53
7. tebuconazole 1	13.3	20.0	0.10	0.20
8. tebuconazole ½+½	3.3	13.3	0.03	0.13
9. difenoconazole 1	10.0	26.7	0.10	0.43
10. difenoconazole ½+½	6.7	20.0	0.07	0.20
Mean	4.3	27.0	0.04	0.31
SED (44 df) Variety	6.26		0.074	
Fungicide	8.89		0.116	
Variety x Fungicide	13.56		0.173	

Table 42. Area affected (%) with light leaf spot and phoma leaf spot, 27 March 1996 (GS 2, 1 - 3, 2) at Udny Station

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	0.8	0.4	0.0	0.1
2. flusilazole plus carbendazim 1+1	0.0	0.3	0.0	0.1
3. flusilazole plus carbendazim 1	0.0	0.0	0.0	0.0
4. flusilazole plus carbendazim ½+½	0.0	0.0	0.1	tr
5. carbendazim 1	0.1	0.0	0.0	0.0
6. carbendazim ½+½	0.1	0.0	0.0	0.1
7. tebuconazole 1	0.3	0.0	0.0	0.1
8. tebuconazole ½+½	0.2	0.0	0.0	0.0
9. difenoconazole 1	0.3	0.0	0.0	0.0
10. difenoconazole ½+½	0.0	0.1	0.0	0.1
Mean	0.18	0.08	0.01	0.05
SED (44 df) Variety	0.085		0.006	
Fungicide	0.159		0.048	
Variety x Fungicide	0.231		0.066	

By stem extension phoma leaf spot had appeared at trace levels and light leaf spot had declined dramatically to affect less than 1% leaf area (Table 42). There were varietal differences for phoma leaf spot severity (Table 42) and for phoma incidence (Table 43) and fungicide differences or light leaf spot incidence. No light leaf spot was recorded in plots treated with difenoconazole (half rate) or flusilazole + carbendazim.

Table 43. Incidence (% plants) of light leaf spot and phoma leaf spot, 27 March 1996 (GS 2,1 - 3, 2) at Udny Station.

Treatment	Phoma leaf spot		Light leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	0.0	3.3	26.7	6.7
2. flusilazole plus carbendazim 1+1	0.0	3.3	0.0	6.7
3. flusilazole plus carbendazim 1	0.0	0.0	0.0	0.0
4. flusilazole plus carbendazim ½+½	3.3	3.3	0.0	0.0
5. carbendazim 1	0.0	0.0	3.3	0.0
6. carbendazim ½+½	0.0	6.7	3.3	0.0
7. tebuconazole 1	0.0	3.3	10.0	0.0
8. tebuconazole ½+½	0.0	0.0	6.7	0.0
9. difenoconazole 1	0.0	0.0	10.0	0.0
10. difenoconazole ½+½	0.0	3.3	0.0	3.3
Mean	0.3	2.3	6.0	1.7
SED (44 df) Variety	0.28		1.93	
Fungicide	2.09		4.19	
Variety x Fungicide	2.85		6.00	

Table 44. Area affected (%) with light leaf spot and phoma leaf spot, 20 May 1996 (GS 3,5) at Udny Station

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	2.43	7.00	0.00	0.07
2. flusilazole plus carbendazim 1+1	5.47	1.83	0.00	0.00
3. flusilazole plus carbendazim 1	5.33	1.17	0.00	0.03
4. flusilazole plus carbendazim ½+½	3.87	2.13	0.00	0.00
5. carbendazim 1	2.77	6.77	0.00	0.00
6. carbendazim ½+½	3.30	4.17	0.00	0.00
7. tebuconazole 1	6.77	1.03	0.00	0.03
8. tebuconazole ½+½	6.63	2.00	0.00	0.03
9. difenoconazole 1	4.00	2.33	0.00	0.00
10. difenoconazole ½+½	5.23	2.90	0.00	0.07
Mean	4.58	3.13	0.00	0.02
SED (44 df) Variety	0.862		0.003	
Fungicide	1.148		0.023	
Variety x Fungicide	1.778		0.032	

By 20 May (GS 3, 5), light leaf spot had increased again and affected 7.0% of untreated Rocket and 2.4% untreated Bristol. This difference was attributed to severe loss of plants in untreated Bristol (Table 44) and produced the further anomaly that treated plots had more light leaf spot than the untreated in Bristol. There were highly significant differences in the light leaf spot severity ($\underline{P}$ = 0.001). Varietal differences were significant for phoma leaf spot incidence (Table 45) and severity (Table 44). Despite loss of plants, Bristol showed the higher disease incidence for light leaf spot (Table 45) and treatments had relatively little inpact on disease incidence. Flusilazole + carbendazim and tebuconazole were the most effective products.

Table 45. Incidence (% plants) of light leaf spot and phoma leaf spot on 20 May 1996 (GS 3, 5) at Udny Station.

Treatment	Light leaf spot		Phoma leaf spot	
	Bristol	Rocket	Bristol	Rocket
1. nil	63.3	83.3	0.0	3.3
2. flusilazole plus carbendazim 1+1	86.7	50.0	0.0	0.0
3. flusilazole plus carbendazim 1	73.3	23.3	0.0	3.3
4. flusilazole plus carbendazim ½+½	73.3	60.0	0.0	0.0
5. carbendazim 1	76.7	86.7	0.0	0.0
6. carbendazim ½+½	70.0	76.7	0.0	0.0
7. tebuconazole 1	86.7	33.3	0.0	3.3
8. tebuconazole ½+½	83.3	43.3	0.0	3.3
9. difenoconazole 1	73.3	53.3	0.0	0.0
10. difenoconazole ½+½	83.3	66.7	0.0	3.3
Mean	77.0	57.0	0.0	1.7
SED (44 df) Variety	6.25		0.28	
Fungicide	10.46		1.58	
Variety x Fungicide	15.48		2.15	

Table 46. Incidence (% plants) and severity of light leaf spot on pods (% area), 23 July 1996 (GS 6,3) at Udny Station

Treatment	% Area		% Plants	
	Bristol	Rocket	Bristol	Rocket
1. nil	1.8	2.1	86.7	93.3
2. flusilazole plus carbendazim 1+1	1.9	1.1	90.0	90.0
3. flusilazole plus carbendazim 1	2.4	1.8	100.0	93.3
4. flusilazole plus carbendazim ½+½	1.7	1.4	93.3	90.0
5. carbendazim 1	1.4	1.4	93.3	86.7
6. carbendazim ½+½	2.0	1.1	86.7	76.7
7. tebuconazole 1	1.0	2.3	96.7	96.7
8. tebuconazole ½+½	2.2	2.2	100.0	96.7
9. difenoconazole 1	1.8	2.8	93.3	100.0
10. difenoconazole ½+½	1.8	2.1	80.0	100.0
Mean	1.9	1.8	92.0	92.3
SED (44 df) Variety	0.12		4.17	
Fungicide	0.32		7.00	
Variety x Fungicide	0.45		10.36	

None of the treatments had a significant effect on the levels of light leaf spot on the pods (Table 46).

Table 47 Incidence and severity of light leaf spot on stems (% area), 23 July 1996 (GS 6,3) at Udny Station

Treatment	% Area		% Plants	
	Bristol	Rocket	Bristol	Rocket
1. nil	1.0	1.7	56.7	73.3
2. flusilazole plus carbendazim 1+1	1.4	0.6	83.3	46.7
3. flusilazole plus carbendazim 1	2.7	0.4	90.0	33.3
4. flusilazole plus carbendazim ½+½	2.7	0.9	86.7	63.3
5. carbendazim 1	1.3	1.9	70.0	86.7
6. carbendazim ½+½	1.7	0.9	83.3	63.3
7. tebuconazole 1	2.2	1.1	76.7	66.7
8. tebuconazole ½+½	2.4	1.0	86.7	56.7
9. difenoconazole 1	2.3	1.4	80.0	73.3
10. difenoconazole ½+½	1.0	1.4	56.7	70.0
Mean	1.9	1.1	77.0	63.3
SED (44 df) Variety	0.36		9.25	
Fungicide	0.46		12.35	
Variety x Fungicide	0.72		19.11	

There were treatment differences (P = 0.05) in light leaf spot severity on stems (Table 47), but not for disease incidence data. However, results are complicated by loss of plants in the untreated control of Bristol, which had lower disease than treated plots. These effects did not apply to Rocket and results on this cultivar probably reflect disease control potential rather better than Bristol.

Table 48. Incidence (% pods) and severity of *Botrytis* on pods (% area), 23 July 1996 (GS 6,3) at Udny Station

Treatment	% Area		% Plants	
	Bristol	Rocket	Bristol	Rocket
1. nil	0.00	0.00	0.0	0.0
2. flusilazole plus carbendazim 1+1	0.00	0.10	0.0	10.0
3. flusilazole plus carbendazim 1	0.27	0.03	13.3	3.3
4. flusilazole plus carbendazim ½+½	0.00	0.03	0.0	3.3
5. carbendazim 1	0.03	0.00	0.0	0.0
6. carbendazim ½+½	0.00	0.00	3.3	0.0
7. tebuconazole 1	0.00	0.00	0.0	0.0
8. tebuconazole ½+½	0.10	0.07	3.3	3.3
9. difenoconazole 1	0.00	0.00	0.0	0.0
10. difenoconazole ½+½	0.00	0.00	0.0	0.0
Mean	0.04	0.02	2.0	2.0
SED (44 df) Variety	0.042		3.13	
Fungicide	0.069		4.17	
Variety x Fungicide	0.102		6.46	

There was a low incidence of botrytis pod rot but no treatment differences (Table 48).

Crop height and internode length

Kingston

No differences in crop height were detected and no measurments were made in 1996.

Otley

There was some unevenness of the crop caused by competition with volunteer barley and in the absence of obvious treatment differences, no height measurments were made.

