VG97051
Ascochyta rot on peas and its control

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Serve-Ag Research

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VG97051

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Ascochyta rot on peas and its control

Final Report

Conducted on behalf of

Horticultural Research and Development Corporation

Project VG97051
(Project completion 30/06/00)

by

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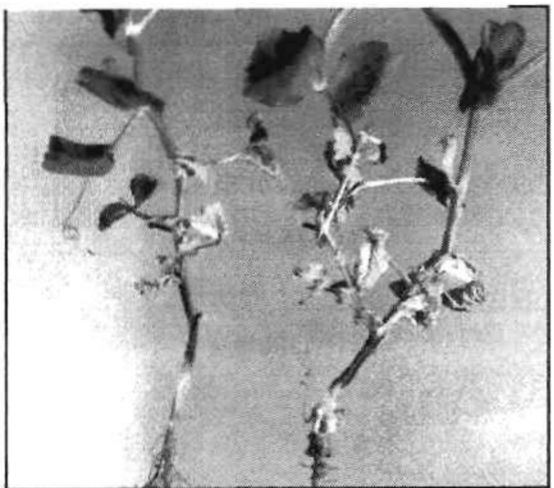
ASCOCHYTA COLLAR ROT



Early collar rot on young plants, which causes dark brown to black lesions of the stem, just above ground level.

- **Ascochyta collar rot** is the most important and widespread disease of processing peas, which poses severe constraints to production.

Plants in low-lying areas are prone to severe collar rot, causing them to mature and flower early compared to the rest of the crop.

- This disease can cause **reduced crop yields** and **uneven pea maturity**.

- As the crop approaches maturity, collar rot infected plants become highly **susceptible to desiccation** under dry conditions, compared to non-infected plants.

Mature plants affected by severe collar rot. The infected lower stems become constricted and brittle.

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Industry Summary

Ascochyta (collar rot) disease is a major concern in pea production. Seed dressings offer some protection early in the life of the crop, but exposure to high levels of soilborne inoculum can lead to lower stem or collar rot infection later in crop development.

This three-year HRDC funded project, which commenced in 1997, aimed to identify options for managing collar rot disease due to soilborne inoculum. Three main areas of study were development of a fungicide control program, evaluation of late fertiliser applications on severely infected crops, and field inspections in commercial crops to identify factors contributing to collar rot disease incidence and severity.

- Studies showed that high ***spray volumes*** (1000 to 3000 L/ha) result in little or no reduction in collar rot severity, when compared to standard practice (150 to 250 L/ha).
- In crops with severe collar rot disease, early foliar treatments of ***Bravo 720®*** (1.1, 1.6 and 1.8 L/ha), using low to moderate spray volumes (250 to 400 L/ha), reduced the severity but not the incidence of collar rot, improving plant growth and increasing pea yield. However, no improvement was apparent in crops that had only mild to moderate collar rot. Bravo, a relatively low cost product, is already registered for use on peas for downy mildew control. Efficacy data generated in this project will be used to support an application to NRA to extend the use of Bravo for *Ascochyta* control on peas.
- ***Shirlan***, applied at a high rate of 500ml/ha, also reduced collar rot severity and improved plant growth, although at lower rates (100 to 200ml/ha), it had little or no effect. Shirlan, a relatively high cost product when applied at 500ml/ha, is not considered to be economical to the pea industry.
- ***Copper hydroxide***, the only product currently registered for *Ascochyta* control on peas, was found to be ineffective against collar rot in this project.
- ***Other products*** evaluated in this project, including Impact (applied as in-furrow, top dressing or foliar treatments), Calixin, Oxine, AgriFos and Rovral, did not reduce collar rot severity.
- ***Late nitrogen or fungicide applications*** did not improve severely diseased plants in field trials.
- All treatments with post-emergent ***herbicide sprays*** increased collar rot severity when compared to the untreated control. However, pre-emergent herbicides Command and Frontier gave good weed control with good plant tolerance, and did not appear to influence collar rot severity.
- ***Field inspections*** were conducted on commercial crops in 1997 and 1998 to identify field factors that may contribute to severe collar rot infection. This knowledge could be used to assist with ground selection, and to identify areas that are prone to severe collar rot, where the use of Bravo would be beneficial.
- An ***information booklet*** on collar rot management has been published and distributed to growers, field officers and other representatives of the processing pea industry. Project findings have also been presented at conferences, and at field and extension days, throughout the life of the project.

