

Contract Report C88/0437
Brussels Sprouts: Control of
Fungal Diseases 1989
Undertaken for Horticultural
Development Council (FV/25/88)

Agricultural Development and Advisory Service

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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INTRODUCTION

Vegetable growers currently face the apparently conflicting demands of producing high quality produce with minimal pesticide usage. Recent ADAS surveys of Brussels Sprouts indicate that a range of diseases commonly cause significant levels of blemish on sprout buttons and can render some crops partially or completely unmarketable.

The Food & Environment Protection Act will increasingly limit the choice of fungicide mixtures and adjuvants and some of the larger growers will need to rationalise current practice. There is also concern that use of MBC fungicides such as benconyl and carbendazim (which are particularly effective against ring spot and light leaf spot) could lead to the selection of fungicide resistant strains of these pathogens. Alternative chemicals or suitable mixtures need to be identified to reduce the risks of fungicide resistance problems developing. Some new recommendations are expected in 1989 and there is limited information on the effectiveness of these new products.

Some difficulties have been experienced in controlling ringspot in Lancashire in 1987 and currently recommended treatments have not given satisfactory control. It is therefore suggested that products be evaluated against ring spot in particular in this project.

Further field trials work is required to establish the efficacy of commercial available fungicides and fungicide mixtures against the major brassica diseases. This would compliment ADAS experimental work on the timing of fungicides and on disease forecasting.

The main objectives of the experiments were

- (1) To determine the efficacy of a range of fungicides for control of ring spot and other diseases on leaves and buttons of Brussels sprouts.
- (2) To establish the benefits of using additional adjuvants or tank mixtures of fungicides on disease control.



Materials and Methods

Sites

The trials were undertaken in commercial crops of Brussels sprouts at Clovelly, Devon (cvs Dolmic and Gabion) and Dunkirk, Kent (cv Rampart). Site details and husbandry are given in Appendix I.

Design

A randomised block design was used with 3 replicates of each treatment. Each plot consisted of 4 rows of 14-16 plants and assessments were made on the two centre rows of each plot at the site in Kent. In Devon, each plot consisted of 4 rows of each variety and assessments were made on the two centre rows.

Treatments

Fungicides and Adjuvants

Table 1 Fungicides and adjuvants active ingredients (a.i) and dose rates

Fungicide	a.i	Amount a.i in product	Dose rate 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
Bravo 500	chlorothalonil	500 g/l	3.0 l
Corbel	fenpropimorph	500 g/l	1.0 l
Folio 575 FW	chlorothalonil + metalaxyl	500 g/l +75 g/l	2.0 l
<u>Adjuvants</u>			
Agral	alkyl phenol ethylene oxide condensate	900 g/l	180 ml
Actipron	mineral oil	97% v/v	6 or 12 l

All treatments were applied in 600 litres of water/ha

Table 2 Treatments

	Fungicide	Rate product/ha
1	Untreated control	
2	Benlate + Agral	1.1 kg + 180 ml
3	Benlate + 1% Actipron	1.1 kg + 6 l
4	Benlate + 2% Actipron	1.1 kg + 12 l
5	Bayfidan	0.5 l
6	Bayfidan + Agral	0.5 l + 180 ml
7	Bravo 5000 + Agral	3.0 l + 180 ml
8	Benlate + Bayfidan	1.1 kg + 0.5 l
9	Benlate + Bravo 500	1.1 kg + 3.0 l
10	Bayfidan + Bravo 500	0.5 l + 3.0 l
11	Folio + Benlate	2.0 l + 1.1 kg
12*	Corbel + Bavistin FL	1.0 l + 1.0 l

*Treatment 12 applied at site in Kent only.

All treatments were applied as 3-spray programmes:-

Devon	3 August	23 August	12 September
Kent	16 August	6 September	27 September

Fungicide application

Fungicides were applied as overhead sprays by Oxford Precision sprayer operated at 3 kPa pressure in 600 litres of water/ha.

Assessments

During the growing season the incidence and severity of diseases were recorded on 10 plants per plot when assessable levels were detected. The harvest sample consisted of 100 buttons (taken as 10 buttons from each of 10 plants and representative of the whole plant) or 50 buttons from each variety (5 plants) at the site in Devon. Buttons with less than 1% surface area affected by blemish were classified as Class I, 1-5% area affected as Class II and >5% as Class III.

