Contract Report C88/0437
Brussels Sprouts: Control of
Fungal Diseases 1988
Undertaken for Horticultural
Development Council (FV/25/88)

Agricultural Development and Advisory Service

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CONTENTS

# BRUSSELS SPROUTS : CONTROL OF FUNGAL DISEASES 1988


## Summary

The fungicides Bayfidan, Benlate and Bravo 500 were applied at recommended rates with various adjuvants or in two way mixtures to brussels sprouts variety Richard in Cornwall and variety Rampart in Kent. All treatments were applied three times between late August and early October as overhead sprays in 600 litres of water/ha.

High levels of ring spot developed on leaves and buttons in Cornwall and all treatments gave control (range 60% with Bravo & Agral to 100% with Benlate & 1% Actipron and Benlate & Bravo). Control of light leaf-spot was achieved with all treatments except Bravo & Agral in Cornwall and ranged from 24% (Bayfidan & Bravo) to 52% (with Benlate & 1% Actipron). Fungicides increased the proportion of marketable buttons in Cornwall from 1% in the untreated to 54% in most effective treatment. Lower disease pressure from light leaf spot at the Kent site was more effectively control (range 79-100% on middle buttons). Fine black spotting was the main blemish at the Kent site and this was attributed to environmental and pest factors rather than disease. Fungicides did not reduce this non-pathological spotting.

**PRINCIPAL WORKERS**

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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.

..... P Gladders MA PhD
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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 button 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 benomyl 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 1988 and there is limited information on the effectiveness of these new products.

Some difficulties have been experienced in controlling ring spot 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 Mitchell, Cornwall (cv Richard) and Dunkirk, Kent (cv Rampart). Site details and husbandry are given in Appendix I.

### Design

A randomised block design was used with 4 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.

### Treatments

### Fungicides and Adjuvants

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

| Fungicide | a. c. | Amount a. c. in product | Dose rate product/ha |
|---|---|---|---|
| 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 |
| Adjuvants | | | |
| 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 500 + 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 |

All treatments were applied as 3-spray programmes:-

| | | | |
|---|---|---|---|
| Cornwall | 23 August | 16 September | 10 October |
| Kent | 17 August | 7 September | 30 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 was recorded on 10 plants per plot when assessable levels were detected. The harvest sample consisted of 100 buttons (taken as 10 button from each of 10 plants and representative of the whole plant). 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 Vanance and treatment means separated by using Duncan's Multiple Range Test.

## Results

Table 3 Summary of disease severity on untreated plants

| Disease | Cornwall | Kent |
|---|---|---|
| on leaves (October) | | |
| ringspot | *** | * |
| alternaria | | ** |
| light leaf spot | * | * |
| downy mildew | | * |
| white blister | | *** |
| powdery mildew | | * |
| on buttons (at harvest) | | |
| light leaf spot | *** | * |
| ring spot | *** | |
| downy mildew | | * |
| white blister | | * |
| black spotting | | * |

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

Table 4 Effect of fungicides on ring spot on leaves, Cornwall

| Treatment | Mean % leaf area affected | |
|---|---|---|
| | 10 October | 31 October |
| Untreated control | 3.7 b | 18.5 c |
| Benlate + Agral | 1.0 a | 1.4 a |
| Benlate + 1% Actipron | 0.1 a | 0 a |
| Benlate + 2% Actipron | 0.1 a | 0 a |
| Bayfidan | 0.7 a | 6.3 b |
| Bayfidan + Agral | 0.7 a | 1.6 a |
| Bravo 500 + Agral | 0.7 a | 1.9 a |
| Benlate + Bayfidan | 0.2 a | 0.9 a |
| Benlate + Bravo 500 | 0.3 a | 0.6 a |
| Bayfidan + Bravo 500 | 0.4 a | 1.1 a |
| SED (27 degrees of freedom) | 0.49 | 1.95 |
| Coefficient of variation (%) | 89.6 | 85.5 |

Treatment means followed by the same letter do not differ significantly

Table 5 Retention of lower leaves on 10 October and 24 October at Mitchell, Cornwall

| Treatment | Mean Index of Leaf Retention (1-5 scale) | |
|---|---|---|
| | 10 October | 24 October |
| Untreated control | 3.8 d | 4.0 d |
| Benlate + Agral | 2.3 bc | 2.8 bc |
| Benlate + 1% Actipron | 1.5 ab | 2.0 ab |
| Benlate + 2% Actipron | 1.0 a | 1.8 a |
| Bayfidan | 2.3 bc | 3.0 c |
| Bayfidan + Agral | 2.8 c | 3.0 c |
| Bravo 500 + Agral | 2.3 bc | 2.5 abc |
| Benlate + Bayfidan | 2.0 bc | 2.5 abc |
| Benlate + Bravo 500 | 1.8 ab | 2.5 abc |
| Bayfidan + Bravo | 2.0 bc | 2.5 abc |
| SED (27 degrees of freedom) | 0.42 | 0.42 |
| Coefficient of Variation (%) | 27.7 | 22.3 |