Technical Summary

Ascochyta (collar rot) disease is a major concern in pea production. Seed dressings offer some protection early in the life of the crop, but exposure to high levels of soilborne inoculum can lead to lower stem or collar rot infection later in crop development.

This three-year HRDC funded project, which commenced in 1997, aimed to identify options for managing collar rot disease due to soilborne inoculum. Three main areas of study were development of a fungicide control program, evaluation of late fertiliser applications on severely infected crops, and field inspections in commercial crops to identify factors contributing to collar rot disease incidence and severity.

Field Trials

Field trials were conducted in Tasmania and Western Australia to evaluate and identify fungicide products and application methods, including low and high spray volumes, foliar sprays, top dressing and in-furrow soil applications, for the control of collar rot.

Studies conducted in 1997 showed that high volume sprays (1000 to 3000 L/ha) resulted in little or no reduction of collar rot severity, and are unlikely to be used by growers, where the standard practice is 150 to 250 L/ha.

Foliar applications of Bravo 720® (1.1, 1.6 and 1.8 L/ha), applied using low to moderate spray volumes (250 to 400 L/ha), reduced the severity but not the incidence of collar rot in six field trials conducted over two years. In crops that had severe collar rot disease, Bravo treatments reduced disease severity, resulting in improved plant growth and higher pea yield. Bravo treatments need to be applied early, at about 5 to 6 nodes or at first sign of the disease, for effective collar rot management.

In crops that had mild to moderate collar rot, Bravo applications did not improve growth or yield.

Foliar sprays of Bravo also reduced *Ascochyta* infections of leaf and pods caused by *Mycosphaerella pinodes* and *Phoma pinodella*, and could potentially be used in the snow pea industry to prevent or reduce *Ascochyta* black spot infections on pods.

Bravo is a relatively low cost product and its use is considered economically feasible to the Tasmanian processing pea industry. Bravo is already registered for use on peas for downy mildew control. Efficacy data generated in this project will be used by CropCare Pty Ltd, to apply to NRA to extend the use of Bravo for *Ascochyta* control on peas.

Shirlan, applied at a high rate of 500ml/ha, also reduced collar rot severity and improved plant growth. At lower rates of 100 to 200ml/ha, Shirlan did not reduce disease severity. Shirlan, a relatively high cost product when applied at 500ml/ha, is not considered to be economical for the pea industry.

Copper hydroxide, the only product currently registered for *Ascochyta* control on peas, was found to be ineffective against collar rot in this project. Other products evaluated, including Impact (applied as in-furrow, top dressing or foliar treatments), Calixin, Oxine, AgriFos and Rovral, did not reduce the extent of collar rot. Late nitrogen or fungicide applications did not improve severely diseased plants in three field trials. Therefore, the practice of applying fungicides or fertiliser near the end of plant maturity to improve growth, or to alleviate nutrient deficiencies due to collar rot, has no proven beneficial effects.

Field Survey & Information Booklet

Field inspections were conducted on commercial crops in 1997 and 1998, to identify field factors and cultural practices that may contribute to severe collar rot infection in commercial crops.

Field survey findings were compiled in a booklet titled "*Ascochyta* Collar Rot on Processing Peas", an information booklet outlining the impact of cultural practices on the *Ascochyta* disease, details of pathogens, disease symptoms, disease cycle, favourable conditions, and methods for managing the disease, which was published and circulated to the processing pea industry in August 2000.

It is anticipated that this information booklet will be used to assist with ground selection and with avoiding practices that could enhance collar rot severity. The information could also be used to identify areas or crops that will be prone to severe collar rot, where the use of Bravo applications would be beneficial.