Statistical Analyses

Results were subjected to analysis of variance and treatment means separated by using Duncan's Multiple Range Test.

Results

Table 3 Summary of disease severity on untreated plants

Disease	Kent	Devon
<u>on leaves</u>		
ringspot	*	***
alternaria	**	*
light leaf spot	*	***
downy mildew	**	
white blister	*	
powdery mildew	***	
<u>on buttons (at harvest)</u>		
light leaf spot	*	***
ringspot		***
alternaria		
downy mildew	*	
white blister		
black spotting		

% incidence * 0-25% affected
 ** 26-50%
 *** >50%

Table 4 Effect of fungicides on ringspot on leaves (23 August) Devon

		Dolmic and Gabion
Treatment		% infection of lower leaves
1	Untreated control	3.0 c
2	Benlate + Agral	1.0a
3	Benlate + 1% Actipron	1.0a
4	Benlate + 2% Actipron	1.0a
5	Bayfidan	1.0a
6	Bayfidan + Agral	1.0a
7	Bravo 500 + Agral	1.0a
8	Benlate + Bayfidan	1.0a
9	Benlate + Bravo 500	1.7 b
10	Bayfidan + Bravo 500	1.0a
11	Folio + Benlate	1.0a
SED (20 df)		0.142
Coefficient of variation (%)		14.0

Treatment means followed by the same letter do not differ significantly

Table 5 Effect of fungicides on ringspot, light leaf spot and oedema (2 October)
cv Dolmic, Devon

Treatment	Mean % Leaf Area Affected				Oedema
	Ringspot		Light Leaf Spot		
	Middle leaves	Bottom leaves	Top leaves	Middle leaves	
1 Untreated control	5.0 b	15.0 b	5.0 d	8.3 b	15.0 de
2 Benlate + Agral	0.0a	0.3a	0.3ab	0.0a	8.7 c
3 Benlate + Actipron (1%)	0.0a	0.3a	0.3ab	0.3a	16.7 e
4 Benlate + Actipron (2%)	0.0a	0.7a	0.0a	0.0a	20.0 e
5 Bayfidan	0.0a	1.0a	1.0 c	0.0a	16.7 e
6 Bayfidan + Agral	0.0a	1.0a	0.7 bc	0.3a	8.3 bc
7 Bravo + Agral	0.0a	1.0a	1.0 c	0.7a	2.0a
8 Benlate + Bayfidan	0.3a	0.7a	0.3ab	0.3a	10.0 cd
9 Benlate + Bravo	0.0a	1.0a	1.0 c	0.0a	0.7a
10 Bayfidan + Bravo	0.0a	1.0a	1.0 c	0.7a	3.0ab
11 Folio + Benlate	0.0a	1.0a	1.0 c	0.0a	5.0ab
SED (20 df)	0.19	1.27	0.27	1.50	2.5
CV (%)	45.3	74.2	31.6	188.8	31.4

Treatment means followed by the same letter do not differ significantly

Table 6 Effect of fungicides on ringspot and light leaf spot (2 October),
cv Gabion, Devon

Treatment	Mean % Leaf Area Affected			
	Ringspot		Light leaf spot	
	Middle leaves	Bottom leaves	Top leaves	Middle leaves
1 Untreated control	5.0 b	15.0 b	4.0 c	6.7 b
2 Benlate + Agral	0.3a	1.0a	1.0ab	0.3a
3 Benlate + Actipron (1%)	0.0a	0.7a	0.3ab	0.0a
4 Benlate + Actipron (2%)	0.0a	0.3a	0.0a	0.0a
5 Bayfidan	0.0a	1.3a	1.3 b	0.7a
6 Bayfidan + Agral	0.0a	1.0a	1.3 b	0.7a
7 Bravo + Agral	0.0a	2.3a	1.3 b	0.7a
8 Benlate + Bayfidan	0.0a	1.0a	1.0ab	0.7a
9 Benlate + Bravo	0.0a	1.0a	1.0ab	0.3a
10 Bayfidan + Bravo	0.0a	1.0a	1.3 b	1.0a
11 Folio + Benlate	0.3a	1.3a	0.3ab	0.0a
SED (20 df)	0.19	1.37	0.56	0.70
CV (%)	45.3	71.2	57.6	86.2