Treatment means followed by the same letter do not differ significantly

Scale 1 - good leaf retention (>80%)
5 poor leaf retention (<20%)

Table 6 Effect of fungicides on button diseases and marketability at harvest, 16 November, Cornwall

| Treatment | % Buttons with Ring spot | % Buttons with Light leaf spot | % Marketable buttons |
|---|---|---|---|
| Untreated control | 52.3 c | 83.5 d | 1 a |
| Benlate + Agral | 2.3 a | 60.3 abc | 34 bcd |
| Benlate + 1% Actipron | 0.0 a | 40.0 a | 53 e |
| Benlate + 2% Actipron | 1.5 a | 47.5 ab | 48 de |
| Bayfidan | 15.5 ab | 56.3 abc | 26 bc |
| Bayfidan + Agral | 10.0 ab | 52.8 abc | 36 cde |
| Bravo 500 + Agral | 21.0 b | 70.0 cd | 17 ab |
| Benlate + Bayfidan | 1.3 a | 57.8 abc | 38 cde |
| Benlate + Bravo 500 | 0.0 a | 43.8 ab | 54 e |
| Bayfidan + Bravo | 10.0 ab | 63.3 bc | 25 bc |
| SED (27 degrees of freedom) | 7.21 | 8.87 | 8.58 |
| Coefficient of variation (%) | 89.7 | 21.8 | 36.6 |

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

Cornwall

Ring spot was present from August onwards but only reached assessable levels in early October (Table 4), when all treatments gave good control. By late October the lower leaves were senescent and assessments on 31 October excluded the dying leaves. All treatments continued to give control of ring spot on leaves but Bayfidan alone gave less control than all other treatments. A further foliage assessment on 16 November showed a decrease in the severity of ring spot to 10% total leaf area affected and all treatments including Bayfidan gave significant control (range 0.1% area in Benlate + Actipron and Benlate tank mixes to 1.8% area with Bravo 500 + Agral).

All treatments increased leaf retention (Table 5) which was largely attributable to ring spot control.

When buttons were harvested on 16 November both ring spot and light leaf spot were present on many buttons. The marketable category (less than 5% button surface with blemish) indicates that both ring spot and light leaf spot were each often affecting more than 5% button area. All treatments except Bravo + Agral improved the marketable fraction and gave control of light leaf spot. Ring spot was more effectively controlled than light leaf spot particularly where Benlate was used. The inclusion of 1% Actipron with Benlate improved the percentage marketable buttons over Benlate + Agral.

The severity of button diseases was reassessed on 2 January after 6 weeks in cold storage (<5 $^{o}$C) and the results are given in Table 7. Treatments differences were similar to those observed on 16 November but marketable percentage increased because of loss of wing leaves. After storage 55% of untreated buttons had 25-50% of button area with light leaf spot and ring spot lesions.

Table 7 Marketability of sprouts after cold storage for 6 weeks, Mitchell, Cornwall

| Treatment | % buttons per category | |
|---|---|---|
| | Class I | Class I & II |
| Untreated control | 0 a | 0 a |
| Benlate + Agral | 29 bc | 72 de |
| Benlate + 1% Actipron | 45 cd | 84 e |
| Benlate + 2% Actipron | 52 d | 88 e |
| Bayfidan | 12 ab | 38 bc |
| Bayfidan + Agral | 20 ab | 53 cd |
| Bravo 500 + Agral | 7 a | 24 b |
| Benlate + Bayfidan | 30 bc | 73 de |
| Benlate + Bravo 500 | 46 cd | 80 e |
| Bayfidan + Bravo | 14 ab | 54 cd |
| SED (27 degrees of freedom) | 9.2 | 11.4 |
| Coefficient of variation (%) | 51.4 | 28.6 |