Darrington

Nickel was slightly taller than Bristol, at the end of flowering (17 June). Single sprays of flusilazole plus carbendazim increased crop height in Bristol. The split dose of tebuconazole reduced crop height slightly in Bristol (Table 49) but not in Nickel.

Table 49. Crop height and internode length (cm) 17 June 1996 at Darrington

Treatment	Crop height (cm)		Internode length (cm)	
	Bristol	Nickel	Bristol	Nickel
1. nil	127.6	133.3	11.9	10.6
2. flusilazole plus carbendazim 1+1	138.2	131.5	12.2	10.8
3. flusilazole plus carbendazim 1	138.2	140.1	11.8	10.5
4. flusilazole plus carbendazim ½+½	130.4	137.6	11.5	10.9
5. carbendazim 1	139.4	138.6	11.8	11.0
6. carbendazim ½+½	132.9	134.3	12.0	10.7
7. tebuconazole 1	134.0	135.5	11.4	11.2
8. tebuconazole ½+½	119.1	133.8	10.3	11.5
9. difenoconazole 1	132.8	137.9	11.9	11.3
10. difenoconazole ½+½	133.5	134.7	12.1	11.0
Mean	132.6	135.7	11.7	10.0
SED (36 df) Variety	1.77		0.07	
Fungicide	3.21		0.32	
Variety x Fungicide	4.54		0.46	

These were significant differences between varieties and in variety x fungicide interactions for internode length ($\underline{P} = 0.01$). The largest effect came from the split dose of tebuconazole on Bristol which reduced internode length from 11.9cm in treated to 10.3 cm (Table 49).

Udny Station

Both variety and fungicide affected plant cover (%) on 20 May and low cover was attributed to light leaf spot causing plant and foliage loss. The control and carbendazim treated plots of Bristol were most severely affected and there were large differences between Bristol and Rocket (Table 50). Prior to harvest, plant height records revealed varietal differences only (Table 50). The split dose of tebuconazole gave shorter plants than the full dose in the autumn on both cultivars, but other treatments gave no consistent effects. On 15 August, lodging affected 32% of Rocket and 50% of Bristol and varietal differences appeared to be the main factor. Most lodging was recorded in plots of Bristol treated with carbendazim which showed 67% plants affected compared with 30% in Rocket for the same fungicide.

Table 50. Plant cover (%) on 20 May 1996 (GS 3,5) and crop height (cm), 1 August 1996 (GS 6.4) at Udny Station

Treatment	% cover		Height	
	Bristol	Rocket	Bristol	Rocket
1. nil	26.0	87.7	101.0	113.5
2. flusilazole plus carbendazim 1+1	68.3	95.0	105.5	113.0
3. flusilazole plus carbendazim 1	64.3	95.3	104.7	117.4
4. flusilazole plus carbendazim ½+½	27.7	94.3	104.5	118.9
5. carbendazim 1	15.0	90.3	96.3	120.7
6. carbendazim ½+½	30.0	90.7	99.6	112.2
7. tebuconazole 1	61.0	96.0	107.0	120.8
8. tebuconazole ½+½	38.3	95.3	96.7	110.5
9. difenoconazole 1	41.0	97.7	88.3	122.5
10. difenoconazole ½+½	35.0	91.7	97.6	108.4
Mean	40.7	93.4	100.1	115.8
SED (44 df) Variety	6.29		2.96	
Fungicide	7.16		4.46	
Variety x Fungicide	11.55		6.72	

Light leaf spot control

Comparison of product efficacy against light leaf spot at various stages is also illustrated using selected results.

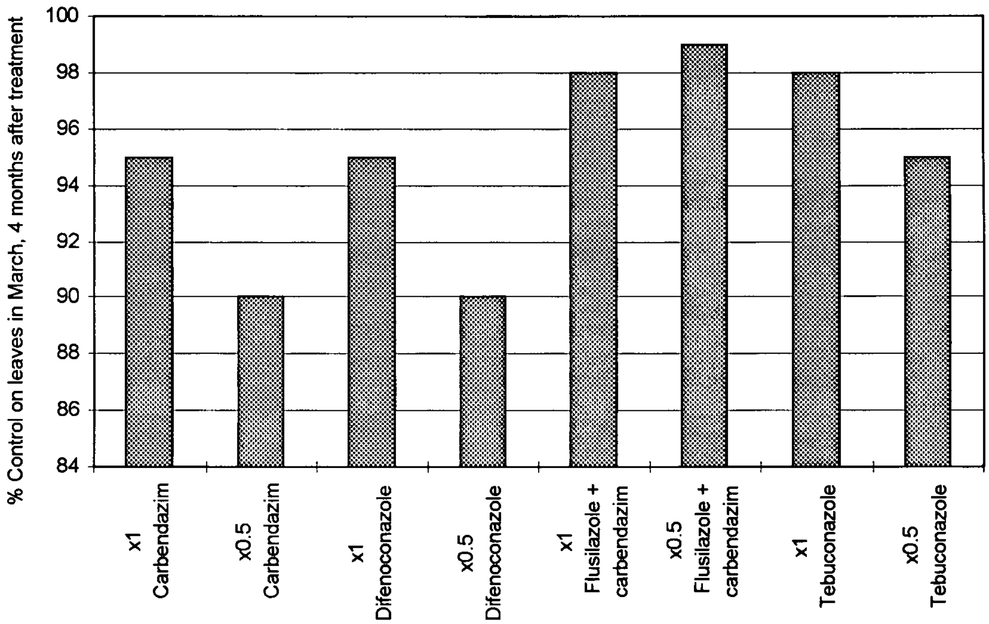

Fig. 1 Control of light leaf spot on leaves under low disease pressure, Kingston, 1996

Control of light leaf spot was maintained by all treatments over the winter period,with both full and half dose rates providing at least 90% control under low disease pressure at Kingston (Fig. 1). By June, flusilazole + carbendazim and tebuconazole were providing rather better control on stems, (still about 90%) than difenoconazole and carbendazim (Fig. 2).

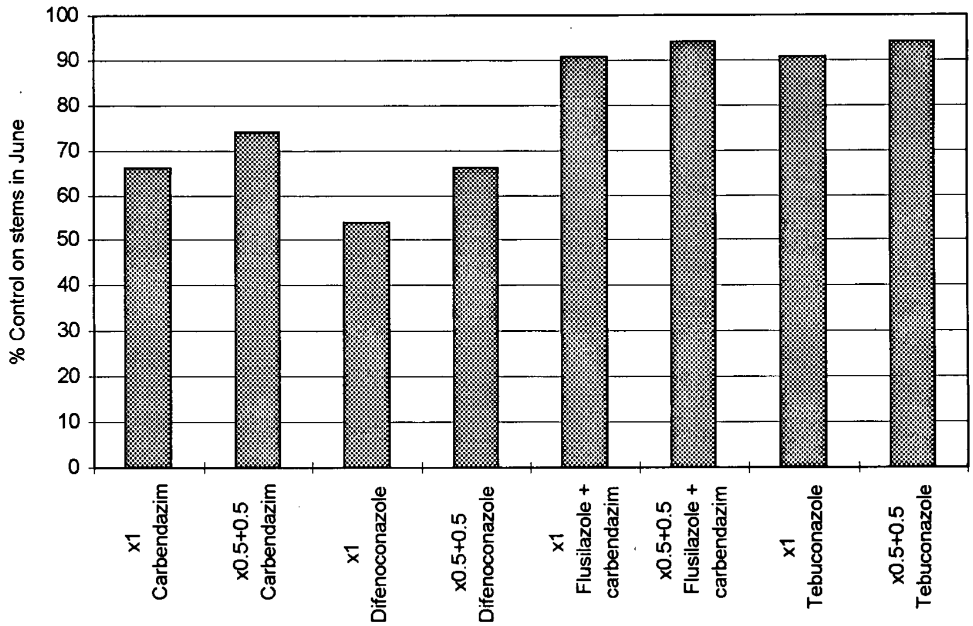

Fig. 2 Control of light leaf spot on stems in June following autumn and spring spray treatments, Kingston, 1996.

At Udny Station, treatments were evaluated against severe autumn and winter infection. Carbendazim aggravated the light leaf spot at full dose and gave poor control at half dose. Dose rate effects were also apparent for difenoconazole which at full dose was only marginally less effective than flusilazole + carbendazim and tebuconazole (Fig. 3).

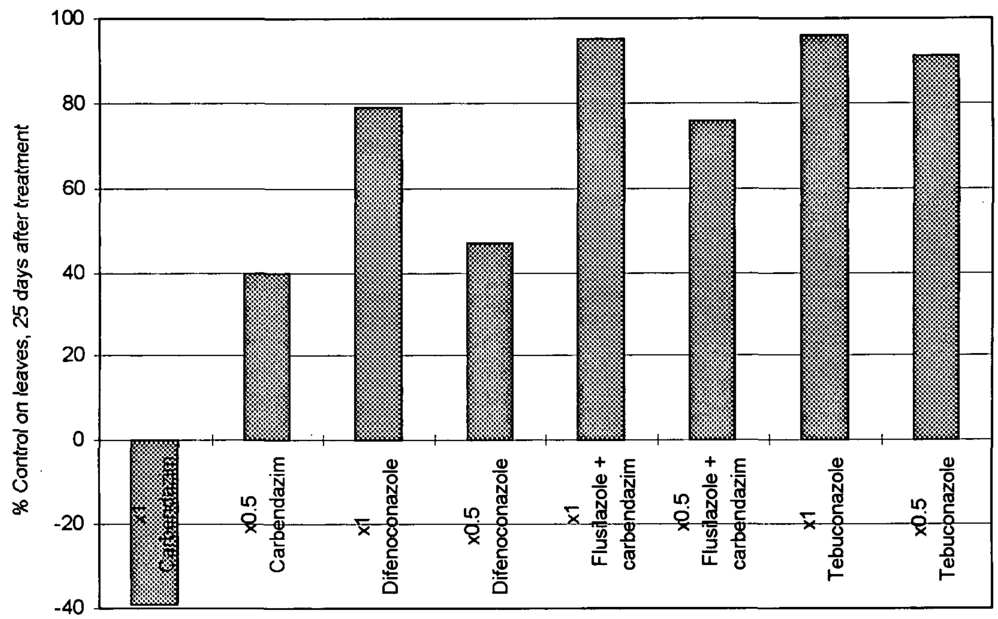

Fig. 3 Control of light leaf spot on leaves under severe disease pressure, 25 days after treatment, Udny Station, 1995/96

The effects of winter kill due to a combination of cold weather and light leaf spot infection was clearly shown on Bristol (the 10 lowest yielding points on Figure 4). In this case, light leaf spot caused up to 75% loss of yield. Where plants (ground cover) was not present pre-flowering, yield was lost.