Project findings were also presented at conferences, and at field and extension days, throughout the life of the project.

Background

Ascochyta disease has influenced pea production for as long as peas have been grown. To guard against this disease, current industry practice is to use Apron and P-Pickel T as a seed dressing. While this offers some protection early in the life of the crop, control is not always adequate, due to plant exposure to high levels of soilborne inoculum, leading to lower stem or collar rot. Collar rot occurs on almost all pea crops after the expiry of the initial protective period provided by the fungicide seed dressings. To date, there are no effective control measures for managing soilborne infections.

This project aimed to identify options for managing collar rot disease due to field inoculum. Studies conducted in this project have been separated into the following sections:

1. Evaluation and development of a fungicide control program.
2. Evaluation of the suitability of late fertiliser applications on severely infected crops.
3. Field inspections to identify important field factors that may contribute to severe collar rot infection in commercial crops.
4. Effects of herbicides on plant susceptibility to collar rot.
5. Extension of project studies, including the publication of an information booklet on collar rot management.

Target Disease

Ascochyta disease complex, caused by the *Ascochyta* pathogens:

- *Phoma pinodella (Ascochyta pinodella)*
- *Mycosphaerella pinodes (Ascochyta pinodes)*
- *Ascochyta pisi*

Common disease names:

- Collar rot
- *Ascochyta* rot
- *Ascochyta* blight
- Black spot
- Black stem
- Foot rot
- Leaf spot

SECTION 1: DEVELOPMENT OF A FUNGICIDE CONTROL PROGRAM

Fungicide Product Formulations

Product	Active ingredient	Concentration of active ingredient	Formulation	Fungicide Group*
Agri-Fos Supa	Phosphonic Acid	400g/L	Liquid	Y
Aliette	Fosetyl-Al	800g/kg	Water Dispersable Granules	Y
Bravo	Chlorothalonil	720g/L	Suspension Concentrate	Y
Calixin	Tridemorph	750g/L	Emulsifiable Concentrate	E
Impact	Flutriafol	250g/L	Soluble Powder	C
Kocide	Copper Hydroxide	400g/kg	Dry Flowable Ganules	Y
Oxine	Chlorine Dioxide	20g/L	Liquid	-
Ridomil Gold MZ	Mancozeb + Metalaxyl	640g/kg + 40g/kg	Wettable Powder	Y & D
Rovral	Iprodione	250g/L	Suspension Concentrate	B
Shirlan	Fluazinam	500g/L	Suspension Concentrate	Y

* The fungicide group, used for resistance management, was developed by Avcare (Appendix iii).

1.1: The effects of spray volumes on the efficacies of Shirlan and Calixin

Summary

Calixin was not effective in reducing collar rot incidence or severity. Shirlan applied at 0.5L/ha did not reduce the percentage of plants infected by collar rot, although it reduced collar rot severity in the pre-harvest assessments for Trials 1 and 2. The addition of a spreading agent, Pulse, did not improve the fungicide efficacy. Unfortunately, Shirlan was deemed to be uneconomical and unlikely to be adopted by growers.

Introduction

Shirlan (fluazinam) and Calixin (tridemorph) were applied at different spray water volumes, to evaluate efficacy for the control of *Ascochyta* collar rot. Shirlan was shown to reduce collar rot severity in a field trial conducted in 1996, although its efficacy may be dependent on its spray water volume (final report). Calixin has been used for *Ascochyta* disease control in New Zealand.

Trial Details

	TRIAL 1	TRIAL 2
LOCATION	Wesley Vale (DD)	East Devonport (RM)
VARIETY	Small Sieve Freezer	Small Sieve Freezer
SOIL TYPE	Ferrosol	Ferrosol
REPLICATES	4	4
SOWING DATE	25 June 97	8 July 97
HARVEST DATE	21 Nov 97	24 Nov 97
PLOT SIZE	2m x 10m	2m x 10m
TRIAL DESIGN	Randomised complete block	Randomised complete block
PLANT DENSITY	100 seeds per m^2	100 seeds per m^2
IRRIGATION	None	None
PREVIOUS CROP	Peas	Poppies

1.1: The effects of spray volumes on the efficacies of Shirlan and Calixin (Cont.)