Treatment means followed by the same letter do not differ significantly

Table 8 Incidence of light leaf spot on buttons on 20 December, Kent

| Treatment | % buttons affected | |
|---|---|---|
| | Middle of Stem | Top of Stem |
| Untreated control | 14.5 b | 5.5 ab |
| Benlate + Agral | 3.0 a | 3.3 ab |
| Benlate + 1% Actipron | 0.3 a | 0.8 a |
| Benlate + 2% Actipron | 0.8 a | 1.3 ab |
| Bayfidan | 3.0 a | 6.8 b |
| Bayfidan + Agral | 1.8 a | 0.5 a |
| Bravo 500 + Agral | 0.0 a | 0.3 a |
| Benlate + Bayfidan | 0.0 a | 0.3 a |
| Benlate + Bravo 500 | 0.3 a | 0.3 a |
| Bayfidan + Bravo | 0.0 a | 0.0 a |
| SED (27 degrees of freedom) | 2.62 | 2.51 |
| Coefficient of variation (%) | 157.7 | 189.5 |

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

Table 9 Incidence of white blister on button on 20 December, Kent

| Treatment | % buttons affected | |
|---|---|---|
| | Middle of Stem | Top of Stem |
| Untreated control | 2.8 | 0.3 |
| Benlate + Agral | 1.3 | 0.0 |
| Benlate + 1% Actipron | 0.5 | 0.3 |
| Benlate + 2% Actipron | 3.3 | 0.0 |
| Bayfidan | 3.0 | 0.3 |
| Bayfidan + Agral | 1.0 | 0.3 |
| Bravo 500 + Agral | 0.0 | 0.0 |
| Benlate + Bayfidan | 4.3 | 1.3 |
| Benlate + Bravo 500 | 0.0 | 0.0 |
| Bayfidan + Bravo | 0.5 | 0.0 |
| SED (27 degrees of freedom) | 2.29 | 0.3 |
| Coefficient of variation (%) | 193.4 | 188.9 |

There were no significant differences between treatments.

Table 10 Incidence of non pathological spotting on buttons on 20 December, Kent

| Treatment | % buttons affected | |
|---|---|---|
| | Middle of Stem | Top of Stem |
| Untreated control | 20.8 | 8.3 |
| Benlate + Agral | 27.8 | 12.5 |
| Benlate + 1% Actipron | 16.0 | 16.8 |
| Benlate + 2% Actipron | 21.3 | 20.0 |
| Bayfidan | 12.0 | 9.0 |
| Bayfidan + Agral | 13.8 | 11.0 |
| Bravo 500 + Agral | 14.3 | 10.3 |
| Benlate + Bayfidan | 24.3 | 10.8 |
| Benlate + Bravo 500 | 10.3 | 15.2 |
| Bayfidan + Bravo | 26.8 | 25.5 |
| SED (27 degrees of freedom) | 10.09 | 8.08 |
| Coefficient of variation (%) | 76.3 | 82.0 |

There were no significant differences between treatments.

**Results (Kent)**

Disease was not recorded at the site until 25 October, when white blister, (63% plants affected) alternaria (A. brassicae) (40% plants affected), light leaf spot (20% plants affected), downy mildew (15% plants affected), powdery mildew (10% plants affected) and ring spot (5% ring spot plants affected) were observed at trace levels.

At the final assessment (20 December), buttons on the lowest third of the stem had blown and were both unassessable and unmarketable. Diseases were assessed separately on buttons from the middle third of the stem and from the top third of the stem.

Light leaf spot was the most important fungal disease recorded at this assessment, followed by white blister and downy mildew.

The most prevalent button blemish, however, was non-pathological spotting, (Table 9) which was caused by the following two factors:

a) feeding and fouling damage caused by cabbage aphid (Brevicoryne brassicae).

b) pepper spotting of the youngest exposed surface of button tissue. This was thought to result from exceptionally soft growth which was damaged by low temperatures (-4.0°C) or thick fogs (possibly carrying some unidentified pollutant), which occurred late in November.

The site was picked over immediately after the final assessment. However, a final visit to the site on 9 February revealed that downy mildew had caused severe damage to remaining buttons, and such was the damage that an adjacent block of cv Gabion was totally unmarketable.

Disease levels were low and in general their distribution was variable across the trial area, which resulted in very high coefficients of variation for all data.

Light leaf spot was the most important button disease recorded on 20 December, affecting, 14.5% of 'middle' button and 5.5% of 'top' buttons (Table 8).

All treatment reduced, the incidence and severity of light leaf spot on 'middle' buttons (Table 8). In untreated plots light leaf spot affected 0.6% button area. Differences between fungicide treatments, however, were not detected.