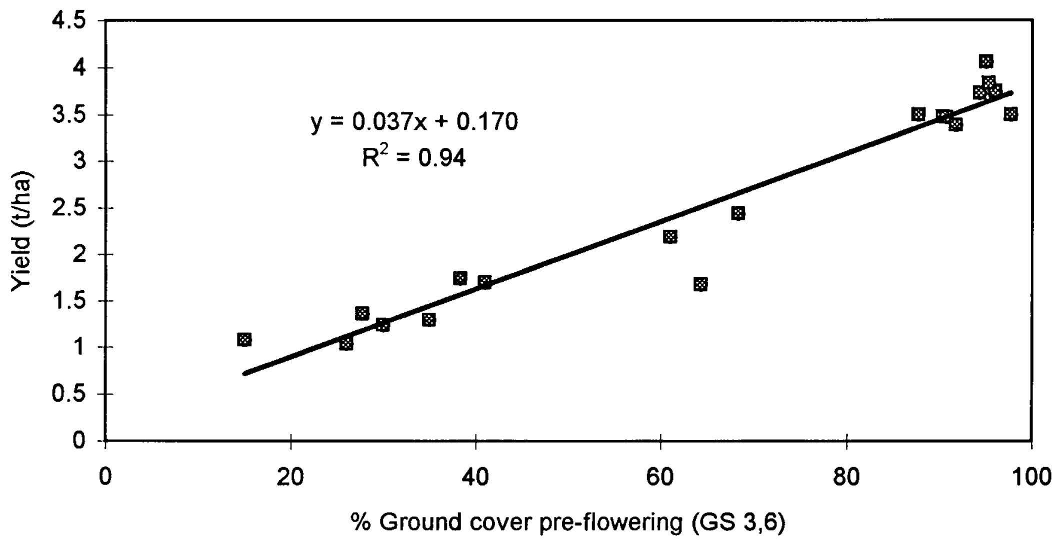

Fig. 4 Relationship between ground cover pre-flowering and yield with severe light leaf spot infection, Udny Station, 1996

1996/97

Kingston

The crop was sown on 13 September and emerged slowly in dry conditions. Bristol had weaker plants and 11 per metre row row compared with 17 per metre row for Nickel on 23 October. Autumn sprays were slightly delayed until 26 November (GS 1,5) due to lack of growth and disease. White leaf spot affected up to 0.04% leaf area on Bristol and 0.02% on Nickel but there was no sign of either light leaf spot or phoma leaf spot when first treatments were applied. During the winter there was some plant loss most noticeably in untreated and carbendazim treated plots of Bristol.

Stem extension sprays were applied on 31 March when white leaf spot affected 6.7% leaf area of Bristol and 8.7% of Nickel. Light leaf spot affected 2% leaf area of Bristol and significant treatment differences were apparent despite most reductions in disease severity (Table 51). White leaf spot was most effectively controlled by flusilazole plus carbendazim and difenoconazole and varietal differences and interactions were also significantly different (Table 51).

Table 51. Leaf area affected (%) with light leaf spot and white leaf spot, 29 March 1997 (GS 3,3) at Kingston

Treatment	Light leaf spot		White leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	2.0	0	6.7	8.7
2. flusilazole plus carbendazim 1 + 1	0.7	0	1.5	0.4
3. flusilazole plus carbendazim 1	0.8	0	0.7	0.2
4. flusilazole plus carbendazim ½ + ½	1.7	0	1.5	1.7
5. carbendazim 1	1.7	0	4.0	4.0
6. carbendazim ½ + ½	1.7	0	4.3	6.3
7. tebuconazole 1	1.1	0	3.7	1.0
8. tebuconazole ½ + ½	0.7	0	5.3	3.0
9. difenoconazole 1	2.7	0	0.7	0.3
10. difenoconazole ½ + ½	3.3	0	1.0	0.4
Mean	1.6	0	2.9	2.6
SED(36df)Variety		0.31		0.66
Fungicide		0.34		0.67
Variety x Fungicide		0.54		1.11

Diseases developed further in early April but were subsequently checked by dry, cold weather. Significant differences between fungicides were apparent for both light leaf spot and white leaf spot (Table 52), reinforcing results obtained in March.

Table 52. Leaf area affected (%) with light leaf spot and white leaf spot (8 days after treatment), 8 April 1997 (GS 3,7) at Kingston

Treatment	Light leaf spot		White leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	1.0	0	5.0	6.7
2. flusilazole plus carbendazim 1 + 1	0.3	0	0.8	0.4
3. flusilazole plus carbendazim 1	0.2	0	0.4	0.1
4. flusilazole plus carbendazim ½ + ½	0.8	0	1.1	0.8
5. carbendazim 1	0.7	0	3.0	2.7
6. carbendazim ½ + ½	0.5	0	2.7	4.0
7. tebuconazole 1	0.4	0	2.8	0.6
8. tebuconazole ½ + ½	0.2	0	4.0	1.7
9. difenoconazole 1	1.7	0	0.5	0.2
10. difenoconazole ½ + ½	1.7	0	0.5	0.1
Mean	0.7	0	2.1	1.7
SED(36df)Variety		0.16		0.49
Fungicide		0.13		0.59
Variety x Fungicide		0.25		0.89

All treatments reduced white leaf spot (Table 53) on both varieties and light leaf spot on Bristol on 29 April.

Table 53. Leaf area affected (%) with light leaf spot and white leaf spot 29 April 1997 (GS 4,5) at Kingston

Treatment	Light leaf spot		White leaf spot	
	Bristol	Nickel	Bristol	Nickel
1. nil	4.7	0	2.0	2.7
2. flusilazole plus carbendazim 1 + 1	1.7	0	0.2	0.1
3. flusilazole plus carbendazim 1	1.3	0	0.0	0.0
4. flusilazole plus carbendazim ½ + ½	2.3	0	0.2	0.1
5. carbendazim 1	2.0	0	0.8	0.7
6. carbendazim ½ + ½	1.7	0	0.7	1.3
7. tebuconazole 1	2.7	0	1.0	0.1
8. tebuconazole ½ + ½	2.7	0	1.5	0.4
9. difenoconazole 1	4.0	0	0.1	0.0
10. difenoconazole ½ + ½	2.7	0	0.0	0.0
Mean	2.6	0	0.7	0.5
SED(36df)Variety	0.23		0.12	
Fungicide	0.17		0.21	
Variety x Fungicide	0.35		0.37	

Control of light leaf spot on stems of Bristol was obtained from all treatments except difenoconazole (Table 54). There was no canker at this site.

Table 54. Light leaf spot on stems (% area), 9 June 1997 (GS 6,1) Kingston

Treatment	Area stems affected (%)	
	Bristol	Nickel
1. nil	8.3	0.2
2. flusilazole plus carbendazim 1 + 1	0.8	0
3. flusilazole plus carbendazim 1	0.8	0
4. flusilazole plus carbendazim ½ + ½	2.0	0
5. carbendazim 1	2.7	0
6. carbendazim ½ + ½	2.7	0
7. tebuconazole 1	2.3	0
8. tebuconazole ½ + ½	1.8	0
9. difenoconazole 1	6.7	0
10. difenoconazole ½ + ½	8.3	0
Mean	3.7	0
SED(36df)Variety		0.61
Fungicide		0.79
Variety x Fungicide		1.13

Plant height

Records of plant height were taken on 19 May (GS 5,9) showed significant differences between varieties, but not between fungicide treatments.

Otley

Table 55. Leaf area (%) infected by Phoma leaf spot on 31 January 1997, Otley

Treatment	Bristol		Nickel	Mean
1. nil	0.77		0.93	0.85
2. flusilazole plus carbendazim 1 + 1	0.67		0.43	0.55
3. flusilazole plus carbendazim 1	0.83		0.67	0.75
4. flusilazole plus carbendazim ½ + ½	0.33		0.63	0.48
5. carbendazim 1	1.03		1.33	1.18
6. carbendazim ½ + ½	0.60		1.17	0.88
7. tebuconazole 1	0.20		0.83	0.52
8. tebuconazole ½ + ½	1.93		2.10	2.02
9. difenoconazole 1	0.83		0.30	0.57
10. difenoconazole ½ + ½	1.10		0.57	0.83
Mean	0.83		0.89	0.86
SED(52df)Variety		0.091		
Fungicide				0.379
Variety x Fungicide		0.549		

Levels of disease were very low in January. Whilst a half dose of tebuconazole appeared to increase the level of disease significantly above the untreated this was probably an artefact of the difficulty in assessing such low levels of the disease as the incidence of phoma leaf spot was similar to the untreated (Table 55).

At the rosette stage, the incidence of phoma leaf spotting was quite high but there were few differences between treatments (Table 56). This was probably due to the time of infection which occurred after the November applications had lost efficacy. There was little sign of the disease at the time of spraying on the 8 November.