Materials & Methods

Two field trials were conducted on the north-west coast of Tasmania, to evaluate the fungicides Shirlan and Calixin, and foliar application methods, for the control of collar rot due to field inoculum. These trials examined the effects of different spray volumes (200, 500, 1000 and 3000 litres/hectare), and the addition of a spreader (Pulse) on spray coverage and *Ascochyta* disease control (Tables 1.1.1 & 1.1.2).

Twenty plants were removed from each trial plot, and assessed for collar rot incidence and severity, before and at harvest. The disease severity was rated as the percentage of stem nodes affected by collar rot.

All data sets were tested for normality before analysis and, where appropriate, transformations applied to normalise the data. With the exception of the percentage of plants with leaf spots in Trial 2, an analysis of variance was performed using StatGraphics Plus 2.0. Comparisons were made of mean values using Duncan's Multiple Range Test.

Results & Discussions

Collar rot was already evident prior to fungicide applications, at about 6 to 7-node growth stage, at the two trial sites. Collar rot incidence was high in both trials at the first disease assessment, being 100% in Trial 1 (Table 1.1.1) and ranging from 93% to 100% in Trial 2 (Table 1.1.2).

Table 1.1.1: The effects of fungicide treatments in Trial 1, at 106 and 149 days after sowing (DAS)

No.	Product	Product rate/ha	Water volume	Timing (weeks after sowing)	% Collar rot incidence	% Collar rot severity	
						106 DAS	149 DAS
1	Calixin	500ml	500	6, 9 & 12	100	22.65 c	39.38 a
2	Calixin	500ml	1000	6, 9 & 12	100	23.51 c	39.66 a
3	Shirlan	500ml	200	6, 9 & 12	100	21.19 c	37.52 a
4	Shirlan	500ml	500	6, 9 & 12	100	18.08 b	42.05 a
5	Shirlan	500ml	1000	6, 9 & 12	100	15.61 ab	31.52 a
6	Shirlan + spreader	500ml	1000	6, 9 & 12	100	16.80 ab	35.17 a
7	Shirlan	500ml	1000	6, then 4 sprays at 7 day interval	100	14.43 a	30.69 a
8	Untreated	n/a	n/a	n/a	100	29.00 d	42.85 a

Within the same column, means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

1.1: The effects of spray volumes on the efficacies of Shirlan and Calixin (Cont.)

All plants were infected at subsequent disease assessments in both trials. In Trial 1, Calixin and Shirlan applications caused a significant reduction in collar rot severity compared to the untreated control in the first disease assessment at 106 days after sowing (Table 1.1.1). Shirlan caused a greater reduction in disease severity compared to Calixin at 106 days after sowing. At harvest, no significant differences in collar rot severity could be observed between treatments in Trial 1.

Calixin caused no significant reduction in the collar rot severity in Trial 2 (Tables 1.2), even at high water volume spray application.

Shirlan, applied at 7-day intervals in 5 sprays, at the high water volume of 1000L/ha until shortly before harvest, resulted in the lowest disease severity in both trials. However, the frequent use of Shirlan, at a cost of about $100/ha per application, was considered by the pea industry in Tasmania to be uneconomical, and unlikely to be adopted by growers.

There was little or no reduction of collar rot severity with Shirlan when applied in 3 sprays with increasing spray volumes, even though tests with water sensitive papers showed that increasing water volume improved the fungicide spray coverage of stems near ground level. The addition of a spreading agent, Pulse, did not improve efficacy.

