FINAL REPORT
PROJECT FV77

SPRING GREENS:
CONTROL OF
FOLIAR DISEASES
(ADAS CONTRACT C001/112)

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Contents

Relevance to growers and practical application

Applications

This project had four main objectives (1) to establish optimum fungicide programmes for spring greens (2) to evaluate new fungicides for efficacy against ring spot, light leaf spot and other foliar diseases (3) to monitor MBC resistance in ring spot and light leaf spot in ware brassicas (4) to review foliar disease epidemics over the period 1981-1990.

Fungicide treatments gave yield responses only under moderate to high disease pressure (i.e. foliar disease affecting 5% leaf area) and there were no responses to treatment under low disease pressure (foliar diseases affecting less than 1% leaf area). Phytotoxicity was noted at one site in a spring-planted crop of spring greens with one new (experimental) fungicide.

New efficacy data are available for ring spot, light leaf spot and alternaria control which will assist product selection among currently recommended fungicides. Two new fungicides which are still under development showed excellent disease control properties against ring spot, light leaf spot and alternaria.

MBC resistance to ring spot was confirmed for the first time in Lancashire and additional cases were confirmed in the South West and in Wales. No MBC resistance has been found in Lincolnshire to date. Growers should no longer rely on MBC fungicides alone for disease control and a range of different active ingredients should be used in spray treatments. The review of foliar diseases provided regional and national summaries of the occurrence of white blister, ring spot, light leaf spot, alternaria and downy mildew. Large variations had occurred from year to year and between regions but weather factors were found to be useful in differentiating epidemic and non epidemic years. Greater use should be made of weather data to identify disease prone areas during the growing season.

Summary

This project focused on several aspects of foliar disease control in ware brassicas. Field evaluation of various commercial fungicides, fungicide mixtures and new componunds was undertaken on spring greens where ring spot was the main target disease. Monitoring of resistance to MBC fungicides in the ring spot fungus was undertaken to establish the extent of the problems following the first reports of MBC resistance in ring spot in the South West. Numerous scattered records of brassica diseases over the period 1981-1990 were collected and reviewed in order to identify critical factors which lead to epidemic development.

1. MBC resistance was confirmed in the brassica ring spot fungus in Lancashire for the first time during this project and further cases were confirmed in south west England and Wales. No MBC resistance was found in the ring spot pathogen in Lincolnshire.

2. MBC fungicides alone can no longer be relied upon to provide highly effective control of ring spot in brassicas in England and Wales and growers should diversify fungicide programmes accordingly. MBC fungicides still showed good activity against light leaf spot but diversification of fungicide usage policy is also advisable for this disease.

3. Both chlorothalonil-based products and triadimenol (Bayfidan, Spinnaker) are alternatives to MBC products for ringspot control; triadimenol gave particularly good control on spring greens. Fenpropimorph + carbendazim was also very effective against ring spot.

4. Good control of light leaf spot was demonstrated with a range of fungicides. Benomyl gave rather better control of light leaf spot than of ring spot. This product also accounted for the greater efficacy of benomyl + chlorothalonil mixtures against light leaf spot. Triadimenol and fenpropimorph + carbendazim treatments were very effective against light leaf spot.

5. New fungicides based on tebuconozole and difenconazole are still under development but showed considerable promise for ring spot, light leaf spot and alternaria control.

6. A range of fungicides applied to over-wintered spring greens had no effect on yield in low disease situations. Some disease control was apparent at harvest in April from spray treatments applied up to 4 months previously at low disease (< 1% area affected)sites. Sprays applied close to harvest were critical for good disease control under more severe disease pressure (2-5% area affected) and significantly increased yield.

7. Further studies are needed to identify critical thresholds for disease control. However, low levels of disease (<1% leaf area affected) do not warrant routine fungicide spray treatments as symptoms often remain confined to the oldest leaves. Some treatments appeared to reduce yield in a spring-planted crop with very low disease levels.

8. A review of foliar disease records over the period 1981-1990 was undertaken. This highlighted regional and seasonal differences in disease epidemics.

9. Daily and monthly weather records of temperature and rainfall were considered useful for interpreting epidemic and non- epidemic years at individual sites.

10. Further use of historical data and interpretation in the light of recent fundamental studies should enable risk assessment schemes for ring spot, light leaf spot, alternaria, white blister and possibly powdery mildew to be developed quickly.

Action points for growers

Routine fungicide treatments to spring greens are unlikely to be cost-effective and should be avoided. Yield responses to fungicide treatment were only detected when foliar diseases were moderately severe (>5% leaf area affected). A two-spray programme during the 6-8 week period prior to harvest with a three week harvest interval was needed to maintain disease control up to harvest.

A range of products is available for foliar disease control. Fenpropimorph (Corbel) + carbendazim (Bavistin FL) and triadimenol (Bayfidan/Spinnaker) gave excellent control of ring spot and light leaf spot. Benomyl (Benlate) was more effective against light leaf spot than ring spot but should not be used exclusively on disease control programmes because the presence of MBC resistance strains may limit its effectiveness.

MBC resistance has now been confirmed in the ring spot pathogen in Wales, the South West, and north west England. Although some sensitive strains were still present in these areas, MBC fungicides should not be used on their own. In other areas where sensitive strains predominate (e.g. Lincs), MBC products should also be used cautiously so as to limit selection of resistant strains.

New products are awaiting approval for use on vegetable brassicas. The new active ingredients tebuconazole and difenozonazole showed good activity against light leaf spot, ring spot and alternaria in this project.

Foliar disease have shown marked local, regional and year-to-year variation. A flexible approach to disease control is required, ideally supported by monitoring of local disease risk and forecasting systems.

Practical and financial anticipated benefits

The project has identified areas in south west and north west England and Wales where MBC resistance is present in ring spot pathogen and together with previous HDC-funded studies (FV25), identified effective alternative fungicides. Cautionary advice to other areas, notably Lincolnshire, can be given so that loss of disease control through fungicide resistance problems can be avoided.

Yield responses to fungicide treatment in low disease situations have not been detected. Carefully targeted sprays in response to the presence of significant levels of disease should help reduce unnecessary sprays particularly early in the life of the crop.

Independent efficacy data are available for two new fungicide products, tebuconazole and difenconazole, which will enable growers to select highly effective products and improve disease control on a range of brassica crops in future. Further work is needed to identify control dose rates and timings for these new products on other brassicas (such as brussels sprouts and autumn cabbage) in relation to disease development.

The review of diseases provided indications that meteorological information linked to crop monitoring could be used more strategically to identify years and localities where risk of disease epidemics was high.

It should now be possible to reduce serious losses from foliar disease in spring greens which occur spasmodically in the South West in particular. MAFF Horticultural Statistics estimated spring cabbage to be valued at £18.5 million in 1993/94 and losses by individual growers have been in excess of 25% in recent years. Reduced losses from disease equivalent to only 1% output might be expected from this project and would produce a benefit of £185,000 per annum. There are potential savings in fungicide costs by avoiding unnecessary or ineffective sprays costing £20/ha on 10% of the production area (600 ha) which offer a further saving of £12,000 per annum. Records of MBC resistance and fungicide efficacy will be relevant to other brassica sectors and even minimal improvements in output (0.1%) could produce benefits of £200,000 per annum.

Experimental Section

Introduction

High levels of disease continue to reduce both yield and quality of a wide range of brassica crops. Recent work has concentrated on disease control in brussels sprouts and on cauliflower seedlings during propagation, but there has been little attention paid to cabbage crops. Severe ring spot *(Mycosphaerella brassicicola)* and also light leaf spot (*Pyrenopeziza brassicae*) have caused significant losses in spring greens over-winter in 1990/91 in the south west and cabbage is now identified as a priority area for development of disease control regimes.

The current R & D programme funded by MAFF Pesticide Safety Division is being carried out predominantly at HRI Kirton and HRI Stockbridge House. This programme concentrates on detailed studies of disease development in brassica crops and the timing of fungicides in relation to various infection criteria and disease thresholds. There is no work currently in progress on brassica crops in the southern or western areas of England and Wales where ring spot and light leaf spot are major problems throughout much of the year.

Disease control in field crops remains difficult particularly with regard to ring spot and light leaf spot. Resistance to benomyl has been confirmed in ring spot at sites in Devon and Wales over the last 4 years. This limits options for disease control and may jeopardise the future of other fungicides, because there is a limited range of alternative fungicides available for use on vegetable brassicas. This limits the options which can be used to minimise risks of selecting fungicide resistant strains. The full extent of MBC resistance in ring spot is not known and growers may be using such products with little prospect of achieving control. The monitoring of fungicide resistance in brassica pathogens was funded by MAFF up until 1990 but this funding is no longer available.

Detailed studies of various brassica pathogens are in progress at HRI Wellesbourne and IACR Rothamsted. Seasonal and site variations in disease development and sudden increases in diseases have been noticed at various ADAS trial sites over several years. A review of the effects of weather conditions on disease development would assist identification of critical features which have led to serious natural epidemics. This would enable disparate records of disease development to be collated and establish more clearly what additional field information is required to validate laboratory studies and basic biological studies currently in progress. Current studies on natural epidemics of brassica diseases are supported by MAFF Policy Divisions at sites in eastern England and HRI Wellesbourne, where ring spot is rarely severe. This project is oriented towards ring spot control in high risk areas in south-west and north-west England.

There are 4 primary objectives for this project:

1) To establish optimum fungicide programmes for spring greens.