The incidence of light leaf spot on 'top' buttons was reduced by all treatments except Bayfidan, Benlate + Agral and Benlate + Actipron (2%). The addition of Agral to Bayfidan improved disease control significantly.

Furthermore, there was a trend to suggest that Benlate was most efficacious when used with 1% Actipron.

Although white blister was the most prevalent leaf disease on 25 October, white blister affected only 2.8% of 'middle' buttons and 0.3% of 'top' buttons on 20 December (Table 9).

Downy mildew was present at low levels (2% affected) only on 'middle' buttons. Significant treatment effects were not detected.

Non-pathological spotting was the most important cause of blemish to buttons on December 20, (Table 10) but treatments had no effect on either incidence or severity of this disorder.

## Discussion

Good control or ring spot was achieved on leaves and buttons for up to 5 weeks after the third spray. All the fungicides used gave significant control including Bayfidan which has no label recommendation for ring spot control. Light leaf spot control was less satisfactory and this was consistent with previous ADAS results which have shown variability from site to site. Control was achieved under low disease pressure in Kent but reached only 52% in Cornwall. Greater understand of disease development is likely to needed in order to achieve consistently high levels of control.

Non-pathological spotting can reduce marketability but fungicides gave no control (Table 10). Fine black spotting has been associated with mild wet conditions in late November and December and over maturity of buttons. These factors appear to have contributed to the problems in Kent. Tunely harvesting of buttons therefore remains a key element of maintaining button quality.

The use of wetter or adjuvants gave little or no benefit but appear to improve consistency under moderate to high disease pressure. The use of Agral improved the performance of Bayfidan on ring spot (Table 4) and light leaf spot (Table 8). Actipron at the 2% rate improved leaf retention over the Agral treatment (Table 5) and there were some trends in disease control, particularly light leaf spot, which merit further investigation. There was little difference between the three fungicide mixtures used and the most effective single fungicide plus additive treatment.

## Conclusions

1. All treatments gave good control of ring spot on leaves and buttons. A provisional ranking order of products in order of effectiveness is Benlate, Bravo 500, Bayfidan.

2. Control of light leaf spot was poor under high disease pressure. The more promising treatments were Benlate + 1% Actipron, Benlate + Bravo 500 and Bayfidan + Agral.

3. The addition of Agral to Bayfidan significantly improved control of light leaf spot and ring spot in some assessments.

4. The addition of 1% Actipron to Benlate gave significantly more marketable buttons than Benlate + Agral.

5. Non-pathological spotting was the main blemish in Kent and this was not reduced by fungicide treatments.

## Recommendations

Treatments should be evaluated for a second year at 2 sites. Additional commercial products should be added if new recommendations are made.

## Acknowledgements

I gratefully acknowledge that individual sites were managed by O W Jones, Starcross and D Slawson, Wye and provided by Mr J Best, Mitchell, Cornwall and Mr V Howland, Dunkirk, Kent.

## Storage of data

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

APPENDIX I

Table A Details of site and crop on trial plots, Mitchell, Cornwall

| | |
|---|---|
| Soil series: | Denbigh |
| Soil texture: | clay loam |
| Drainage: | Good |
| Soil analysis: | |
| pH | 5.4 |
| P Index | 2 |
| K Index | 1 |
| Mg Index | 1 |
| Cultivar: | Richard |
| Planting date: | 13 June 1988 |
| Spacing: | 0.50 x 0.75 m |
| Fertiliser: (kg/ha) | |
| (i) | 242 N, 121 P, 121 K, pre planting |
| (ii) | 88 N, 15 July |
| | 88 N, 26 August |
| Herbicides: | |
| (i) | Ramrod at planting |
| (ii) | Semeron at 5 true leaves |
| Fungicides to surrounding crop: | Benlate + Rovral + Agral on 17 Sept and 7 and late Oct. |
| Insecticides: | |
| (i) | Yaltox at planting |
| (ii) | Decis 2 applications |
| Harvest date: | 16 November 1988 |

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 | 5.5 |
| P Index | 3 |
| K Index | 3 |
| Mg Index | 2 |
| Cultivar: | Rampart |
| Planting Date: | 24 May (modules) |
| Spacing: | 0.56 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). |
| Spacing: | 0.56 x 0.77 m |
| Herbicides: | Treflan (at drilling)<br>Ramrod (26 May)<br>Semeron (14 July) |
| Insecticides: | None |
| Harvest Date: | 20 December 1988 (where applicable) |

* adjacent to previous seasons Brussels sprout crop.

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