Table 56. Incidence (% plants affected) of phoma leaf spot on 31 January 1997, Otley

Treatment	Bristol		Nickel	Mean
1. nil	43.3		40.0	41.7
2. flusilazole plus carbendazim 1 + 1	36.7		30.0	33.3
3. flusilazole plus carbendazim 1	26.7		46.7	36.7
4. flusilazole plus carbendazim ½ + ½	20.0		50.0	35.0
5. carbendazim 1	53.3		59.0	56.2
6. carbendazim ½ + ½	40.0		73.3	56.7
7. tebuconazole 1	13.3		50.0	31.7
8. tebuconazole ½ + ½	43.3		69.3	56.3
9. difenoconazole 1	53.3		13.3	33.3
10. difenoconazole ½ + ½	52.0		36.7	44.3
Mean	41.9		46.3	44.1
SED (52 df)Variety		3.76		
Fungicide				10.51
Variety x Fungicide		14.81		

At the time of spray application on 21 March, untreated Bristol had 2.9% leaf area affected by phoma leaf spot compared with 2.8 % in Nickel. Assessment on 22 April at the onset of flowering showed that Nickel was more prone to phoma leaf spot than Bristol (Table 57). Treatments which included a stem extension application, with the exception of tebuconazole, significantly reduced the amount of phoma leaf spotting.

Table 57. Leaf area affected (%) by phoma leaf spot on 22 April 1997, Otley

Treatment	Bristol		Nickel	Mean
1. nil	1.3		4.8	3.1
2. flusilazole plus carbendazim 1 + 1	0.9		1.9	1.4
3. flusilazole plus carbendazim 1	1.2		4.4	2.8
4. flusilazole plus carbendazim ½ + ½	0.5		1.3	0.9
5. carbendazim 1	2.2		2.4	2.3
6. carbendazim ½ + ½	1.7		1.4	1.6
7. tebuconazole 1	1.8		3.1	2.4
8. tebuconazole ½ + ½	1.9		2.1	2.0
9. difenoconazole 1	3.5		3.1	3.3
10. difenoconazole ½ + ½	0.8		0.4	0.6
Mean	1.4		2.0	1.7
SED (52 df)Variety		0.085		
Fungicide				0.69
Variety x Fungicide		0.94		

At the time of spray application on 21 March untreated plots 77% of Bristol had phoma lesions compared with 63% in Nickel. A split application of difenoconazole applied in March significantly reduced the number of plants affected by the leaf spot stage of the disease (Table 58). This data shows that the autumn applications were no longer effective when the disease appeared in the spring.

Table 58. Incidence of phoma leaf spot (% plants affected) on 22 April 1997, Otley

Treatment	Bristol		Nickel	Mean
1. nil	36.7		83.3	60.0
2. flusilazole plus carbendazim 1 + 1	40.0		50.0	45.0
3. flusilazole plus carbendazim 1	50.0		80.0	65.0
4. flusilazole plus carbendazim ½ + ½	40.0		43.3	41.7
5. carbendazim 1	60.0		73.3	66.7
6. carbendazim ½ + ½	50.0		53.3	51.7
7. tebuconazole 1	60.0		90.0	75.0
8. tebuconazole ½ + ½	53.3		46.7	50.0
9. difenoconazole 1	83.3		80.0	81.7
10. difenoconazole ½ + ½	30.0		30.0	30.0
Mean	46.4		59.0	
SED (52 df)Variety		7.81		
Fungicide				9.60
Variety x Fungicide		15.23		

Cankers were predominantly above the basal leaf scars on the aerial part of the stem, indicating late infection. Split doses of flusilazole + carbendazim, difenoconazole and tebuconazole significantly reduced the canker index as did the autumn and spring full dose of flusilazole + carbendazim although the degree of control was poor (Table 59). The split dose of carbendazim did not reduce the canker index significantly. The autumn applications were not as effective in reducing cankers, this was probably due to the late infection which occurred in December after the efficacy of the early November applications had declined.

Table 59. Phoma stem lesion index, 8 July 1997, Otley

Treatment	Bristol		Nickel	Mean
1. nil	94.2		86.9	90.5
2. flusilazole plus carbendazim 1 + 1	75.0		65.6	70.3
3. flusilazole plus carbendazim 1	74.1		84.5	79.3
4. flusilazole plus carbendazim ½ + ½	73.3		71.0	72.2
5. carbendazim 1	92.5		79.8	86.1
6. carbendazim ½ + ½	85.0		93.6	89.3
7. tebuconazole 1	78.9		95.8	87.3
8. tebuconazole ½ + ½	63.1		71.9	67.5
9. difenoconazole 1	84.2		72.0	78.1
10. difenoconazole ½ + ½	80.6		64.2	72.4
Mean	79.1		79.3	79.2
SED (52 df)Variety		2.36		
Fungicide				8.42
Variety x Fungicide		11.72		

Table 60 Crop height and internode length (mm), 29 July 1997, Otley

Treatment	Plant height (mm)		1st internode		2nd internode		3rd internode		4th internode	
	Bristol	Nickel	Bristol	Nickel	Bristol	Nickel	Bristol	Nickel	Bristol	Nickel
1. nil	2150	2167	930	957	93.3	90.0	86.7	80.0	103.3	76.7
2. flusilazole plus carbendazim 1 + 1	1817	2077	867	917	106.7	110.0	90.0	93.3	83.3	86.7
3. flusilazole plus carbendazim 1	2197	2110	997	813	110.0	66.7	90.0	96.7	80.0	80.0
4. flusilazole plus carbendazim ½ + ½	1967	2077	800	1043	90.0	73.3	60.0	120.0	110.0	73.3
5. carbendazim 1	2180	2087	1087	930	83.3	123.3	93.3	90.0	70.0	93.3
6. carbendazim ½ + ½	1973	2197	893	880	113.3	100.0	83.3	73.3	66.7	83.3
7. tebuconazole 1	1967	1907	890	767	83.3	73.3	120.0	90.0	80.0	90.0
8. tebuconazole ½ + ½	2133	2190	873	950	103.3	100.0	93.3	100.0	106.7	83.3
9. difenoconazole 1	2293	1970	983	587	76.7	93.3	83.3	70.0	96.7	93.3
10. difenoconazole ½ + ½	1910	2140	770	940	70.0	100.0	96.7	83.3	86.7	83.3
Mean	2039	2061	906	862	89.0	89.0	86.4	88.1	83.8	86.7
SED (52 df)Variety	5.22		3.42		0.52		0.28		0.60	
Variety x fungicide	16.24		17.78		2.24		2.13		2.19	
CV (%)	9.5		25.1		31.0		30.8		31.4	

There were no significant differences in yield of seed. Phoma leaf spot came in to the crop late and levels of disease remained low until close to harvest when a high proportion of plants showed moderate to severe stem cankers. These cankers developed late and no early senescence was observed.

There were no significant effects of treatment on plant height or length of internodes (Table 60).

High Mowthorpe

The crop established well. Disease levels were low in November/ December and only built up appreciably during stem extension growth in the spring. On 21 April, light leaf spot was present in all plots of Bristol, and was present at low levels on Rocket. The benefits of a full dose strategy in the autumn were still apparent, particularly for difenoconazole (Table 61)

At pod ripening in July, light leaf spot was present on stems and pods in all plots of Bristol, largely mirroring the levels present on the leaves in April. Only slight infection was noted in Rocket. Control of light leaf spot on stems in June was still effective following autumn full dose or autumn + spring split dose programmes of flusilazole plus carbendazim or tebuconazole. There were limited effects of treatment on light leaf spot on pods and carbendazim as split dose aggravated pod infection. Treatments were variable and inconsistent against phoma stem infections (Table 63) and there were no significant differences.

Table 61. Leaf area affected (%) with light leaf spot and phoma leaf spot, 21 April 1997 at High Mowthorpe

Treatment	Light leaf spot		Phoma	
	Bristol	Nickel	Bristol	Nickel
1. nil	2.25	0	0	0
2. flusilazole plus carbendazim 1+1	0.17	0	0	0
3. flusilazole plus carbendazim 1	0.12	0	0	0
4. flusilazole plus carbendazim ½+½	0.23	0	tr	0
5. carbendazim 1	2.29	tr	0	0
6. carbendazim ½+½	2.61	tr	0	0
7. tebuconazole 1	0.87	0	0	0
8. tebuconazole ½+½	0.35	tr	tr	0
9. difenoconazole 1	0.79	0	tr	tr
10. difenoconazole ½+½	2.15	0	0	tr
Mean	1.18	tr	tr	tr
SED (36 df) Variety	0.194		<0.001	
Fungicide	0.269		0.001	
Variety x Fungicide	0.380		0.003	

Table 62. Pod and stem area affected (%) by light leaf spot at pod ripening, 14 July 1997 at High Mowthorpe

Treatment	Pods		Stems	
	Bristol	Nickel	Bristol	Nickel
1. nil	6.32	0	1.87	tr
2. flusilazole plus carbendazim 1+1	3.72	0	0.28	0
3. flusilazole plus carbendazim 1	7.87	0	0.18	0
4. flusilazole plus carbendazim ½+½	2.73	0	0.08	tr
5. carbendazim 1	8.03	tr	1.82	tr
6. carbendazim ½+½	19.18	0	2.02	tr
7. tebuconazole 1	7.48	0	0.20	0
8. tebuconazole ½+½	4.90	0	0.32	0
9. difenoconazole 1	9.47	0	0.90	tr
10. difenoconazole ½+½	9.52	tr	0.92	0
Mean	7.93	tr	0.86	tr
SED (36 df) Variety	3.199		0.218	
Fungicide	2.558		0.332	
Variety x Fungicide	3.618		0.471	

Table 63. Canker index 14 July 1997 at High Mowthorpe

Treatment	Bristol	Nickel
1. nil	18.8	12.5
2. flusilazole plus carbendazim 1+1	14.6	4.2
3. flusilazole plus carbendazim 1	22.9	14.6
4. flusilazole plus carbendazim ½+½	14.6	20.8
5. carbendazim 1	8.3	14.6
6. carbendazim ½+½	8.3	10.6
7. tebuconazole 1	16.7	22.9
8. tebuconazole ½+½	8.3	16.7
9. difenoconazole 1	14.6	6.2
10. difenoconazole ½+½	4.2	8.3
Mean	13.1	13.1
SED (36 df) Variety	0.63	
Fungicide	5.38	
Variety x Fungicide	7.61	

Table 64. Plant height (cm) at end of flowering at High Mowthorpe, 1997

Treatment	Bristol	Nickel
1. nil	135.4	134.5
2. flusilazole plus carbendazim 1+1	137.9	130.2
3. flusilazole plus carbendazim 1	140.5	134.8
4. flusilazole plus carbendazim ½+½	137.8	136.7
5. carbendazim 1	134.5	134.0
6. carbendazim ½+½	134.1	134.2
7. tebuconazole 1	139.6	127.6
8. tebuconazole ½+½	138.3	136.4
9. difenoconazole 1	139.6	132.0
10. difenoconazole ½+½	139.4	132.6
Mean	137.7	133.2
SED (36 df) Variety	3.89	
Fungicide	2.16	
Variety x Fungicide	3.05	

Although, in the past, plots treated with tebuconazole have shown a difference in plant height, little such effect was observed in this experiment.