2) To evaluate newly recommended and novel fungicides with potential for use on spring greens for efficacy against ring spot, light leaf spot and other foliar diseases.

3) To monitor the incidence of MBC resistance in ring spot and light leaf spot in ware brassicas.

4) To review the effect of weather conditions on natural epidemics of ring spot and other diseases in brussels sprouts (completed as a separate report July 1992).

Field experiments **Site and crop details are provided in Appendix I**

Methods

1991/92 Experiment

One experiment was carried out in a commercial crop of spring greens cv. First Early Market in west Cornwall. A second experiment to have been carried out in Lancashire in spring 1992 was rescheduled to autumn 1992. Site and husbandry details are given in Appendix 1.

Table 1. Fungicides, adjuvant, active ingredients (ai) and dose rates in 1991/92.

Fungicide/ adjuvant	ai	Amount ai in product	Dose rates (product/ha)
Bavistin FL	carbendazim	500 g/l	1.0 l
Bayfidan	triadimenol	250 g/l	0.5 l
Benlate	benomyl	500 g/kg	1.1 kg and 0.55 kg
Bravo	chlorothalonil	500 g/l	3.0 l and 1.5 kg
Corbel	fenpropimorph	750 g/l	1.0 l
Maneb	maneb	800 g/kg	1.7 kg
UK 443d	tebuconazole	250 g/l	0.5 l and 0.75 l
Agral	alkyl phenol ethylene oxide	900 g/l	0.3 l

Table 2. Treatments and dose rates in 1991/92.

Fungicide		Dose rate used in trial (product/ha)
1.	Unsprayed control	-
2.	Benlate + Agral	1.1 kg + 0.3 l
3.	Bravo + Agral	3.0 l + 0.3 l
4.	Bravo + Benlate + Agral	3.0 ; + 1.1 kg + 0.3 l
5.	Bayfidan + Agral	0.5 l + 0.3 l
6.	Bravo + Benlate + Agral	1.5 l + 0.55 kg + 0.3 l
7.	Corbel + Bavistin FL	1.0 l + 1.0 l
8.	UK 443 d	0.5 l
9.	UK 443 d	0.75 l
10.	Bravo + Benlate + Agral (2 early sprays)	3.01 + 1.1 kg + 0.3 l
11.	Bravo + Benlate + Agral (2 late sprays)	3.0 l + 1.1 kg + 0.3 l
12.	Maneb + Agral	1.7 kg + 0.3 l

All treatments were applied in 300 l/ha water using an Oxford Precision Sprayer with a 3 m boom fitted with 03-F110 jets operated at 2 bar pressure.

Table 3. Treatment applications in 1991/92.

Spray timing Target: Actual:	Late October 24 October	Late November 20 November	Late December 24 December
Treatment (as Table 2)			
1	-	-	-
2	+	+	+
3	+	+	+
4	+	+	+
5	+	+	+
6	+	+	+
7	+	+	+
8	+	+	+
9	+	+	+
10	+	+	-
11	-	+	+
12	+	+	+

1992/93 Experiments

Experiments were located in over-wintered commercial crops of spring greens cv. Winter Green at Helston Cornwall and cv. Prince Green at Burscough, Lancashire. A second experiment at Burscough, Lancashire was carried on cv. Durham Elf between May-July 1993.

All treatments were applied in 300 l/ha water using an Oxford Precision Sprayer operating at 2 bar pressure fitted with 03-F110 jets (low drift) in Cornwall and F80-03 jets in Lancashire.

Table 4. Fungicides, adjuvant, active ingredients (ai) and dose rate in 1992/93.

Fungicide	ai	Amount of ai in product	Dose rates (product/ha)
Bavistin FL	carbendazim	500 g/l	1.01
Bayfidan	triadimenol	250 g/l	0.51
Benlate	benomyl	500 g/kg	1.1 kg and 0.55 kg
Bravo	chlorothalonil	500 g/l	3.01 and 1.51
Corbel	fenpropimorph	750 g/l	1.01
Maneb	maneb	800 g/kg	1.7 kg
UK 433d	tebuconazole	250 g/l	0.751 and 0.51
Agral	alkyl phenol ethylene oxide	900 g/l	0.31

Table 5. Treatments and dose rates in 1992/93.

	Treatments	Dose rate used in trial (product/ha) for each application	Number of sprays applied
1.	Unsprayed control	-	0
2.	Benlate + Agral	1.1 kg + 0.31	3
3.	Bravo + Agral	3.01 + 0.31	3
4.	Bravo + Benlate + Agral	3.01 + 1.1 kg + 0.31	3
5.	Bayfidan + Agral	0.51 + 0.31	3
6.	Bravo + Benlate + Agral	1.51 + 0.55 + 0.31	3
7.	Corbel + Bavistin FL	1.01 + 1.01	3
8.	UK 443d	0.51	3
9.	UK 443d	0.751	3
10.	Bravo + Benlate + Agral - 2 early sprays	3.01 + 1.1 kg + 0.31	2
11.	Bravo + Benlate + Agral - 2 late sprays	3.01 + 1.1 kg + 0.31	2
12.	Maneb + Agral	1.7 kg + 0.31	3

Table 6a. Treatment applications in 1992/93 - over-wintered crops.

Spray timing:			
Target:	Late October	Late November	Late December
Actual: Cornwall	29 October	8 December	22 December
Lancashire	29 October	28 November	31 December
Treatment			
1	-	-	-
2	+	+	+
3	+	+	+
4	+	+	+
5	+	+	+
6	+	+	+
7	+	+	+
8	+	+	+
9	+	+	+
10	+	+	-
11	-	+	+
12	+	+	+

Table 6b. Treatment applications in 1992/93 - spring crops.

Spray timing:			
Target:	Early June	Mid-June	Late June
Actual:			
Lancashire	7 June	-	22 June
Treatment			
1	-		-
2	+		+
3	+		+
4	+		+
5	+		+
6	+		+
7	+		+
8	+		+
9	+		+
10	+		-
11	-		+
12	+		+

1993/94 Experiments

Two experiments were carried out in 1993/94. These were located in commercial crops of cv. Winter Green at Hayle,Cornwall and cv. Elf at Benington, Lincolnshire. Site and crop details are in Appendix 1.

Table 7. Fungicides, adjuvant, active ingredients (ai) and dose rates in 1993/94.

Fungicide/ adjuvant	ai	Amount of ai in product	Dose rate (product/ha)
A7402G	difenoconazole	250 g/l	0.3 l
Bavistin FL	carbendazim	500 g/l	1.0 l
Bayfidan	triadimenol	250 g/l	0.5 l
Benlate	benomyl	500 g/kg	1.1 kg and 0.55 kg
Bravo	chlorothalonil	500 g/l	3.0 l and 1.5 kg
Corbel	fenpropimorph	750 g/l	1.0 l
Maneb	maneb	800 g/kg	1.7 kg
UK 443d	tebuconazole	250 g/l	0.75 l and 0.5 l
Agral	alkyl phenol ethylene oxide	900 g/l	0.3 l

Table 8. Treatments and dose rates in 1993/94.

	Treatment	Dose rate used in trial (product/ha) for each application
1.	Unsprayed control	-
2.	Benlate + Agral	1.1 kg + 0.3 l
3.	Bravo + Agral	3.0 l + 0.3 l
4.	Bravo + Benlate + Agral	3.0 l + 1.1 kg + 0.3 l
5.	Bayfidan + Agral	0.5 l + 0.3 l
6.	Bravo + Benlate + Agral	1.5 l + 0.55 kg + 0.3 l
7.	Corbel + Bavistin FL	1.0 l + 1.0 l
8.	UK 443 d	0.5 l
9.	UK 443 d	0.75 l
10.	Bravo + Benlate + Agral (2 early sprays)	3.01 + 1.1 kg + 0.3 l
11.	Bravo + Benlate + Agral (2 late sprays)	3.01 + 1.1 kg + 0.3 l
12.	Maneb + Agral	1.7 kg + 0.3 l
13.	A7402G	0.3 l
14.	A7402G (2 late sprays)	0.3 l

Table 9. Treatment applications in 1993/94.

Spray timing:			
Target:	January	February	March
Actual: Cornwall	26 January	16 February	16 March
Lincolnshire	31 January	21 March	11 April
Treatment (see Table 8)			
1	-	-	-
2	+	+	+
3	+	+	+
4	+	+	+
5	+	+	+
6	+	+	+
7	+	+	+
8	+	+	+
9	+	+	+
10	+	+	-
11*	-	+	+
12	+	+	+
13	+	+	+
14	-	+	+

* Single spray on 21 March only at Lincolnshire site

Treatments were applied in 300 litres water/ha by Oxford Precision Sprayer fitted with Teejet XR11003 nozzles operated at 2 bar pressure (Cornwall) or MDM Precision Sprayer with Lurmark 02F 80 nozzles operated at 2 bar pressure.

Disease assessments

Disease assessments were carried out on untreated control plots at each spray date and at harvest on 10 plants per plot. As disease levels were very low, the number of infected leaves per plant was recorded at harvest in Cornwall in 1993. Mean disease severity was recorded as the percentage leaf area affected.

Yield determinations

Yield was assessed as the weight of marketable fraction using 20 heads per plot and expressed in tonnes/ha. Harvest date coincided with that selected by the grower for the surrounding crop.

Statistical analyses

Results were subjected to analysis of variance with treatment means separated using Duncan's Multiple Range Test at the 5% level unless otherwise stated. Disease data were transformed to angles or square roots prior to analysis when percentage data showed a skewed distribution.