Treatment means followed by the same letter do not differ significantly

Table 7 Effect of fungicides on ringspot (21 November), cv Gabion, Devon

	Treatment	Top	Mean % leaf area affected		
			(Arcsin)	Middle	(Arcsin)
1	Untreated control	4.7	12.4 de	25.0	28.7 g
2	Benlate + Agral	2.3	8.7ab	11.7	19.5 de
3	Benlate + Actipron (1%)	2.0	8.1ab	6.7	14.6 bc
4	Benlate + Actipron (2%)	2.0	8.1ab	6.7	14.6 bc
5	Bayfidan	4.3	11.9 cde	18.3	24.4 f
6	Bayfidan + Agral	5.0	12.8 e	16.7	23.3 ef
7	Bravo + Agral	3.0	9.9 bcd	4.0	11.2ab
8	Benlate + Bayfidan	3.0	9.7 bc	10.7	18.5 cd
9	Benlate + Bravo	1.3	6.5a	4.3	11.2ab
10	Bayfidan + Bravo	2.0	7.9ab	2.0	7.9a
11	Folio + Benlate	1.3	6.5a	3.7	10.5ab
SED (20 df)			0.114		0.188
CV (%)			15.0		13.7

Arcsin - angular transformations used for percentage values in analysis of variance

Treatment means followed by the same letter do not differ significantly

Table 8 Effect of fungicides on button diseases at harvest (18 October) cv Dolmic, Devon

	Treatment	Mean % Buttons Affected		
		More than 5% surface area diseased	Ringspot	Light Leaf spot
1	Untreated control	92.6 c	85.3 c	80.0 d
2	Benlate + Agral	45.4 b	28.7 b	39.3 bc
3	Benlate + Actipron (1%)	16.0ab	2.3a	16.0abc
4	Benlate + Actipron (2%)	18.0ab	0.7a	18.0abc
5	Bayfidan	44.0 b	29.3 b	42.0 c
6	Bayfidan + Agral	26.0ab	19.3ab	18.0abc
7	Bravo + Agral	18.6ab	8.7a	18.0abc
8	Benlate + Bayfidan	22.0ab	11.3a	14.0abc
9	Benlate + Bravo	6.6a	0.0a	6.7a
10	Bayfidan + Bravo	10.6a	7.3a	5.3a
11	Folio + Benlate	8.6a	2.7a	8.0ab
SED (20 df)		13.34	8.42	13.69
CV (%)		58.2	58.3	69.5

Treatment means followed by the same letter do not differ significantly

Table 9 Effect of fungicide on button disease at harvest (21 November) cv Gabion, Devon

Treatment	% Buttons with more than 5% surface area diseased	Mean % Buttons Affected Ringspot	Light leaf spot
1. Untreated control	88.3 c	80.7 d	88.3 c
2. Benlate + Agral	86.0 c	50.3 c	86.0 c
3. Benlate + Actipron (1%)	81.0 bc	18.0ab	81.0 bc
4. Benlate + Actipron (2%)	56.0a	22.3ab	56.0a
5. Bayfidan	77.7abc	55.7 c	77.7 bc
6. Bayfidan + Agral	80.7 bc	59.3 c	80.7 bc
7. Bravo + Agral	89.0 c	27.7 b	89.0 c
8. Benlate + Bayfidan	75.0abc	44.3 c	75.0abc
9. Benlate + Bravo	60.7ab	8.3a	60.7ab
10. Bayfidan + Bravo	69.0abc	10.7ab	69.0abc
11. Folio + Benlate	77.3abc	10.7ab	77.3abc
SED (20 df)	9.44	7.91	9.44
CV (%)	15.1	27.5	15.1

Treatment means followed by the same letter do not differ significantly



Results

Devon

Ringspot was present at low levels on the oldest leaves when the first sprays were applied on 3 August. All treatments had given control of ringspot by 23 August (Table 4). By early October both ringspot and light leaf spot were well established on the lower and middle leaves (respectively) but good control was achieved by all the treatments (Tables 5 and 6).