Tillycorthie

The trial was sown on 13 August 1996, an ideal time for sowing winter oilseed rape in Aberdeenshire. The weather was dry at the time of sowing and crops went into good seedbeds. After sowing, the weather was mild, with some rainy days, giving the crop the perfect start. Emergence was rapid and even. By the time of the first spray application on 13 November 1996, plants from both varieties were large, with and average 7 - 9 leaves present. The winter and early spring weather was mild but very windy, with some rain. In March/April conditions were dry and there were concerns about moisture stress. There were a few heavy rain showers in late April/early May which relieved moisture stress. On 1 and 2 May, temperatures were above 20 °C, but on the morning of May 6 there were 5 cm of snow on the ground. The plots were only slightly affected by pigeon damage and soon recovered. The crop started to flower in late April, 3-4 weeks earlier than normal. There were some obvious height differences at this time.

Disease development

Many oilseed rape crops were sown before last years oilseed rape was harvested. This was the case on Tillycorthie farm. The trial was approximately 100 metres from last year's trial site. It was predicted light leaf spot levels would be high, but the dry autumn prevented this. Light leaf spot was not present on leaves at the time of the first spray application in November, even after incubation. No further assessments were carried out during the winter but light leaf spot was detected in plots of Bristol adjacent to the trial in late November.

By mid-February light leaf spot was visible in untreated plots of both Bristol and Rocket after incubation. Disease infection reached a maximum in untreated plots of Bristol in April when 100% plants (13.43% area) were affected. Disease development in Rocket was slower and in April had reached 63% plants (4.6% area) affected. By early May disease incidence and severity in both varieties was identical, disease on Bristol having dropped slightly but that on Rocket having increased compared with levels in April. The incidence and severity of light leaf spot on the stems and pods were higher in Bristol than in Rocket.

No phoma leaf spot or canker was recorded. Downy mildew was present at low levels on leaves of both varieties, particularly Rocket, throughout the autumn and spring. Alternaria was present at low levels on leaves in November, particularly on the variety Rocket. Alternaria did not appear again until pod development when again Rocket showed greatest infection. Botrytis was present on stems and pods. Bristol showed higher levels of Botrytis on the stems but Rocket showed higher levels on the pods.

Disease Control

There were significant differences between fungicides but not between the varieties Bristol and Rocket and no significant variety x fungicide interactions in February (Table 65). The main effect was from fungicides and there were significant effects for incidence and severity on 20 February and 14 May particularly when averaged across varieties (Table 66). There were significant effects of fungicide on light leaf spot severity on stems and pods on 23 July(Tables 67 and 68). Good control of light leaf spot was achieved throughout the autumn and spring with the application of tebuconazole and flusilazole plus carbendazim. A half dose of product applied in the autumn and again at stem extension was better than a single full dose application in the autumn. Difenoconazole was less effective, giving significant reduction of light leaf spot severity and incidence (half doses only) in May only (Table 66). Carbendazim gave little or no control of light leaf spot, with disease levels often higher than the untreated. A half dose of tebuconazole or flusilazole plus carbendazim in the autumn and again at stem extension significantly reduced severity of light leaf spot on stems and pods but had no effect on the numbers of plants affected. Two half doses of difenoconazole reduced stem and pod infection but this was not significant. Carbendazim had no effect on light leaf spot on stems and pods.

Downy mildew levels were low and fungicide treatment actually increased infection slightly compared with the control. Fungicide had no effect on levels of botrytis or alternaria.

Table 65. Incidence (% plants) and severity of light leaf spot, 20 February 1997 (GS 1, 10- 1,13) at Tillycorthie

Treatment	% Plants		% Leaf area	
	Bristol	Rocket	Bristol	Rocket
1. nil	56.7	10.0	5.23	0.73
2. flusilazole plus carbendazim 1+1	23.3	3.3	1.37	0.20
3. flusilazole plus carbendazim 1	20.0	0.0	1.43	0.00
4. flusilazole plus carbendazim ½+½	36.7	0.0	3.27	0.00
5. carbendazim 1	56.7	26.7	5.07	4.33
6. carbendazim ½+½	60.0	3.3	6.30	0.33
7. tebuconazole 1	3.3	0.0	0.20	0.00
8. tebuconazole ½+½	40.0	6.7	2.60	0.40
9. difenoconazole 1	46.7	3.3	5.60	0.17
10. difenoconazole ½+½	43.3	0.0	4.53	0.00
Mean	38.7	5.3	3.56	0.62
SED (44 df) Variety	0.93		1.37	
Fungicide	9.09		1.15	
Variety x Fungicide	1.22		2.06	

Table 66. Incidence (% plants) and severity of light leaf spot in relation to fungicide treatment, 20 February 1997 (GS 1,10 -1,13) and 14 May 1997(GS 4,7-4,8) at Tillycorthie

Treatment	% Plants		% Leaf area	
	20 Feb	14 May	20 Feb	14 May
1. nil	33.3	96.7	2.98	8.92
2. flusilazole plus carbendazim 1+1	13.3	8.3	0.78	0.28
3. flusilazole plus carbendazim 1	10.0	80.0	0.72	4.97
4. flusilazole plus carbendazim ½+½	18.3	28.3	1.63	0.83
5. carbendazim 1	41.7	81.7	4.70	5.62
6. carbendazim ½+½	31.7	90.0	3.32	5.62
7. tebuconazole 1	1.7	48.3	0.10	1.88
8. tebuconazole ½+½	23.3	10.0	1.50	0.27
9. difenoconazole 1	25.0	88.3	2.88	5.40
10. difenoconazole ½+½	21.7	70.0	2.27	2.55
Mean	22.0	60.2	2.09	3.63
SED (36 df)				
Fungicide	9.09	8.42	1.15	1.02

Table 67. Incidence of stem infection and area of stems affected (%) with light leaf spot, 23 July 1997 (GS 6,2) at Tillycorthie

Treatment	% plants affected		% stem area affected	
	Bristol	Rocket	Bristol	Rocket
1. nil	100.0	86.7	16.73	2.77
2. flusilazole plus carbendazim 1+1	100.0	76.7	8.90	1.83
3. flusilazole plus carbendazim 1	100.0	90.0	12.13	3.03
4. flusilazole plus carbendazim ½+½	96.7	76.7	9.87	1.47
5. carbendazim 1	100.0	90.0	15.83	2.97
6. carbendazim ½+½	100.0	93.3	14.23	2.80
7. tebuconazole 1	96.7	73.3	6.90	2.43
8. tebuconazole ½+½	100.0	66.7	8.37	1.20
9. difenoconazole 1	100.0	93.3	12.70	3.30
10. difenoconazole ½+½	96.7	86.7	10.70	2.73
Mean	99.0	83.3	11.64	2.45
SED (36 df) Variety	1.45		1.522	
Fungicide	8.43		1.611	
Variety x Fungicide	11.92		2.643	

Table 68. Incidence (% plants) and severity of light leaf spot on pods (% area), 23 July 1997 (GS 6,2) at Tillycorthie

Treatment	% Area		% Plants	
	Bristol	Rocket	Bristol	Rocket
1. nil	23.47	0.83	93.3	30.0
2. flusilazole plus carbendazim 1+1	9.93	0.50	100.0	33.3
3. flusilazole plus carbendazim 1	14.43	0.90	100.0	36.7
4. flusilazole plus carbendazim ½+½	11.87	0.13	90.0	10.0
5. carbendazim 1	17.43	1.27	96.7	46.7
6. carbendazim ½+½	14.83	0.90	93.3	36.7
7. tebuconazole 1	11.43	0.53	96.7	23.3
8. tebuconazole ½+½	11.40	0.07	93.3	6.7
9. difenoconazole 1	17.67	1.00	100.0	40.0
10. difenoconazole ½+½	12.87	0.63	96.7	26.7
Mean	14.53	0.68	96.0	29.0
SED (36 df) Variety	4.424		2.08	
Fungicide	2.125		7.99	
Variety x Fungicide	5.263		11.29	

DISCUSSION

1994/95 season

Disease

At Trerulefoot, light leaf spot on the leaves reached 19% area affected on Bristol, only trace levels were recorded in Rocket. Carbendazim was ineffective in controlling the disease. Only full doses of the other products were effective in controlling light leaf spot. Canker was not a problem at this site. Disease levels were low at the Stonham site, light leaf spot reaching only 4.6% leaf area affected and canker at only 0.2% on leaves. All treatments, except carbendazim, reduced disease levels. Canker levels on stems were moderate, but treatments had little effect on its severity. At Darrington, disease levels were low, with light leaf spot only affecting 6.9% area of stems. Again there was an indication that carbendazim was not controlling light leaf spot. Full doses of fungicides applied in the autumn were more effective in controlling canker than split-half doses. At Tillycorthie, canker was absent. Light leaf spot did not reach high levels, but carbendazim was ineffective in providing disease control. In contrast to the sites at Stonham and Darrington the full dose in the autumn gave better control of light leaf spot.