Laboratory tests

Isolates of *Mycosphaerella brassicicola* were obtained from surface-sterilised ring spot lesions collected from naturally infected crops. Up to 10 separate isolates per crop were tested for sensitivity to benomyl using 5 mg/l benomyl in potato dextrose agar (PDA) and duplicate agar disks at each concentration. Isolates producing growth at 5 mg/l benomyl after about 21 days at 20°C were classified as resistant and were retested at concentrations of 5, 50 and 500 mg/l benomyl in PDA. Sensitive isolates were retested at concentrations of 0.025, 0.05, 0.10 mg/l benomyl in PDA with higher concentrations as necessary to determine MIC values (MIC - the minimum concentration giving inhibition of mycelial growth).

Results

Field experiments

1991/92 Experiment

Cornwall

Ring spot remained at low levels (<0.1% leaf area affected) throughout the life of the crop and no treatment differences were detected. Differences in plant vigour and yield were not significantly different (Table 10). There were no phytotoxic effects from these treatments.

Table 10. Effect of fungicide treatments on ring spot, vigour and yield of spring greens in Cornwall in 1992.

Treatments (as Table 2)		Dates applied			% Leaf area affected by ring spot on:		Vigour	Yield
		25 Oct	20 Nov	24 Dec	3 Dec	17 Dec	(1-9 Scale) 17 March	(t/ha) 17 March
1.	Control	-	-	-	0.08	0.08	3.5	14.12
2.	Benlate	+	+	+	0.03	0.08	4.3	14.07
3.	Bravo	+	+	+	0.03	0.05	3.8	14.47
4.	Bravo + Benlate	+	+	+	0.03	0.10	3.5	14.52
5.	Bayfidan	+	+	+	0	0.05	3.5	14.12
6.	Bravo + Benlate (½)	+	+	+	0.03	0.08	3.8	13.27
7.	Corbel + Bavistin	+	+	+	0.10	0.05	3.5	13.47
8.	UK 443 d (0.5 l)	+	+	+	0	0.08	3.3	14.39
9.	UK 443 d (0.75 l)	+	+	+	0.03	0.05	3.3	15.32
10.	Bravo + Benlate	+	+	-	0.03	0.08	3.3	13.67
11.	Bravo + Benlate	-	+	+	0	0.10	3.8	13.37
12.	Maneb	+	+	+	0	0.08	3.8	14.54
	SED (33 df)				0.031 NS	0.035 NS	0.37 NS	0.49 NS

* Agral added to treatments 2-6 and 10-12

NS No significant differences

1992/93 Experiments

Table 11 Effect of fungicide treatments on ring spot and yield of spring greens in Cornwall in 1993.

Treatments		Mean number of leaves per plant with ring spot* at harvest	Yield from harvest on 21 April 1993 (t/ha)
1.	Untreated	0.89 c	15.16
2.	Benlate + Agral	0.78 bc	17.21
3.	Bravo + Agral	0.59 abc	17.17
4.	Bravo + Benlate + Agral	0.47 abc	14.35
5.	Bayfidan + Agral	0.35 a	14.51
6.	Bravo + Benlate (half rate) + Agral	0.41 ab	16.46
7.	Corbel + Bavistin FL	0.46 ab	15.40
8.	UK443d (0.5l)	0.30 a	14.38
9.	UK443d (0.75l)	0.32 a	13.80
10.	Bravo+Benlate+Agral (2 early sprays)	0.56 abc	15.48
11.	Bravo+Benlate+Agral (2 late sprays)	0.59 abc	12.50
12.	Maneb + Agral	0.66 abc	14.23
SED	(33 df) (11 df for yield)	0.170	1.589
CV	(%)	45	10.6
Significance Level		5%	NS**

Treatment means followed by the same letter do not differ significantly.

* Disease <2% area affected; all diseased leaves unharvestable because of age.

** NS = no significant differences between treatments means.

Cornwall

Ring spot was present at very low levels during the season despite above average rainfall in the autumn and no other diseases reached recordable levels. At harvest, ring spot was confined to the oldest (non-marketable) leaves. Treatment with UK443d, Bayfidan + Agral , Corbel + Bavistin and Bravo + Benlate (half rate) + Agral had fewer infected leaves than the untreated. In addition, UK443d and Bayfidan + Agral were superior to the Benlate + Agral treatment but not to the other treatments (Table 11). There were no signs of phytotoxicity. Yields were unaffected by treatments in a crop which had very variable plant size (Table 11), following weather damage in February.

Lancashire (over-wintered crop)

Trace amounts of white blister (*Albugo candida*) and downy mildew (*Peronospora parasitica*) were present when the first sprays were applied on 29 October. Subsequently, white blister increased slightly during November before declining during December but there were no treatment differences. The crop remained virtually disease-free during the winter and only low levels of alternaria (*Alternaria brassicae*), downy mildew and ring spot were present at harvest in April (Table 12). UK443d, Corbel + Bavistin and Benlate + Agral gave control of alternaria compared with untreated but UK443d (0.75l rate) and Corbel + Bavistin appeared to aggravate downy mildew. There was no evidence of phytotoxicity at this site. There were no effects on ring spot and yields were unaffected by treatments.

Lancashire (spring-planted crop)

The first sprays were applied on 7 June at the 3-4 leaf stage. Adverse weather conditions delayed the second spray application and this left insufficient time for a third treatment prior to harvest. Plants were disease free on 7 June but traces of downy mildew were detected on 22 June and at harvest (Table 13). White blister, alternaria and ring spot were found on occasional plants at harvest but there were no treatment differences. Sprays of UK443d appeared to be phytotoxic and had stunted growth. This resulted in a significant yield reduction at harvest (Table 13).

Table 12. Effect of fungicide sprays on foliar diseases at harvest and yield of over-wintered spring greens in Lancashire in 1993.

	Treatment	Mean % area affected by ring spot	alternaria	downy mildew	Yield (t/ha)
1.	Untreated	0.02	0.20 c	0.24 a	35.57
2.	Benlate + Agral	0.09	0.02 ab	0.30 ab	30.41
3.	Bravo + Agral	0.01	0.07 abc	0.34 ab	32.19
4.	Bravo + Benlate + Agral	0.09	0.05 abc	0.22 a	30.25
5.	Bayfidan + Agral	0.02	0.07 abc	0.34 ab	35.40
6.	Bravo + Benlate (half rate) + Agral	0.06	0.07 abc	0.18 a	31.86
7.	Corbel + Bavistin FL	0.07	0.02 ab	0.77 c	35.73
8.	UK443d (0.5l)	0.00	0.01 a	0.40 ab	32.69
9.	UK443d (0.75l)	0.02	0.01 a	0.60 bc	31.52
10.	Bravo+Benlate+Agral (2 early sprays)	0.04	0.19 bc	0.25 a	36.90
11.	Bravo+Benlate+Agral (2 late sprays)	0.04	0.17 c	0.30 ab	30.69
12.	Maneb + Agral	0.08	0.04 abc	0.47 abc	33.18
	SED (33 df)	0.048	0.063	0.146	4.05
	Significance Level	NS	5%	5%	NS

NS = No significant differences between treatment means

Treatment means followed by the same letter do not differ significantly

Table 13. Effect of fungicide sprays on downy mildew and yield of spring-planted spring greens in Lancashire in 1993.

	Treatment	% downy mildew 22 June	16 July	Yield (t/ha)
1.	Untreated	0.04	0.07	37.76 c
2.	Benlate + Agral	0.02	0.06	31.87 bc
3.	Bravo + Agral	0.01	0.05	30.64 abc
4.	Bravo + Benlate + Agral	0.01	0.03	33.81 c
5.	Bayfidan + Agral	0.00	0.04	31.30 abc
6.	Bravo + Benlate (half rate) + Agral	0.01	0.02	29.79 abc
7.	Corbel + Bavistin FL	0.00	0.09	30.97 abc
8.	UK443d (0.5l)	0.00	0.04	27.00 ab
9.	UK443d (0.75l)	0.01	0.01	25.96 a
10.	Bravo+Benlate+Agral (2 early sprays)	0.01	0.04	35.46 c
11.	Bravo+Benlate+Agral (1 late spray)	0.01	0.02	35.41 c
12.	Maneb + Agral	0.03	0.02	33.95 c
	SED (33 df)	0.01	0.04	2.51
	CV%			<11.2
	Significance Level	NS	NS	5%

NS = No significant differences

Treatment means followed by the same letter do not differ significantly

1993/94 Experiments

Cornwall

Ring spot was already established in the crop when the first sprays were applied on 26 January. Most treatments gave control of both light leaf spot (Table 14) and ring spot (Table 15) only three weeks later (16 February), an exception being Bravo + Agral. By mid March, disease severity had increased and significant differences between treatments were apparent (Table 14 and 15). UK443d, Bayfidan + Agral and Corbel + Bavistin FL were particularly effective and gave highly significant ($P<0.001$) control of both ring spot and light leaf spot. A7402G gave excellent control of ring spot and was very effective against light leaf spot. Disease pressure diminished prior to harvest but differences between treatments could be differentiated statistically. All treatments gave significant

control of ring spot (except Maneb + Agral - Table 15) and light leaf spot (Table 14). Benlate + Agral was rather more effective against light leaf spot than against ring spot. Bravo + Agral and Maneb + Agral were less effective than most other treatments. There were differences between full and half rate treatments with Benlate + Bravo + Agral but two late sprays were superior to two early sprays for disease control and yield. Disease control resulted in significant yield responses of up to 32% (Table 16).