Oedema-like symptoms were conspicuous near the margins of the top leaves of cultivar Dolmic. Treatment differences were noted (Table 5). There was significantly less spotting in plots which had received Bravo, Bravo mixtures, Bayfidan + Agral, or Folio + Benlate. In view of the occurrence of these symptoms on untreated plants it is thought that this reaction was not due to phytotoxicity.

A further assessment of the later maturing cultivar Gabion was carried out on 21 November, ten weeks after the final spray (Table 7). Good control of ringspot on the middle leaves was still apparent with Benlate + Actipron (both rates), Bravo + Agral and the four tank-mix treatments. Benlate + Agral was less effective than Benlate + Actipron and Bayfidan without Agral was less effective than Benlate + Agral or Bravo + Agral. On the top leaves, the four tank mix treatments and Benlate + adjuvant treatments were the most effective.

At harvest on 18 October, 93% of untreated buttons of cultivar Dolmic were considered unmarketable (>5% button area with blemish) but this was reduced by at least half by all treatments (Table 8). Very good control of both ringspot and light leaf spot on buttons was achieved with Bravo, Bravo mixtures and Benlate + Actipron. The addition of Actipron to Benlate significantly improved the control of ringspot over a Benlate + Agral treatment, Bayfidan alone appeared to be less effective than Bayfidan + Agral and Bravo + Agral but the differences were generally not statistically significant (Table 8).

Gabion was harvested about 4 weeks later than Dolmic, ten weeks after the third spray treatment had been applied. Both ringspot and light leaf spot were severe and affected 81% and 88% buttons respectively in control plots. Good control of

ringspot was still apparent with Bravo mixtures (87-90% control) and with Folio + Benlate (87% control). Benlate + Actipron was more effective than Benlate + Agral, Bayfidan, Bayfidan + Agral and Bayfidan + Benlate for ringspot control (Table 9). Light leaf spot control was poor and only Benlate + 2% Actipron and Benlate + Bravo gave significant reductions on buttons.

Kent

When the first spray was applied on 16 August all plants had powdery mildew which affected 0.3% area of lower leaves and 6.4% stem area. Traces of downy mildew and alternaria were noted on 40% and 30% plants respectively. Clubroot was present in the crop and affected 27% plants when averaged over assessments on the three dates when sprays were applied. Disease levels declined during September and on 27 September powdery mildew severity affected 0.2% lower leaf area and 3.5% stem area. Alternaria, downy mildew and white blister affected 10% plants at trace levels on 6 September but only Alternaria persisted until 27 September.

Initial assessments on buttons on 14 November showed no disease at present. By 12 December traces of light leaf spot and downy mildew affected 0.8% and 1% buttons respectively. The main problem on buttons was feeding and fouling damage from cabbage aphid (Brevicoryne brassicae). This affected 59%, 37% and 14% of buttons at bottom, middle and top of untreated plants (respectively).

There were no symptoms of phytotoxicity in any treatment.

Discussion

Starting the spray programme in early August provided good control of ringspot on leaves up to harvest in Devon. Untreated plants were partially defoliated by ringspot in November and this disease pressure produced significant differences between treatments (see Table 7). Control of ringspot on the top leaves of cv Gabion on 21 November suggested that many treatments had not provided a full 10 weeks protection. Disease control in the surrounding commercial crop was superior to that in the trial plots and this was attributed to use of a fourth spray of Benlate + Actipron in early October.

Good control of light leaf spot was demonstrated on leaves of both Dolmic and Gabion with all the fungicide programmes. However, control of light leaf spot on buttons of cv Dolmic was less effective than on leaves and some differentiation of treatment efficacy was detected.

As disease control on the two varieties in Devon was similar early in the season (see Tables 5 and 6) the differences between varieties at the final harvest (Tables 8 and 9) probably reflect differences in persistence of treatments rather than varietal effects.