In summary, across all sites carbendazim was not effective in controlling either canker or light leaf spot. With regard to fungicide dose, where disease pressure was high, such as Trerulefoot and Tillycorthie, the full dose was required to provide adequate disease control. Split doses worked under low disease pressure, when applied in either the autumn or spring. With reference to canker, a split dose was less effective than a full dose application in the autumn. Flusilazole plus carbendazim gave better control of light leaf spot than the other fungicides. Flusilazole plus carbendazim and difenoconazole gave better control of canker. However, the results from the carbendazim treatment suggests that the mbc component in the flusilazole plus carbendazim is not making a contribution to disease control.

The different responses to disease control of dose in the two diseases have important implications for a combined control strategy in decision support systems, and underline the importance of developing a reliable method of forecasting risk for the two diseases.

The results also underline the importance of cultivar resistance in the control of the two diseases.

Crop height

Rocket was taller than Bristol at Trerulefoot and Darrington, but shorter at Stonham and Tillycorthie. The effects of treatments were inconsistent, but flusilazole plus carbendazim tended to increase crop height at all sites. At the Trerulefoot site, there was there a reduction in height from tebuconazole in both cultivars. Height reduction in the absence of significant disease levels was a feature of tebuconazole at some other sites in 1995 (Gladders, unpublished data), confirming the conazole group of fungicides' propensity for producing growth regulatory effects.

Yield

The untreated yield of Rocket was higher than Bristol at all sites except Stonham, demonstrating the better performance of resistant cultivars in the presence of disease. This was also repeated in fungicide treated plots as Rocket out-yielded Bristol at the same three sites. Despite low levels of disease in Rocket it was still responsive to fungicide treatment, producing higher yields at all sites. Carbendazim also produced yield responses at the English sites, particularly at the full dose in the autumn, but yield responses were not obtained from the carbendazim treatments in Scotland.

In general, across all sites and cultivars, carbendazim was not effective in controlling disease and producing a positive yield response. There was little to choose between the performance of the other fungicides except that flusilazole plus carbendazim and difenconazole tended to out-yield those plots treated with tebuconazole. The split-dose treatment tended to be slightly better than the full dose in the autumn.

1995/96 season

Kingston

At Kingston, autumn growth was slow and the crop had produced on 4-6 leaves by early December. White leaf spot was the main disease at that stage but it made little progress up to the end of March. Light leaf spot had appeared by stem extension stage and was effectively controlled by full and half dose treatments. Only 16 days after the spring sprays were applied, several treatments gave over 90% control of both white leaf spot (on both varieties) and of light leaf spot on Bristol. There is a suggestion that both light leaf spot and white leaf spot control in April were attributable to the effects of the December sprays as there were no clear differences between single autumn sprays and the autumn + spring split dose treatments. Work with fungicides for phoma control suggest that treatments remain effective for 6-8 weeks under high disease pressure. It is clear that at Kingston December sprays at full dose rate were still providing a high degree of control up to mid-April. Indeed, stem infection was still low in the most effective treatments in June, but split doses were consistently more effective than single autumn doses. This effect carried through to yield in most cases. Carbendazim and difenoconazole were starting to become less effective than flusilazole + carbendazim or tebuconazole in June. Light leaf spot was most prevalent on the stem bases, suggesting spread had occurred from the lower leaves during March/April. The absence of pod infection indicates weather conditions were unfavourable for late season spread as the disease was clearly established in the crop and had potential for late infection. Similarly, white leaf spot development depends on rain splash up the plant during stem extension growth and infection conditions for this disease also seem to have been lacking.

Otley

Both light leaf spot and phoma leaf spot were present at low levels in December, the former most probably arising from stubble debris which was spread over plots post-emergence. Although cold weather favoured light leaf spot development at other inoculated sites in eastern England only traces of infection were present from spring onwards. Phoma leaf spot gave rise to little canker infection at harvest, and canker incidence was well below that seen further west in Cambridgeshire and

Northamptonshire. It had been apparent in the autumn, however, that parts of Suffolk showed much lower phoma incidence, as such areas had such low early autumn rainfall. In the absence of significant disease, this site was particularly high yielding and there was no clear evidence of 'physiological' effects of fungicides on yield.

Darrington

Despite inoculation with rape stubble, diseases remained at low levels throughout the life of the crop. Autumn growth was slow in the dry weather and the crop reached the four leaf stage in late November. There was some late development of light leaf spot on pods and stems but data showed a skewed distribution and it was not possible to draw any conclusions about fungcide activity in July. Light leaf spot severity did not reflect NIAB ratings for the two varieties, in fact stem infection was rather more severe on Nickel. Canker was present at very low levels and although treatments appeared to be having some beneficial effects on Nickel, the two full dose sprays of flusilazole + carbendazim showed the most severe canker infection when averaged over both cultivars. It had been expected that this would have been amongst the most effective treatments and superior to the split half dose regime.

Udny Station

This experiment was sown later than optimum for the area because of wet weather in mid August. Nevertheless, plants established well. Severe frosts,with temperatures falling to -20°C over Christmas, together with early light leaf spot infection lead to severe winter kill in Bristol. Poor ground cover subsequently allowed weeds to become competitive late in the season. Early and severe light leaf spot attacks have reduced populations (and yield) by up to 50% in previous experiments on winter oilseed rape. At this site, yield loss is estimated to be about 3 t/ha by comparison with treated Rocket, which equated to a 75% loss.

The crop had reached the 5-leaf stage on 20 November when the first sprays were applied. Light leaf spot was not apparent in the crop but appeared after incubation of samples. This suggested that a major infection event had occurred about one latent period (*c*. 250 day degrees) prior to 20 November. Treatment evaluation on 15 December is likely to comprise both curative and protectant activity. Carbendazim was notably less effective than other treatments and this may be the result of failure to control MBC resistant strains. Previous experiments, however, have suggested that MBC products perform best when used as 'protectants'. Dose rate effects with poorer control at half rates than full rate were apparent in December (4 weeks after treatments) on Bristol but not on Rocket.

Light leaf spot declined to less than 1% leaf area affected in March but had increased again by May. In March, there were conspicuous effects on plant colour and vigour with a mosaic of plots with green and yellow plants. Untreated and carbendazim treated plots of Bristol could be readily distinguished by their lack of plants, yellowing of foliage and stunting. Some treated plots of Bristol were visually more vigorous but all were less vigorous than Rocket. These effects were reflected in final yield. A linear regression analysis using mean yield for all treatments on both cultivars showed a highly significant relationship ($P < 0.001$) between yield and percentage ground cover pre-flowering. Even the highest dose of fungicide used could not provide good control of light leaf spot and standard split dose programmes allowed up to 20% of lost yield to be recovered. Clearly, alternative strategies based on three or four applications of fungicide might well be required to compensate for inferior disease resistance. The timing of the first spray may well have been too late to prevent some crop damage and hence yield loss. These deficiencies are being addressed in an on-going HGCA-funded project on light leaf spot forecasting.

Crops were slow to grow away in the spring and were up to 4 weeks later than normal. The benefits of autumn sprays appeared to persist up to 20 May assessments (only 6 days after the spring sprays) particularly on Rocket. The sparse plant populations in control and some treated plots of Bristol (< one plant/m^2 in some cases) modified the pattern of disease development so that disease severity was lower in untreated than treated plots. Leaf infection was assessed again on 23 July and this highlighted good activity from fluzilazole + carbendazim and tebuconazole on Rocket, but not on Bristol. The low disease in carbendazim treated Bristol is a reflection of the lower plant population than in other fungicide treatments.

Treatments generally increased the height of Rocket apart from the split applications of tebuconazole but differences were much smaller on Bristol.

Light leaf spot developed to a limited extent on stems and pods late in the season. Crops spread slowly and there was rather lodging in Bristol than Rocket. The trial was swathed in mid August but harvesting was delayed longer than usual by wet weather. The impact of light leaf spot on a susceptible variety is clearly shown at this site where untreated Bristol yielded 1.04 t/ha compared with 3.50 t/ha for untreated Rocket.

1996/97 season

Kingston

Light leaf spot was evident by late March but was still able to reduce yield by about 0.7 t/ha as judged from the yield response to the split dose of flusilazole plus carbendazim. Under these conditions, the autumn spray at full dose would appear to have lacked persistence from yield responses but it clearly still reduced stem lesions in June. White leaf spot may occasionally affect yield but useful control was provided by all treatments. Decisions on white leaf spot control need to be refined to take account of its limited ability to move up the plant by splash dispersal in the spring. If highly susceptible varieties are screened out in early trials with varieties, this disease should remain a minor problem. The lack of yield response to carbendazim at this contrasts with positive responses in previous experiments in the south west. It provides useful evidence for the unpredictable nature of responses to these fungicides, which are now most valued for sclerotinia control.

Otley

Disease levels were low mainly due to low rainfall and this resulted in no significant yield responses to fungicide programmes.

Significant rainfall to trigger the release of spores did not occur until mid to late November. Assessments of disease at the time of autumn application on 8 November showed no trace of the disease. However, with wet conditions soon after application good protection should have been achieved, as the fungicides are only active as protectants. Levels of disease were so low that even by 31 January the untreated plots had only modest levels of infection.

By mid-March levels of phoma had developed but there was still no sign of light leaf spot. With two thirds of untreated plants showing symptoms there were significant reductions as a result of treatment.

Had the level of disease observed in April (Table 57) occurred in January (Table 55) then a considerable yield reduction could have been expected. The relatively late infection, in common with the previous two seasons, meant that whilst cankers had formed, their effect was reduced because by the time they were capable of restricting crop development the plants were senescing naturally.