Table 14. Effect of fungicides on the severity of light leaf spot on spring greens in Cornwall 1994.

		% leaf area with light leaf spot							
	Treatment	16 Feb	16 Mar			19 Apr			
1.	Untreated	2.1 e	5.5	(13.3)	* h	2.80	(9.56)	*f
2.	Benlate + Agral	1.2 abc	2.1	(8.3)	def	0.16	(2.31)	ab
3.	Bravo + Agral	1.7 cde	3.6	(10.9)	fgh	1.10	(5.88)	de
4.	Bravo + Benlate + Agral	1.5 bcd	1.8	(7.5)	cde	0.45	(3.38)	abc
5.	Bayfidan + Agral	1.1 ab	0.7	(4.6)	abc	0.03	(0.98)	a
6.	Bravo + Benlate + Agral (half rate)	1.2 abc	2.0	(8.0)	def	0.30	(3.06)	abc
7.	Corbel + Bavistin FL	1.3 bcd	0.6	(4.2)	ab	0.08	(1.59)	ab
8.	UK443d (0.5l)	1.1 ab	0.2	(2.7)	a	0.06	(1.26)	ab
9.	UK443d (0.75l)	1.6 bcde	0.9	(5.5)	abcd	0.07	(1.52)	ab
10.	Bravo+Benlate+Agral (2 early sprays)	1.3 bcd	1.5	(6.9)	bcde	0.90	(5.25)	cde
11.	Bravo+Benlate+Agral (2 late sprays)	1.8 de	2.8	(9.5)	efg	0.21	(2.61)	ab
12.	Maneb + Agral	1.5 bcd	4.4	(12.0)	gh	1.82	(7.11)	e
13.	A7402G	0.7 a	1.6	(7.0)	bcde	0.49	(3.73)	bcd
14.	A7402G (2 late sprays)	1.4 bcd	2.3	(8.2)	def	0.43	(3.26)	abc
	SED (39 df)	0.24	1.40			1.11		
	Significance Level	0.1%	0.1%			0.1%		

* Angular transformed data analysed

Treatment means followed by the same letter do not differ significantly

Table 15. Effect of fungicides on the severity of ring spot on spring greens in Cornwall in 1994.

		% leaf area with ring spot				
	Treatment	16 Feb	16 Mar	19 Apr		
1.	Untreated	3.7 e	2.8 f	4.15	(11.70)	*e
2.	Benlate + Agral	2.5 abc	1.4 bcd	0.89	(5.38)	b
3.	Bravo + Agral	3.5 de	2.6 ef	1.94	(7.87)	cd
4.	Bravo + Benlate + Agral	2.4 abc	1.1 ab	0.91	(5.32)	b
5.	Bayfidan + Agral	2.1 ab	0.3 a	0.09	(1.69)	a
6.	Bravo + Benlate + Agral (half rate)	2.1 ab	1.5 bcd	1.04	(5.68)	bc
7.	Corbel + Bavistin FL	2.3 abc	0.3 a	0.05	(1.05)	a
8.	UK443d (0.5l)	1.7 a	0.1 a	0.10	(1.78)	a
9.	UK443d (0.75l)	1.7 a	0.2 a	0.08	(1.58)	a
10.	Bravo+Benlate+Agral (2 early sprays)	2.8 bcd	1.7 bcde	2.52	(9.14)	d
11.	Bravo+Benlate+Agral (2 late sprays)	2.8 bcd	2.4 def	1.29	(5.73)	bc
12.	Maneb + Agral	2.7 bcd	2.2 cdef	2.72	(9.46)	de
13.	A7402G	1.7 a	0.1 a	0.14	(2.01)	a
14.	A7402G (2 late sprays)	3.2 cde	1.3 a	0.55	(3.45)	ab
	SED (39 df)	0.39	0.49	1.11		
	Significance Level	0.1%	0.1%	0.1%		

* Angular transformed data analysed

Treatment means followed by the same letter do not differ significantly

Table 16. Effect of fungicide treatment on yield and relative yield of spring greens in in Cornwall in 1994.

	Treatment	Yield (t/ha)		Relative yield
1.	Untreated	14.02	ab	100
2.	Benlate + Agral	17.48	cd	125
3.	Bravo + Agral	14.62	abc	104
4.	Bravo + Benlate + Agral	17.69	cd	126
5.	Bayfidan + Agral	17.24	cd	123
6.	Bravo + Benlate + Agral (half rate)	16.72	bcd	119
7.	Corbel + Bavistin FL	16.59	abcd	118
8.	UK443d (0.5l)	16.67	bcd	119
9.	UK443d (0.75l)	18.48	d	132
10.	Bravo+Benlate+Agral (2 early sprays)	13.54	a	97
11.	Bravo+Benlate+Agral (2 late sprays)	17.35	cd	124
12.	Maneb + Agral	16.74	bcd	119
13.	A7402G	17.08	bcd	122
14.	A7402G (2 late sprays)	15.88	abcd	113
	SED (39 df)	1.363		
	CV(%)	11.7		
	Significance Level	0.1%		

Treatment means followed by the same letter do differ significantly

Lincolnshire

An assessment on 10 plants at 4-5 leaf stage on 11 December showed that 85% of plants were affected with ring spot with an average of 6.9 spots/plant and an average leaf area of 2.8%. A 25 plant sample assessed across the site at the 4-6 leaf stage on 31 January (the day the first spray treatments were applied) showed that 68% of plants were affected with ring spot. Ring spot was mainly confined to the lowest leaf with an average of 7.4% leaf area of the oldest leaf affected.

On 23 March, there was no effect of treatments on ring spot on newly developed leaves or on leaf area affected. However, there was a treatment effect on ring spot on the whole of the plant with less disease following treatments of the higher rate of UK443d and A7402G (Table 17).

Table 17. Effect of fungicide treatments on ring spot on spring greens in Lincolnshire on 23 March 1994.

	Treatment	% plants (new leaves) affected	% plants affected	% leaf area affected
1	Unsprayed Control	0.0	17.5 abcd	0.7
2	Benlate + Agral	2.5	2.5 ab	0.1
3	Bravo + Agral	15.0	20.0 bcd	0.6
4	Bravo + Benlate + Agral	2.5	7.5 abcd	0.3
5	Bayfidan + Agral	5.0	7.5 ancd	0.3
6	Bravo + Benlate + Agral (half rate)	7.5	12.5 abcd	0.3
7	Corbel + Bavistin FL	5.0	5.0 abc	0.0
8	UK443d (0.5 l)	7.5	7.5 abcd	0.2
9	UK443d (0.75 l)	0.0	0.0 a	0.0
10	Bravo + Benlate + Agral (2 early sprays)	10.0	10.0 abcd	0.1
11	Bravo + Benlate + Agral (1 late spray)	15.0	25.0 d	0.7
12	Maneb + Agral	7.5	22.5 cd	0.8
13	A7402G	0.0	0.0 a	0.0
14	A7402G (2 late sprays)	7.5	17.5 abcd	0.9
SED (39 df)		5.66	8.14	0.37
Significance Level		NS	5%	NS

NS - No significant differences

Treatment means followed by the same letter do not differ significantly.

At harvest on 16 May, plants were assessed in the plots and treatment differences were found in the % plants and % leaf area affected with alternaria and ring spot. Treatments which reduced the incidence and severity of both diseases were Corbel + Bavistin, the two UK443d treatments and the three-spray programme of A7402G. (Table 18)

Table 18. Effect of fungicide treatments on ring spot and alternaria on spring greens pre-harvest in Lincolshire on 16 May 1994.

	Treatment	% plants affected by alternaria	% leaf area affected by alternaria	% plants affected by ringspot	% leaf area affected by ringspot
1	Unsprayed Control	8.9 c	1.2 bc	67.5 d	1.1 bc
2	Benlate + Agral	8.8 c	2.2 c	25.0 abcd	0.5 abc
3	Bravo + Agral	5.4 bc	0.5 ab	26.2 abcd	0.6 abc
4	Bravo + Benlate + Agral	5.7 bc	0.4 ab	26.2 abcd	0.7 abc
5	Bayfidan + Agral	6.8 bc	0.8 ab	20.0 abcd	0.5 abc
6	Bravo + Benlate + Agral (half rate)	9.3 c	1.4 bc	57.5 cd	1.3 c
7	Corbel + Bavistin FL	4.1 ab	0.4 ab	11.2 abc	0.3 ab
8	UK443d (0.5 l)	0.8 a	0.0 a	10.0 abc	0.2 ab
9	UK443d (0.75 l)	1.4 a	0.0 a	7.5 ab	0.2 ab
10	Bravo + Benlate + Agral (2 early sprays)	9.2 c	1.3 bc	42.5 abcd	0.7 abc
11	Bravo + Benlate + Agral (1 late spray)	7.8 bc	1.3 bc	55.0 bcd	0.9 abc
12	Maneb + Agral	7.8 bc	1.0 ab	40.0 abcd	0.8 abc
13	A7402G	1.6 a	0.0 a	5.0 a	0.1 a
14	A7402G (2 late sprays)	5.9 bc	0.5 ab	23.7 abcd	0.5 abc
SED (39 df)		1.29	0.37	15.25	0.30
Significance Level		0.1%	0.1%	1%	1%

Data square root transformed

Treatment means followed by the same letter do not differ significantly (P = 0.01)

Treatment differences were found in the incidence and severity of both alternaria and ring spot on the harvested samples. The incidence and severity of both diseases was reduced by Corbel + Bavistin and the two UK443d treatments. The severity of alternaria and the incidence and severity of ringspot was reduced by the 3 spray programmes of Bravo + Benlate + Agral (Treatments 4 and 6) and the two A7402G treatments. (Table 19).