The benefits of using adjuvants or mixtures of products were not apparent until the final assessments. The addition of Actipron improved control of ringspot on Dolmic (Table 8) and Gabion (Table 9) over Benlate + Agral but had less effect on control of light leaf spot. Most of the two-spray mixtures gave good control of ringspot and were comparable to Benlate + Actipron treatments. However Benlate + Bayfidan was less effective against ringspot on cv Gabion (Tables 7 and 9) than other mixtures. The benefits of mixtures were less apparent for light leaf spot control and few differences reached statistical significance.

It is thought that part of the ringspot population at the Devon site was resistant to benomyl and other MBC fungicides. Confirmatory tests are being progressed under MAFF Chief Scientists Group funding. Benlate continued to give good control at this site which contrasts with poor control in Eire and Australia recently. It was noticeable however that Benlate + Actipron gave better control of ringspot than Benlate + Agral this year. This was not apparent under slightly lower disease pressure in 1988.

Conclusions

- * Assessments made on two dates in Devon on different varieties suggested that some treatments gave control for about 6 weeks whilst others gave good control for 10 weeks.
- * All treatments gave good control of ringspot on leaves and buttons. The ranking order of products in order of effectiveness was Benlate + Actipron, Bravo + Agral, Benlate + Agral and Bayfidan.
- * Control of light leaf spot was achieved up to 18 October particularly with mixtures of fungicides Benlate + Bravo, Bayfidan + Bravo and Folio + Benlate.
- * Light leaf spot was only partially controlled on buttons 10 weeks after the final spray. Benlate + Bravo and Benlate + 2% Actipron which gave 31% and 37% control respectively were the most effective treatments.
- * The addition of Actipron to Benlate improved the control of ringspot over Benlate + Agral at harvest and influenced light leaf spot control when used at 2%.
- * There were small benefits from using mixtures of fungicides and differences were generally not statistically significant. Benlate + Bayfidan was less effective than other mixtures against ringspot 10 weeks after the final spray.

Recommendations

This report completes the two year contract for this project. Comparative data on light leaf spot and ringspot has been obtained but this clearly forms a small base from which to extrapolate to brassica production as a whole in the UK. I recommend that work of this kind should be extended to a wider range of sites and be modified to include:

- (a) products with new or pending recommendations
- (b) other diseases (powdery mildew, alternaria, downy mildew, white blister)
- (c) programmes in which products alternate
- (d) sites with fungicide resistant strains of pathogens

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Storage of Data

Site records will be stored at Starcross (Clovelly site) and Wye (Dunkirk site) for a period of 2 years.

APPENDIX I

Table A Details of site and crop on trial plots, Clovelly, Devon

Soil Series:	Neath
Soil Texture:	Sandy clay loam
Drainage:	Good
Soil analysis:	
pH	6.1
P Index	2
K Index	2
Mg Index	2
Cultivar:	Dolmic and Gabion
Planting Date:	18 May 1989
Spacing:	0.50 x 0.75 m
Fertiliser:	
(kg/ha)	
(i)	62.5 N, 34.3 P, 62.5 K
(ii)	18.75 N mid-June, 28 N early August and mid September
Herbicides:	
(i)	Treflan (pre planting)
(ii)	Ramrod + Dacthal c 8 June
Fungicides to surrounding crop:	Benlate + 1% Actipron 3 Aug, 23 Aug, 12 Sept, c 3 Oct
Insecticides:	
(i)	Ambush (July & August)
(ii)	Aphox (mid September)
Harvest date:	18 October and 21 November 1989

APPENDIX I

Table B Details of site and crop on trial plots Dunkirk, Kent

Soil Series:	Hamble 1
Soil Texture:	Silty loam
Drainage:	Good
Soil analysis:	
pH	6.6
P Index	4
K Index	3
Mg Index	2
Cultivar:	Rampart
Planting Date:	6 June (modules)
Spacing:	0.51 x 0.77 m
Fertiliser: (kg/ha) on 17 May	135 N, 75 P, 75 K
Top Dressing:	None (land received a heavy dose of chicken manure over winter).
Herbicides:	Decimate (at drilling)
Insecticides:	Metasystox + Ambush C. Trial plots received additional Ambush C sprays on 15 September and 25 October.
Harvest date:	12 December 1989

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