March applications of difenoconazole at 0.25l/ha reduced disease levels significantly. Cankers appeared after flowering and flusilazole + carbendazim at 0.8l or 0.4l , tebuconazole and difenoconazole all reduced the disease index, the time of infection resulted in yield responses being small and not significant.

It was noted that the cankers tended to form higher up the stem rather than at the base which is explained by the late infection period when the stem was beginning to extend. Fungicide applications had no effect on crop architecture.

Assessing the risk from phoma infection needs to start in the autumn soon after drilling. Dry autumns similar to the previous two years are not conducive to disease attack. Consequently applications of fungicide applied routinely in October have often lost their potency by the time of disease infection. In 1997, this was the case even later as the applications in early November were not effective. Yield loss from phoma declines if the disease does not infect early in the autumn (ADAS, unpublished data). In these situations, a single fungicide application applied when the disease does become apparent even when this is not until the spring may be more cost effective. This would also target light leaf spot which tends to move up the plant during stem extension.

High Mowthorpe

There were responses of up to 0.93 t/ha on Bristol with good responses to all the flusilazole plus carbendazim treatments. This suggests some flexibility in timing, although tebuconazole performed rather better as a split programme than as a single autumn spray. Light leaf spot was not particularly severe in the spring, but plants did show extensive pod infection following a wet June. Treatments gave rather poor control of pod symptoms and in this case a late spray may have produced an additional yield response. A visual assessment of the colour of the plots at ripening agreed well with final yield.

Table 70. Average scores for plot colour at ripening (1 = green, 5 = completely brown) at High Mowthorpe, 1997

Treatment	Colour score
1.	4.7
2.	3.2
3.	3.3
4.	3.7
5.	4.2
6.	4.0
7.	3.3
8.	3.8
9.	3.3
10.	3.3

Tillycorthie

The development of light leaf spot and its subsequent control with the application of two half doses of tebuconazole and flusilazole plus carbendazim in the autumn and spring had no effect on yield. This was a pattern that was repeated throughout the north-east of Scotland. Crops, which in June appeared to have a high yield potential, were disappointing and yielded less than normal. The work provided further evidence that control of light leaf spot throughout the season is not always converted to yield benefits. The work provided evidence that triazole products differed in their efficacy, with the new product difenoconazole being less effective than the standard products of tebuconazole and flusilazole plus carbendazim. The work also showed that in Scotland, MBC fungicides are ineffective against light leaf spot.

General Discussion

The main disease encountered in these experiments was light leaf spot and this has undoubtedly influenced the overall mean yield responses and margins over fungicide costs. Some caution is therefore needed before extrapolating from these results to situations where phoma is the major cause of yield loss. Some phoma leaf spot and canker did develop but severe basal cankers, which follow early autumn leaf spotting, were not encountered. Interestingly, it was only at two sites in Suffolk that untreated Bristol out-yielded the canker susceptible Rocket and Nickel and these sites had the most phoma and lowest light leaf spot. Different priorities for resistance may therefore needed to be considered in different parts of the UK. This contrasted with Aberdeen in 1995/96, where severe light leaf spot caused extensive death of plants in a hard winter and was estimated to have reduced the yield of Bristol by 3 t/ha (75%). This is one of the most severe attacks ever encountered experimentally.

A feature of the experiment at Udny Station in 1995/96 was the failure to restore yield of Bristol to the level of that of Nickel even with two full doses of fungicide. The current project had selected treatments timings largely on a calendar basis and there is scope to refine timing in relation to disease development or the onset of epidemics. The most profitable treatment was flusilazole plus carbendazim applied at full dose in the autumn. This mean result obscures the reliable performance of split dose flusilazole plus carbendazim at many sites. Indeed, when averaged over both variety types, the full dose in autumn yielded 3.77 t/ha and split dose 3.76 t/ha. The two full doses represents twice the current legal maximum, but gives some guide to yield which might be recovered with optimised timing of low doses. The slightly higher yields obtained with the extra full dose treatment (0.17 t/ha) were not cost-effective, but dose represent yield which might be achieved with improved targetting of treatments.

These experiments have identified useful differences in disease control efficacy. Flusiazole plus carbendazim and tebuconazole gave the most effective control of light leaf spot. Observations on phoma, together with recent MAFF-funded experiments (ADAS unpublished data) indicate that flusilazole plus carbendazim and difenoconazole are the most active fungicides. However, all materials have limited curative activity once phoma leaf spotting is established on the plant. All the fungicides controlled white leaf spot with flusilazole + carbendazim and difenoconazole showing very good activity.

Carbendazim treatment did produce some yield responses in England notably on Bristol in the north and the south west, but produced little or no effect in Scotland. It is probable that MBC-resistant strains of light leaf spot were present at the sites in Scotland and thEse were not controlled by carbendazim. Overall 18 out 48 carbendazim treatments gave lower yields (mathematically) than the untreated. These fungicides still have a useful role against sclerotinia stem rot in particular, but the benefits of using them during the autumn and winter is likely to be unpredictable and generally small.

There were effects of fungicides on plant growth. Tebuconazole reduced plant height in the period between stem extension and flowering, but differences after flowering were often not apparent. Conversely, other fungicides increased plant height compared with the untreated control, reflecting improved crop vigour where light leaf spot was controlled. Fungicides may have direct physiological effects on the plant which contribute to yield response and quantitification of some of these effects form part of on-going HGCA-funded work on the physiology of oilseed rape (J Spink, pers. comm.).

The challenge remains to identify sites and seasons where there is a high risk of yield loss. A table which relates risk of yield loss (or yield responses to fungicides) to disease pressure and cultivar susceptibility/resistance provides a useful framework for decision making. Local experience augmented by disease forecasts will enable disease pressure to be estimated at the county or even farm level. Disease resistance ratings are available from NIAB and these will provide a means of identifying crops (varieties) at risk and an economic basis for fungicide treatment.

Table 71. Matrix showing risk of yield loss (√√ = high, √ = moderate, 0 = low) in relation to cultivar resistance and disease pressure.

Disease pressure	Disease resistance rating		
	Susceptible	Moderately resistant	Resistant
High	√√	√	√
Moderate	√	√	0
Low	√	0	0

High disease pressure and susceptible variety combinations were exemplified by light leaf spot epidemics on Bristol in Scotland in 1995/96 (> 1t/ha). Low light leaf spot pressure in Suffolk in 1995/96 gave negligible crop infection and no yield responses on Bristol (Table 6). A resistant variety under high disease pressure may show some response to fungicides as indicated by light leaf spot on Rocket in Scotland in 1995/96 (responses -0.03-0.56 t/ha) depending on fungicides used.

Arguably, the pressure from phoma was low to moderate in this project and with moderate susceptibility, yield responses were rarely more than 0.5 t/ha. None of the sites would be considered as being subject to high disease pressure from canker.

Given the poor average margins over fungicide costs in these experiments (Table 8), it is clear that improved targeting of fungicides to high risk situations is urgently required. Recent developments in forecasting light leaf spot and other diseases will greatly aid this process. In addition, the development of variation with improved disease resistance should assist the development of integrated disease control. In these experiments, the superior resistance of Rocket/Nickel to light leaf spot averaged 0.53 t/ha yield or £79/ha across all treatments. Untreated Nickel/Rocket (3.82 t/ha) gave higher yields than the highest yielding fungicide treatment on cv. Bristol (3.71 t/ha).

The results of this project contribute substantially to our understanding and use of cultivar resistance and fungicide selection for light leaf spot control. More detailed investigation of spray timing is in progress in MAFF- and HGCA-funded projects on canker and light leaf spot respectively. Recent MAFF work has indicated the importance of using fungicides early in the development of phoma leaf spot epidemics (Gladders, 1998) and the industry has responded by making greater use of autumn sprays. There are large seasonal variations in the onset of disease epidemics and frequent monitoring is essential if recent problems with spray timing are to be overcome (Gladders, 1998). At the farm level, application of this knowledge should lead to improved yields and gross margins in winter oilseed rape.

Major Conclusions

- There were significant benefits (up to £79/ha) from using varieties with good resistance to light leaf spot compared with using a highly susceptible cultivar

- Varieties with good resistance to light leaf spot (Nickel/Rocket) gave higher yields without fungicide than a susceptible variety (Bristol) with fungicide treatment.

- Average yield benefits from fungicide use at 11 sites were small and the best treatment gave a margin of £32/ha over fungicide costs.

- There are major differences between sites, seasons and varieties in disease control requirements. Many fungicide treatments were not cost-effective and treatments should be targeted to crops with a high risk of yield loss >0.3 t/ha.

- Differences in product efficacy were identified for
    - light leaf spot
    - phoma leaf spot
    - white leaf spot

- A split dose approach using half-dose treatments in autumn and spring gave consistent results for disease control and yield response. A full dose treatment in autumn may be appropriate where high disease pressure occurs in the autumn

- Single sprays gave long lasting control of light leaf spot at some sites in England and may be the most cost-effective option under low to moderate disease pressure.

- Carbendazim gave variable results for disease control and yield response and performed poorly in Scotland where MBC resistance is present in the light leaf spot pathogen.

- Further development of disease forecasting schemes and risk assessment is required to determine whether fungicidal control is necessary and if so, to improve timing.

- The development of cultivars with improved disease resistance offers substantial savings on fungicide costs. A simple scheme to integrate disease pressure and cultivar resistance is outlined to guide decision making on farms.

Priority areas for future research

The development of varieties with improved disease resistance should be strongly encouraged.

Optimisation of fungicide use through understanding of timing and dose rate in relation to crop disease development.

Disease forecasting for light leaf spot, phoma canker and sclerotinia stem rot are major priorities as these diseases show major variation in severity between years and between crops.

Integration of control measures with genetic resistance and refinement of disease-yield loss relationships for the major cultivars.

Development and validation of a decision support system for diseases of oilseed rape.