Table 19. Effect of fungicide treatments on diseases on harvested samples of spring greens in Lincolnshire on 16 May 1994.

	Treatment	% plants affected by alternaria	% leaf area affected by alternaria	% plants affected by ring spot	% leaf area affected by ring spot
1	Unsprayed Control	52.5 abc	0.9 ab	52.5 d	1.1 c
2	Benlate + Agral	68.7 c	0.8 ab	45.0 bcd	0.6 abc
3	Bravo + Agral	46.2 abc	0.6 ab	32.5 abcd	0.7 abc
4	Bravo + Benlate + Agral	31.2 ab	0.4 ab	22.5 abcd	0.6 abc
5	Bayfidan + Agral	71.2 c	0.8 ab	25.0 ancd	0.5 ab
6	Bravo + Benlate + Agral (half rate)	51.2 abc	0.7 ab	31.2 abcd	0.6 abc
7	Corbel + Bavistin FL	26.2 a	0.3 a	11.2 ab	0.3 ab
8	UK443d (0.5 l)	27.5 a	0.2 a	20.0 abcd	0.4 ab
9	UK443d (0.75 l)	21.2 a	0.2 a	6.2 a	0.2 a
10	Bravo + Benlate + Agral (2 early sprays)	73.7 c	1.1 b	37.5 abcd	0.8 bc
11	Bravo + Benlate + Agral (1 late spray)	63.7 bc	1.1 b	41.2 abcd	0.6 abc
12	Maneb + Agral	67.5 c	0.9 ab	47.5 cd	0.8 bc
13	A7402G	32.5 ab	0.3 a	12.5 abc	0.3 ab
14	A7402G (2 late sprays)	31.2 bc	0.3 a	8.7 a	0.3 ab
SED (39 df)		11.15	0.25	11.44	0.18
Significance level		0.1%	1.0%	0.1%	1%

Data square root transformed

Treatment means followed by the same letter do not differ significantly (P = 0.01)

At harvest, it was apparent that some plots had no mayweed present. An assessment revealed that there was an effect of treatments, with no mayweed present, in plots treated with Corbel + Bavistin. (Table 20).

Table 20. Effect of fungicide treatments on mayweeds in Linconshire on 16 May 1994.

	Treatment	Mayweed score (0 = clean 5 = overrun)
1	Unsprayed Control	3.2 b
2	Benlate + Agral	3.0 b
3	Bravo + Agral	3.7 b
4	Bravo + Benlate + Agral	2.2 b
5	Bayfidan + Agral	3.5 b
6	Bravo + Benlate + Agral (half rate)	3.5 b
7	Corbel + Bavistin FL	0.0 a
8	UK443d (0.5 l)	3.5 b
9	UK443d (0.75 l)	2.5 b
10	Bravo + Benlate + Agral (2 early sprays)	4.0 b
11	Bravo + Benlate + Agral (1 late spray)	3.5 b
12	Maneb + Agral	3.0 b
13	A7402G	3.5 b
14	A7402G (2 late sprays)	2.7 b
SED (39 df)		0.64
Significance level		0.1%
CV%		30.3

Treatment means followed by the same letter do not differ significantly (P = 0.01)

There was no effect of treatments on untrimmed or trimmed yield. (Table 21)

Table 21. Effect of fungicide treatments on yield (t/ha) of spring greens in Lincolnshire in 1994.

	Treatment	Untrimmed Yield (t/ha)	Trimmed Yield (t/ha)
1	Unsprayed Control	34.55	29.16
2	Benlate + Agral	38.26	30.34
3	Bravo + Agral	35.22	29.16
4	Bravo + Benlate + Agral	38.09	32.19
5	Bayfidan + Agral	39.77	33.37
6	Bravo + Benlate + Agral (half rate)	34.55	29.66
7	Corbel + Bavistin FL	42.64	35.56
8	UK443d (0.5 l)	40.11	35.22
9	UK443d (0.75 l)	35.39	30.51
10	Bravo + Benlate + Agral (2 early sprays)	39.77	34.04
11	Bravo + Benlate + Agral (1 late spray)	34.21	27.64
12	Maneb + Agral	42.47	36.07
13	A7402G	37.42	32.19
14	A7402G (2late sprays)	39.61	33.71
SED (39 df)		3.865	3.057
Significance Level		NS	NS

NS - No significant differences

Results

Laboratory tests

Ring spot isolates were obtained from 12 crops (11 brussels sprouts, one cabbage) during the autumn and winter 1993/94 but no further cases of resistance to benomyl were confirmed (Table 22).

The current status of ring spot resistance is summarised in Fig. 1. Whilst resistance to MBC fungicides has been found in the south-west and north-west of England and in west Wales, no cases were recorded in Lincolnshire.

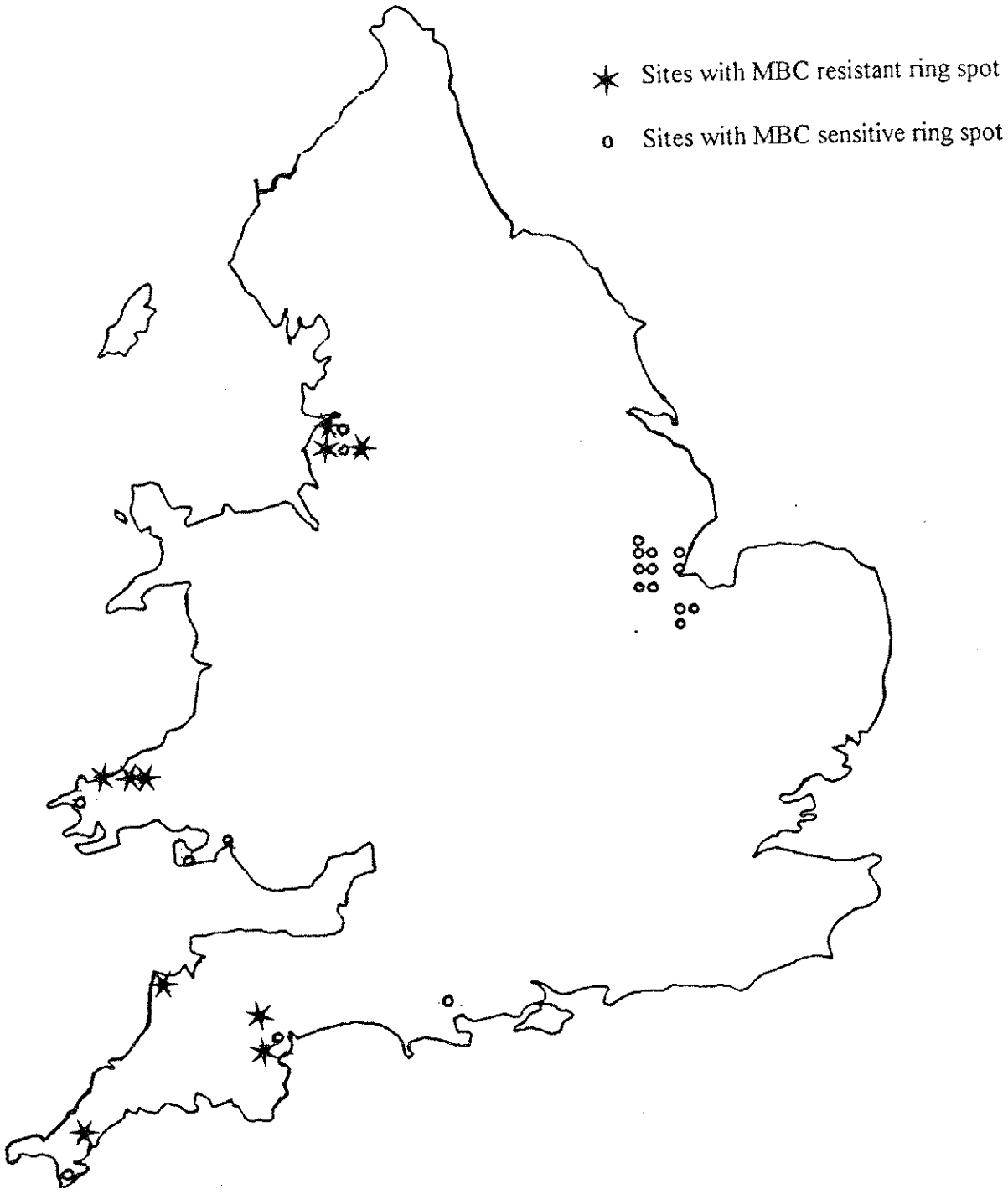
Table 22. Source of ring spot isolates and incidence of resistance to benomyl during 1993/94.

Location of site	Crop	Number of isolates tested	% isolates resistant to benomyl
Lancashire			
Hesketh Bank	Brussels sprouts	1	0
Lincolnshire			
Bennington	Cabbage	9	0
Hubberts Bridge	Brussels sprouts	10	0
Hubberts Bridge	Brussels sprouts	2	0
Hubberts Bridge	Brussels sprouts	3	0
Quadring	Brussels sprouts	4	0
Quadring	Brussels sprouts	5	0
Quadring	Brussels sprouts	7	0
Pinchbeck	Brussels sprouts	4	0
Pinchbeck	Brussels sprouts	4	0
Pinchbeck West	Brussels sprouts	3	0
Quadring	Brussels sprouts	4	0
Total (12 sites)		56	0

Attempts to isolate ring spot or light leaf spot were unsuccessful on a number of samples which arrived in poor condition. These included light leaf spot on cabbage and cauliflower from Cleveland and on spring greens from Cornwall and ring spot on brussels sprouts and spring greens from Lincs, spring greens from Cornwall, cabbage and brussels sprouts from Lancs.

Secondary tests to determine the minimum inhibitory concentration (MIC) of benomyl showed that most (80%) isolates failed to grow at 0.4 mg/l benomyl but occasional isolates had MIC value of 0.8 or 1.0 mg/l benomyl. At 0.2 mg/l benomyl, mycelial growth was 77% of that recorded on untreated control plates.

Fig. 1 Current status of MBC resistance in brassica ring spot (*Mycosphaerella brassicicola*)



Review of weather factors and epidemics of foliar diseases of brassicas 1981-1990.

The review compiled by Owen Jones, ADAS Starcross considered the regional and national importance of the major foliar diseases of ware brassicas namely:-

Alternaria or dark leaf spot (*Alternaria brassicae* and *Alternaria brassicicola*)
Downy mildew (*Peronospora parasitica*)
Light leaf spot (*Pyrenopeziza brassicae*)
Ringspot (*Mycosphaerella brassicicola*)
White blister (*Albugo candida*)

National summaries for the five major disease which can be effectively controlled with fungicides (Fig. 2) illustrated the large differences which can occur from year to year. Alternaria was prominent in the early 1980's and then declined and it is only recently that disease severity has reached significant levels again. Powdery mildew is commonly found in the eastern half of England and it became noticeably more severe during 1990. Light leaf spot declined in importance towards the end of the decade which coincided with reduced disease severity in winter oilseed rape. Areas with intensive oilseed rape cropping were often most at risk, but severe attacks have occurred in disease-conducive areas such as west Wales, Cornwall and Lancashire. Ring spot is very severe in some localities but only occasionally seen in large areas of central, eastern and northern England. Dry winters have checked its activity in recent years and in 1993/94 the most widespread attacks of ring spot occurred in the East around the wash. White blister occurs regularly where is well established in traditional brassica growing areas but seasonal differences are apparent particularly in eastern England. Although white blister occurred in late summer in some years, it was most frequently found in late autumn.

Ring spot was most prevalent in western areas from Devon and Cornwall, to the Welsh coast and into Lancashire. Localised outbreaks occur close to the East Anglian coast and the disease flares up in Lincolnshire every few years (Fig. 3).

A considerable number of experiments have been carried out over the last decade to investigate diseases and their control in brassica crops. Data are therefore already available which will be useful for validating disease models being developed at HRI with both MAFF and HDC funding. Comparisons were drawn between sites with severe disease epidemics and those with low disease. Specific examples taken from the Review illustrated the progress of ring spot (Fig. 4), ring spot and light leaf spot (Fig. 5) and powdery mildew (Fig. 6) epidemics. The appearance of ring spot symptoms about 4 weeks after rain is in agreement with published reports (Gotz *et al.* 1993).

The following features were identified from experiments on brussels sprouts maturing during the period October to January.

Ring spot	Epidemics promoted by long periods of rainfall (high rainfall and high numbers of rain days) and mild temperatures. Low rainfall for a few weeks is sufficient to check disease development.
Light leaf spot	Summer and autumn rainfall patterns appear to be critical and low disease was associated with a dry July.
White blister	Epidemics were associated with persistence of maximum temperatures above 15°C (from May to October).
Alternaria	The combination of high maximum temperatures and high rainfall in August favoured epidemics whilst low September rainfall halted the epidemic.
Powdery mildew	Prolonged high temperatures between May and October with low summer and autumn rainfall were a feature of sites with epidemics. In epidemic years the disease was detected in August and became severe by October.

Quantitative data on disease incidence and severity were collected by ADAS during 1983-1985 from 137-166 crops per year of brussels sprouts. (Wafford *et al.*, 1986) There was considerable year to year variation in disease incidence and severity over this 3 year period notably for light leaf spot which affected leaves of only 3.1% plants (15% crops) in 1983 but 18% plants (51% crops) in 1985. (Gladders *et al.*, 1984).

Interactions with oilseed rape were investigated and circumstantial evidence produced that light leaf spot had spread from oilseed rape to adjacent sprouts (Wafford *et al.*, 1986). Since that report, ring spot has been monitored in oilseed rape in the south west and now also has potential to interact with vegetable brassicas (Zornbach, 1991). At present, however, the main interaction appears to be due to spread of ring spot from fodder brassicas to oilseed rape. (Gladders, 1993).

Fungicide usage in brassicas during the period of the review between 1981 and 1986 but then appeared to stabilise.

Table 23. Area of vegetable brassicas treated with fungicide and quantity of fungicide used in relation to area grown.

Year	Area grown (ha)	Treated area (ha)	Fungicide used (kg active ingredient)
1981	47,805	4,863	3,202
1986	47,968	45,820	37,555
1991	41,067	36,922	36,078

Data from Thomas *et al.*, 1992.

Disease monitoring provided some circumstantial evidence that the applications of 2 or more sprays of fungicide had reduced disease incidence (Wafford *et al.*, 1986). This was in agreement with results of ADAS spray timing experiments which showed that two spray programmes gave good disease control (Davies *et al.*, 1986) Single sprays could be very effective but unless the critical conditions which lead to severe attacks can be identified for a range of pathogens, results with single sprays will be variable.

Fig. 2

National Disease Summaries.

Year	Ringspot	Light Leaf Spot	White Blister	Alternaria	Powdery Mildew
1981	*	*	*	**	*
1982	*	*	*	**	*
1983	*	*	**	**	**
1984	**	**	**	*	**
1985	**	**	**	*	*
1986	**	**	*	*	*
1987	*	*	*	*	*
1988	*	**	**	*	*
1989	*	*	**	*	**
1990	**	*	**	*	***

* slight infection reported ** generally moderate infection

*** severe infections in most areas

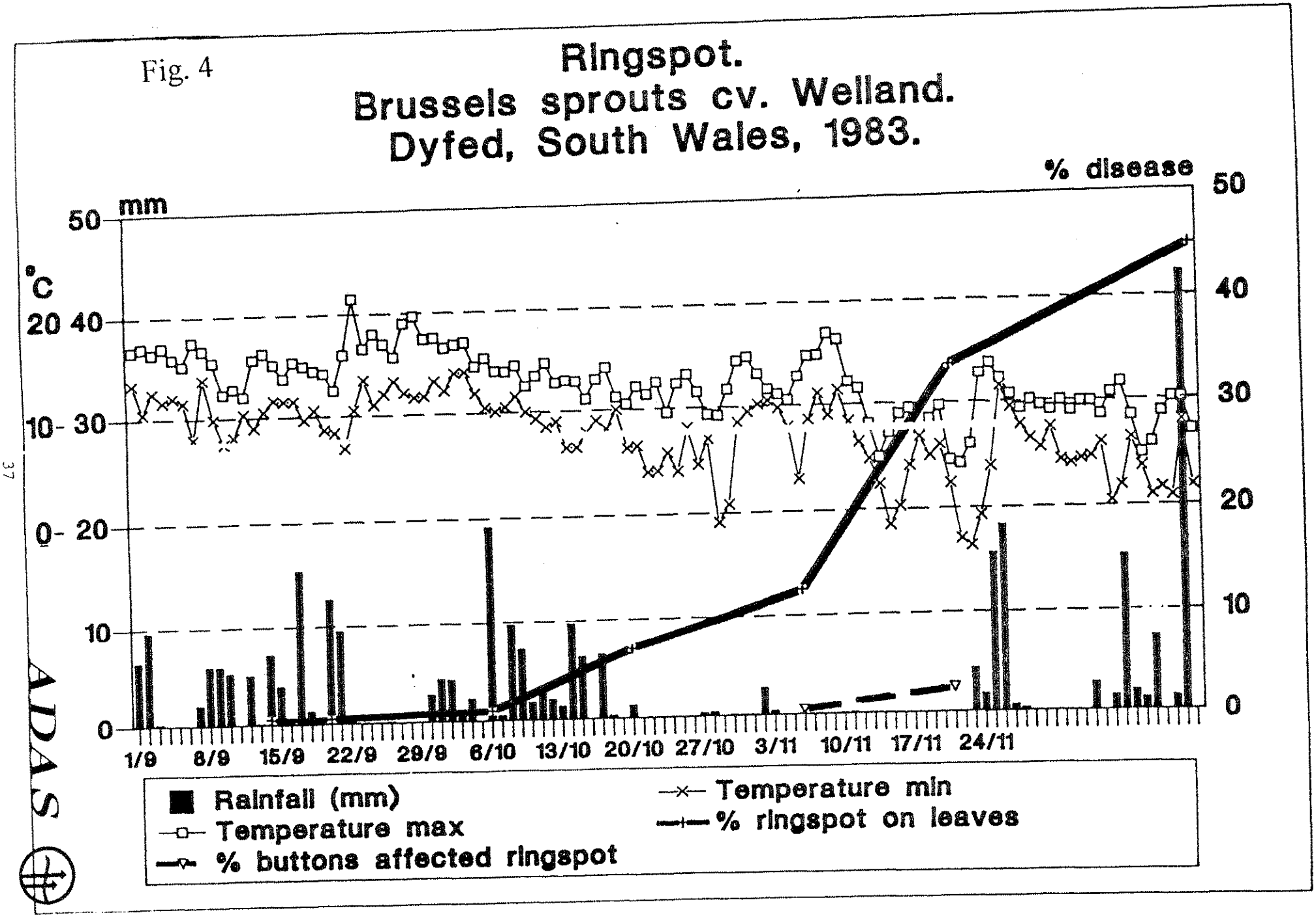
Fig. 3 **Regional Disease Summaries.** Ringspot.