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APPENDIX I

SITE AND TREATMENT DETAILS

1994/95

Site	Trerulefoot	Stonham	Darrington	Tillycorthie
Soil texture	Sandy clay loam	Sandy clay loam	Sandy silty clay loam	Silty clay loam
Soil analysis				
pH	-	7.8	8.0	5.9
P	-	31	56	8.6
K	-	165	245	179
Mg	-	64	438	246
Fertiliser	133 kg/ha N	290 kg/ha Sulphur 40 kg/ha 11 Mar 1995	Not known	180 kg/ha N Thiovit 10 kg/ha 5 Apr 1995
Previous cropping				
1993	Winter barley	Set-aside	Set-aside	Set-aside
1992	Winter barley	Winter wheat	Winter wheat	Winter wheat
1991	Winter oats	Winter wheat	Winter wheat	Potatoes
Residue disposal	Removed	Removed	Chopped	Chopped, baled and removed
Cultivations	Ploughed and power harrowed	Ploughed, power harrowed and rolled	Ploughed pressed/power harrowed	Ploughed, power harrowed, rolled after drilling
Sowing date	16 Sep 1994	7 Sep 1994	23 Aug 1994	30 Aug 1994
Seed rate (kg/ha)	7.0	7.5	8.0	6.0
Fungicide application				
autumn	-	24 Nov 1994	24 Nov 1994	16 Nov 1994
spring	4 Apr 1995	4 Apr 1995	21 Mar 1995	10 Apr 1995
Method				
Sprayer	OPS	OPS	OPS	AZO propane
Nozzles	Lurmark F110	Lurmark F110	Lurmark F110	Lurmark F110
Pressure (kPa)	200	250	250	250
Volume (l/ha)	300	200	200	198
Herbicide	Kerb 3 Nov 1994	Treflan and Butisan S 15 Sep 1994	Butisan S 23 Aug 1994	Butisan S 25 Aug 1994
Insecticide	Cypermethrin 14 Apr 1995	Fastac 12 Apr, 3 May 1995	Decis 6 Oct 1994	Nil
Desiccant/swathed	Glyphosate 10 Jul 1995	Swathed 17 Jul 1995	Swathed 5 Jul 1995	Swathed 9 Aug 1995
Harvest	28 Jul 1995	24 Jul 1995	13 Jul 1995	16 Aug 1995

APPENDIX I contd.

SITE AND TREATMENT DETAILS 1995/96

Site	**Kingston**	**Otley**
Soil texture	Stony clay loam	Clay loam (Hanslope)
Soil analysis		
pH	6.8	8.1
P	25.2	11.4
K	101	132
Mg	73	53
OM	3.7%	-
Fertiliser	Seedbed N 40 kg/ha Spring N 241 kg/ha	40 kg/ha N 20 Sept 50 kg/ha N 11 Feb 70 kg/ha N 11 Mar Bitersaltz(magnesium sulphate) 4kg/ha + Solubor 2.5 kg/ha 28 May
Previous cropping		
1995	Winter wheat	Winter barley
1994	Potatoes	Winter wheat
1993	Wheat	Linseed
1992	Winter oats	Winter wheat
Residue disposal	Baled & removed	Baled & removed
Cultivations	Ploughed, pressed and cultivated (x1) drilled and rolled	Disced, packed & rolled 28 & 30 Aug
Sowing date	13 Sept 1995	6 Sep 1995
Seed rate (kg/ha)	7.0	7.0
Fungicide application		
autumn	4 Dec 1995	29 Nov 1995
spring	27 March 1996	17 Apr 1996
Method Sprayer	OPS	OPS
Nozzles	Lurmark F110	Lurmark F110 -03
Pressure	200	200
(kPa)	300	200
Volume (l/ha)		
Herbicide	Butisan (1.5 l/ha) pre-em. Falcon (0.3 l/ha) 2 Nov 1995 + 16 Feb 1996	Butisan S (1.3 l/ha)+ Fusilade (0.375 l/ha) + Agral (0.4 l/ha) 13 Oct
Insecticide		Cyperkill (0.2 l/ha) with herbicide 13 Oct + (0.25 l/ha) 25 April Hallmark (0.15 l/ha) 28 May
Molluscicide		Decoy (3 kg/ha) 15 Sept PBI slug pellets (7 kg/ha) 25 Sept
Desiccant/swathed	Direct combined	Swathed 24 Jul 1996
Harvest	13 + 14 Aug 1996	6 Aug 1996

APPENDIX I contd.

SITE AND TREATMENT DETAILS 1995/96

Site	Darrington	Udny Station
Soil texture	Sandy clay loam	Sandy clay loam
Soil analysis		
pH	8.3	6.2
P	23	
K	110	
Mg	333	
OM (%)	3.04	
Fertiliser	Seedbed - Nil	At sowing NPK 18:90:90 kg/ha 90 kg/ha N + 57 kg S 4 Mar + 5 Apr
Previous cropping		
1995	Winter barley	Winter barley
1994	Winter wheat	Spring barley
1993		Winter wheat
1992		Winter wheat
Residue disposal	Chopped & ploughed	Baled & removed
Cultivations	Ploughed	Ploughed, levelled, power harrowed, rolled and drilled.
Sowing date	14 Sept 1995	28 Aug 1995
Seed rate (kg/ha)	7.0	6.0
Fungicide application		
autumn	20 Nov 1995	20 Nov 1995
spring	30 Apr 1996	4 May 1996
Method		
Sprayer	OPS	AZO propane
Nozzles	Lurmark F110	Lurmark F110
Pressure (kPa)	200	250
Volume (l/ha)	200	198
Herbicide	Pilot (0.1 l/ha) + Fusilade (2 l/ha) 13 Oct	Butisan S (1.5 l/ha) 26 Aug
Insecticide	Decis (0.25 l/ha) with herbicide 13 Oct	Fastac (0.2 l/ha) 2 May
Desiccant/swathed	Swathed mid July	Swathed mid Aug 1996
Harvest	5 Aug 1996	8 Sept 1996

APPENDIX I contd.

SITE AND TREATMENT DETAILS 1996/97

Site	Kingston	Otley
Soil texture		
	Sandy loam	Clay loam (Hanslope)
Soil analysis		
pH	6.9	7.8
P	Index 3	Index 1
K	Index 2	Index 2-
Mg	Index 2	Index 2
OM	4.5%	-
Fertiliser	Seedbed - Spring N 212 kg/ha Sulphur 30 kg/ha	29 kg/ha N 9 Sept 50 kg/ha P 17 Oct 44 kg/ha N 14 Feb 75 kg/ha N 3 Mar 71 kg/ha N 20 Mar
Previous cropping		
1996	Winter wheat	Winter wheat
1995	Winter oats	Sugar beet
1994	Winter wheat	Winter wheat
1993	Winter oats	Winter wheat
Residue disposal	Baled & removed	Baled & removed
Cultivations	Ploughed, pressed and cultivated (x1) drilled and rolled	Ploughed and pressed Power harrowed and rolled
Sowing date	13 Sept 1996	4 Sep 1996
Seed rate (kg/ha)	4.3 Bristol, 5.8 Nickel (120 seeds/m)	5.0
Fungicide application		
autumn	26 Nov 1996	8 Nov 1996
spring	31 March 1997	21 Mar 1997
Method Sprayer	OPS (2m boom)	OPS
Nozzles	Lurmark F110	Lurmark F110 -03
Pressure	260	200
(kPa)	300	200
Volume (l/ha)		
Herbicide	Butisan S(1.4 l/ha) pre-em. Falcon (0.25 l/ha)	Butisan (1.0 l/ha)+ Treflan (2 l/ha) pre-em 8 Sept Laser (0.75 l/ha) 14 Nov Fusilade 250EW (0.25 l/ha) 13 Mar
Insecticide	None	Cyperkill (0.2 l/ha) 24 Sep & 14 Nov Cypermethrin (0.26 l/ha) 2 April Fastac (0.1 l/ha) 1 May
Molluscicide	None	Mini Slug Pellets (6.9 kg/ha) 24 Sept
Fungicide (overall)	None	Carbendazim (0.5 l/ha) 1 May
Desiccant/swathed	Direct combined	Swathed 26 Jul 1997
Harvest	1 Aug 1997	4 Aug 1997

SITE AND TREATMENT DETAILS 1996/97

Site	**High Mowthorpe**	**Tillycorthie**
Soil texture	Sandy clay loam	Sandy clay loam
Soil analysis		N/A
pH	7.6	
P	Index 3	
K	Index 2	
Mg	Index 2	
OM (%)	3.04	
Fertiliser	Seedbed - Nil 26 kg/ha N 14 Oct 49 kg/ha N 3 Mar 146 kg/ha N 20 Mar	At sowing NPK 18:90:90 kg/ha 90 kg/ha N + 57 kg S 3 Mar + 11 Apr
Previous cropping		
1996	Winter barley	Grass
1995	Winter wheat	Grass
1994		Grass
1993		
Residue disposal	Baled & removed	
Cultivations	Ploughed & pressed, Power harrowed & rolled	Ploughed, levelled, power harrowed x2, drilled and rolled.
Sowing date	14 Sept 1995	13 Sept 1996
Seed rate (kg/ha)	6.0 Bristol, 6.9 Rocket	6.0
Fungicide application		
autumn	16 Dec 1996	13 Nov 1996
spring	14 Apr 1997	10 April 1997
Method		
Sprayer	OPS	AZO propane
Nozzles	Lurmark F110	Lurmark F110
Pressure (kPa)	200	250
Volume (l/ha)	200	198
Herbicide	Butisan S (1.5 l/ha) 22 Aug Pilot (250ml/ha) 7 Nov	Butisan S (1.5 l/ha) 21 Aug
Molluscicide		Slug pelllets by hand 11 Sept
Insecticide	Decis (0.5 l/ha) 15 Apr	Fastac (0.2 l/ha) 2 May
Desiccant/swathed	Swathed 23 July 1997	Swathed 18 Aug 1997
Harvest	5 Aug 1997	22 Aug 1997