\- nil or not recorded * slight ** moderate *** severe infections in most areas

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
York/Humberside	-	-	-	-	*	-	-	-	-	-
East Midlands (Lincs)	-	-	-	*	*	***	**	**	*	*
E. Anglia (Beds, Norfolk, Suffolk)	*	*	*	*	*	*	*	*	*	*
S. East (Kent)	-	*	*	*	*	-	-	*	*	*
S. West (Glos)	**	**	*	*	**	**	*	**	**	*
W. Midlands (Hereford & Worcester)	**	***	**	*	*	*	*	*	*	**
N. West (Lancs & Mersey)	***	***	***	**	**	*	***	**	**	**
Wales	***	**	***	***	***	**	***	*	*	***

ADAS

Fig. 4


Ringspot.
Brussels sprouts cv. Welland.
Dyfed, South Wales, 1983.
% disease
mm
°C
50
40
30
20
10
0
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11
Rainfall (mm)
Temperature max
% buttons affected ringspot
Temperature min
% ringspot on leaves

ADAS

Fig. 5

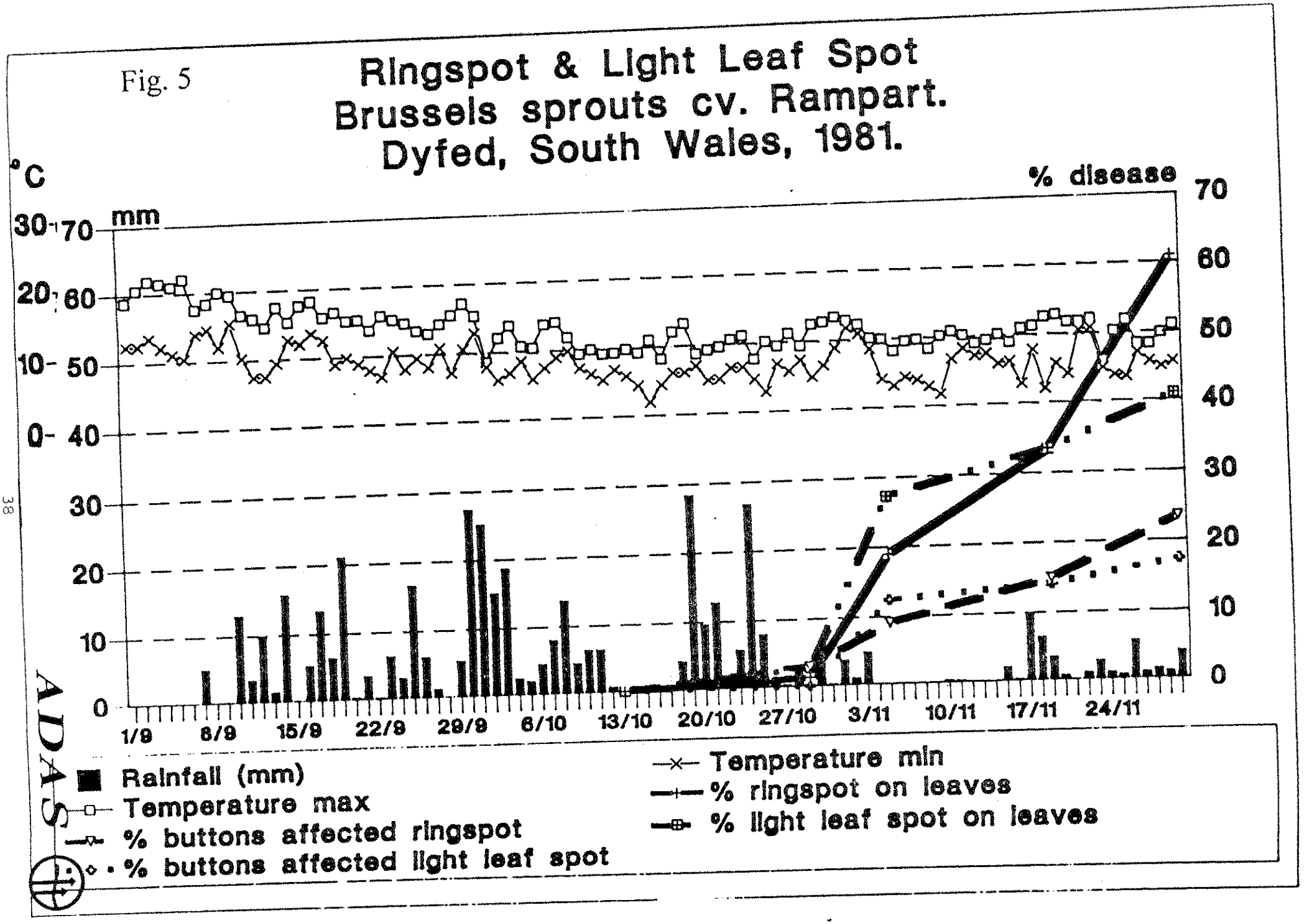
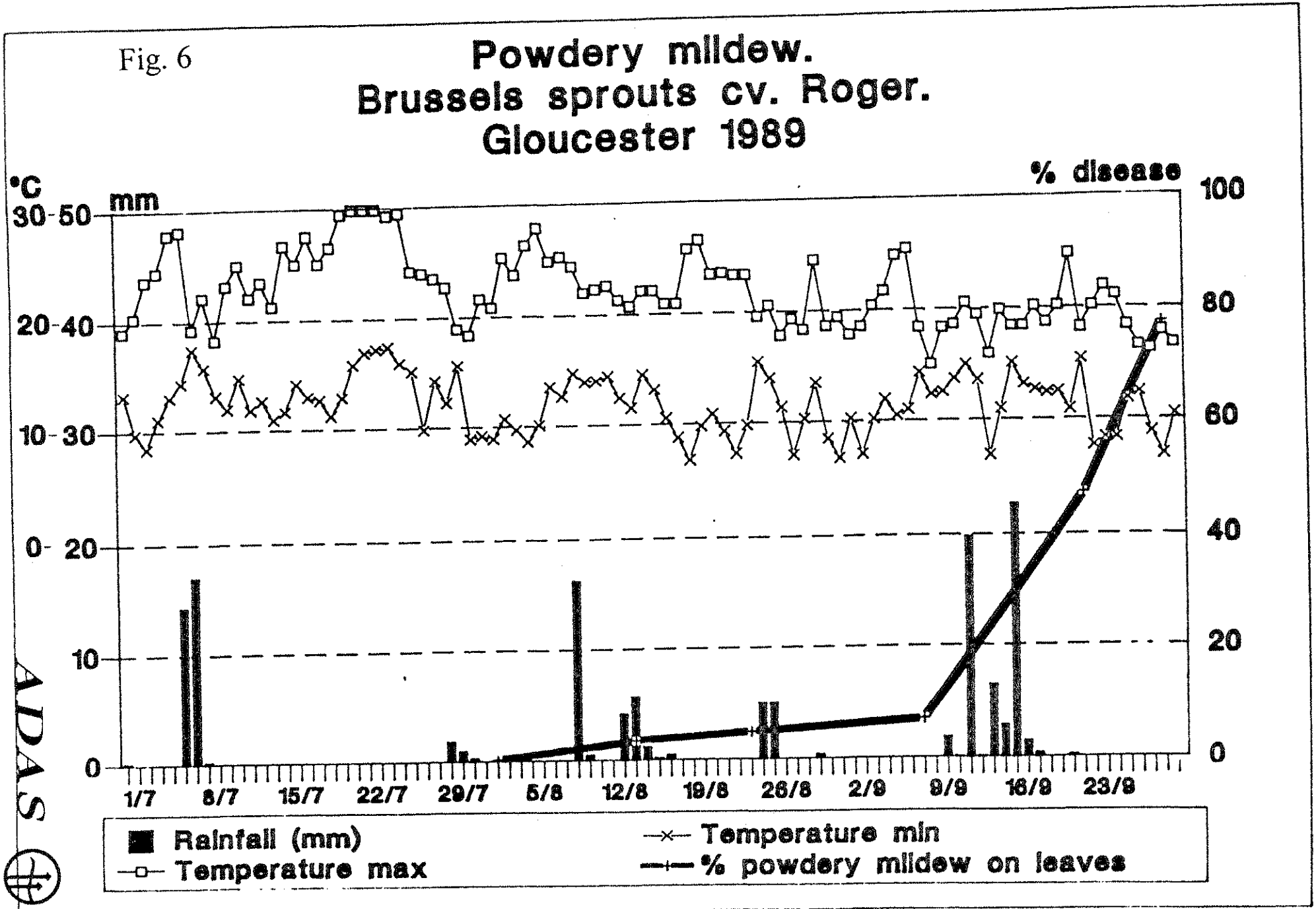

Ringspot & Light Leaf Spot
Brussels sprouts cv. Rampart.
Dyfed, South Wales, 1981.
°C
mm
% disease
30
20
10
0
70
60
50
40
30
20
10
0
70
60
50
40
30
20
10
0
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11
Rainfall (mm)
Temperature max
% buttons affected ringspot
% buttons affected light leaf spot
Temperature min
% ringspot on leaves
% light leaf spot on leaves
ADAS

Fig. 6


Powdery mildew.
Brussels sprouts cv. Roger.
Gloucester 1989
°C
mm
% disease
30
50
20
40
10
30
0
20
10
0
100
80
60
40
20
0
1/7
8/7
15/7
22/7
29/7
5/8
12/8
19/8
26/8
2/9
9/9
16/9
23/9
Rainfall (mm)
Temperature max
Temperature min
% powdery mildew on leaves

ADAS

Conclusions and Discussion

In 1991/92, disease levels remained low following below average rainfall between September and March (except for October). There were no effects of fungicide treatments on disease. The plots treated with UK443d (0.75 l/ha) gave the highest yield but differences were not significant.

Crop development was delayed at both sites in 1992/93 because of adverse weather conditions in February and March. A harvest was taken in April (over a month late) but this highlighted the difficulties of devising a fungicide programme for crops where harvesting may be re-scheduled several weeks later. In the event, disease pressure was low and treatments such as UK443d (tebuconazole), Corbel + Bavistin and Benlate + Agral suppressed alternaria up to harvest from a programme ending in late December. There appeared to be some aggravation of downy mildew by Corbel + Bavistin and one of the tebuconazole treatments. Under low disease pressure no treatment produced a significant yield response or improved leaf quality and treatments could not be considered cost-effective.

Moderate levels of ring spot occurred at the site in Lincolnshire in the late autumn and during the winter in 1993/94. Infection was mainly confined to the lower leaves. In the spring 1994, some ring spot infection was recorded on the new growth but there was no effect of January sprays in mid March. However, when whole plants were assessed, with infection mainly on the lower leaves, there was less ring spot following treatments of the higher rate of UK443d and A7492G applied in January. At harvest, both ringspot and alternaria had developed on the untreated plants with up to 67% and 80% plants affected respectively albeit at low levels and mainly on the older leaves. Plants were assessed in the plots pre-harvest and also on the harvested plants and the results of the assessments were similar. The best control of both diseases was from the two UK443d treatments which gave equally good results and from the two treatments of A7402G which performed similarly i.e. 3 sprays compared with two late sprays.

Control of both alternaria and ring spot was achieved with the 3-spray programmes of Corbel + Bavistin and with Benlate + Bravo + Agral. The Lincolshire site provided new data on alternaria efficacy for both existing products and for products under development. Maneb + Agral gave poor control of alternaria and reducing the rate of Benlate + Bravo + Agral by half, impaired alternaria control compared with the full rate. As infection was mainly confined to the lower leaves it was not surprising that treatments had no effect on untrimmed or trimmed yields.

It was of interest that the Corbel + Bavistin treatment completely controlled mayweed in Lincolnshire and this appears to be the first report of such activity.

In 1991/92, resistance to benomyl in the ring spot pathogen was confirmed at two sites in Wales and two sites in Devon.

The first records of MBC resistance in the ring spot pathogen in Lancashire were obtained but this constituted a small proportion (12-20%) of the population. The affected crops were believed to have been untreated with fungicide and this may explain the difference with previous records at sites in the south west and Wales which were fungicide treated and showed high levels of resistance (80-100%) in the ring spot population in 1991/92. A further case of MBC resistance was found in south west England in 1992. In 1993/94, all isolates tested were found to be MBC sensitive. The majority came from eastern England, where ring spot epidemics occur spasmodically. Only one of the Lincolnshire crops, which yielded ring spot isolates, is thought to have been treated with an MBC product. Overall, therefore, it appears that selection pressure for MBC resistance is lower in the east than in the west. MBC products should continue to provide good disease control for growers with light leaf spot and ring spot problems in eastern counties.

It would now be prudent to assume that MBC resistance in the ring spot pathogen population could be present quite widely on farms in England and Wales particularly where the disease occurs regularly. This emphasises the need to diversify fungicide programmes where ring spot is one of the target diseases in control programmes. Previous HDC-funded work (FV25) indicated that chlorothalonil and triadimenol could provide control of ring spot. However, the period of protection provided by these alternatives may not be long as that previously provided by benomyl when used on a 'sensitive' population. The current work on spring greens showed that benomyl can still provide good control of ring spot and light leaf spot but triadimenol (Bayfidan), fenpropimorph (Corbel) + carbendazim (Bavistin FL), tebuconazole (UK443d) and difenoconazole (A7402G) are comparable or slightly more effective.

Benlate remained amongst the most effective products for light leaf spot (Table 14) and Bayfidan was also highly effective. The new products UK443d and A7402G were also outstanding.

Chlorothalonil and maneb gave rather limited control of light leaf spot and ring spot in 1993/94. Results with a benomyl + chlorothalonil treatment at either full or half rate were comparable to benomyl alone. There was no advantage in increasing the rate of UK443d from 0.5 l/ha to 0.75 l/ha for control of ring spot and light leaf spot but yield differences between the two rates approached statistical significance (13%) and merits further investigation. In contrast, a yield reduction was detected following the use of UK443d in 1993 (Table 13). Sprays were first applied at the 3-4 leaf stage when temperatures were 18°C. This compound does show growth regulatory activity on oilseed rape and further work appears to be required to establish guidelines for safe use on very young crops.

Comparison of timing of sprays of benomyl + chlorothalonil showed that the later sprays were most effective for disease control at harvest and yield, and significantly better than the early sprays (treatment 10, Tables 14, 15 and 16). Given that the presence of low levels of disease during the

early stages of crop development did not result in loss of yield, disease thresholds rather than mere presence of disease, should be considered when applying fungicide sprays. The results from Cornwall suggest that thresholds of about 5% leaf area affected by ring spot may be appropriate, particularly when new products such as tebuconazole (Folicur) become available. Light leaf spot appeared suddenly in mid-February 1994 in the crop in Cornwall and forecasting systems would be of great benefit in identifying local risks from this disease. However, light leaf spot was well controlled by two late sprays of Benlate + Bravo (Table 14), endorsing the view that fungicide protection over the last 6-8 weeks before harvest is a practical strategy.

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Appendix 1 Site details 1991/92 Experiment

Location	Mullion, Cornwall
Cultivar	First Early Market
Sowing date	24 August 1991
Plot size	3.0 x 10.0 m
Spacing:	0.60 x 0.26 m
Soil texture	Sandy clay loam
Soil analysis	
pH	6.4
P Index	3
K Index	2
Mg Index	4
Fertilisers	No base treatments
Herbicides	propachlor as Ramrod 27 August 1991
Previous cropping	1991 W Barley 1990 W Barley
Harvest date (plots):	17 March 1992

Appendix 2 Site Details 1992/93 Experiments

	Site 1	Site 2	Site 3
Location	Tregaddra Farm Cury Cross Lanes, Helston, Cornwall	Bank Farm Burscough Lancashire	New Lane Burscough Lincolnshire
Cultivar	Winter Green	Prince Green	Durham
Sowing date	15 August 1992	28 August 1992	10 May 1993
Plot size	10.0 x 3.0 m	7.0 x 1.8 m	7.0 x 1.8 m
Soil texture	Sandy clay loam	Organic sandy loam	Sandy silt loam
Soil analysis pH	6.5	6.7	6.4
P Index	3	5	3
K Index	2	2	2
Mg Index	4	3	3
Fertilisers			(N-150 kg/ha
Seedbed	None	None	(P- 50 kg/ha
Top dressing	100 kg/ha 6 September	120 kg/ha September	(K- 75 kg/ha
(rate of product)	125 kg/ha 25 September	120 kg/ha late March	75 kg/ha
Herbicides	Clout 7 October	Treflan pre-drilling Ramrod pre-emergence	Tristar predrilling Ramrod pre-emergence
Insecticides:	-	-	Yaltox granules at DMS (x2) drilling
Molluscicides	Slug pellets 6 September	None	None Cyperneltum (xi)
Previous cropping	1992 Brassicas 1991 Cereals	1992 Lettuce 1991 Lettuce	- -
Preplanting cultivation	Ploughed	Power harrowed	-
Harvest date	21 April 1993	27 April 1993	16 July 1993

Appendix 3 Site Details 1993/94 Experiments

	Site 1	Site 2
Location	Leedstown, Hayle, Cornwall	West End, Benington, Boston, Lincs
Cultivar	Winter Green	Elf
Sowing date	Late September 1993	1 August 1993
Planting date	N/A	22 September 1993
Plot size	10.0 x 2.5 m (6 rows)	5.0 x 1.5 m
Plant spacing	0.15 x 0.42 m	0.20 x 0.36 m plots (1.83 m bed)
Soil texture	Silty clay loam	Silty loam
Soil analysis pH P Index K Index Mg Index	7.4 2 2 2	Not available
Altitude	60 m	Sea level
Fertilisers Seedbed	-	Nil
Top dressing	mid January	166 kg/ha 6 April 94
Herbicides	-	Carbetamex 11 November 1993 Ramrod + Trifluralin 22 September 1993 All at rec. rates
Molluscicides	-	No
Previous cropping	1993 W Wheat 1992 Narcissus	1993 W Wheat 1992 Green Cabbage 1991 OW Cauliflower/Summer Cauliflower
Preplanting cultivation	Ploughed	Plough and power harrowed twice
Harvest date	19 April 1994	16 May 1994