Table 1.1.2: The effects of fungicide treatments in Trial 2, at 98 and 139 days after sowing (DAS)

No.	Product	Product rate/ha	Water volume	Timing (weeks after sowing)	% Collar rot incidence at 98 DAS#	% Collar rot severity	
						98 DAS*	139 DAS*
1	Calixin	500ml	1000	6, 9 & 12	98.75	21.14 c	45.74 cd
2	Calixin	500ml	3000	6, 9 & 12	98.75	18.71 abc	50.13 d
3	Shirlan	500ml	200	6, 9 & 12	98.75	17.54 ab	42.69 bc
4	Shirlan	500ml	1000	6, 9 & 12	100.00	20.46 bc	38.57 ab
5	Shirlan	500ml	3000	6, 9 & 12	100.00	17.39 ab	39.48 abc
7	Shirlan + spreader	500ml	1000	6, 9 & 12	96.25	17.02 a	38.07 ab
6	Shirlan	500ml	1000	6, then 4 sprays at 7 day interval	93.75	17.29 ab	36.48 a
8	Untreated	n/a	n/a	n/a	98.75	21.06 c	43.16 bc

*Not significantly different at the 5% level according to analysis of variance.

* Within the same column, means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control

Summary

Six field trials were conducted in the 1998 season to evaluate the efficacy of fungicide applications (3 in Tasmania and 3 in Western Australia). These trials indicated that foliar applications of Bravo 720 (1.1 and 1.6L/ha) in three sprays, were effective in reducing collar rot severity, by reducing the extent of the stem base infections. Bravo, especially at the higher rate of 1.6L/ha, showed a consistent trend of reducing collar rot severity in 3 foliar spray trials. Bravo is a low cost fungicide product, and could be cost effective to the pea industry.

Foliar applications of Shirlan (500ml/ha) only caused a significant reduction in collar rot severity in one of the 3 trials. A mixture of Bravo and Shirlan, when applied at 1.1L and 250ml/ha in Trial 1, also reduced collar rot severity, but not when applied at 1.1L and 100ml/ha in Trial 4. In addition to the inconsistent level of reduction in collar rot at 500ml/ha, Shirlan was not considered to be economical for the pea industry.

Impact, applied as either in-furrow or foliar applications, did not reduce collar rot incidence or severity compared to the untreated control in Trial 3. The lack of control by Impact in-furrow treatments may have been due to the late development of collar rot in the trial area. Collar rot was evident on plants at 13 weeks after sowing, when plants had reached the flowering stage.

Introduction

Following studies conducted in 1997 (Section 1.1), further field trials were conducted to evaluate low cost fungicide products, as well as other new products, for collar rot control. Impact, which was registered for the control of blackleg disease caused by *Phoma lingam* on canola, was also included in the evaluations. A total of 6 field trials were conducted in the 2 major processing pea production regions; 3 in north-west Tasmania, and 3 in the Kendenup region of Western Australia.

These trials were conducted to evaluate the efficacy of different fungicides, application methods and rates. Fungicide application methods examined included foliar, in-furrow and top dressing applications.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Field trials conducted in Tasmania

Trial Details

	TRIAL 1	TRIALS 2 & 3
LOCATION	East Devonport (AB)	Forth (FVRS)
VARIETY	Small Sieve Freezer	Small Sieve Freezer
SOIL TYPE	Ferrosol	Ferrosol
REPLICATES	4	5
SOWING DATE	17 July 98	18 August 98
Harvest date	24 November 98	8 & 10 December 98
PLOT SIZE	1.6m x 8m	1.6m x 8m
TRIAL DESIGN	Randomised complete block	Randomised complete block
PLANT DENSITY	100 seeds per m^2	100 seeds per m^2
IRRIGATION	None, relied on rainfall only	Irrigated with fixed Monsoon irrigator

Materials & Methods

Fungicide applications

Foliar fungicide applications were applied using a knapsack precision sprayer fitted with 1.5 metre boom, with TX26 hollow cone jets, at 483L/ha water volume and 400 kPa pressure. Foliar fungicide treatments were first applied at 10 weeks after sowing, at 5-6 node growth stage, when about 30% of plants showed first signs of collar rot infection.

In Trial 3, for in-furrow fungicide treatments (1, 2 & 4), Impact was first sprayed evenly onto NPKS fertiliser, allowed to air-dry and then drilled in proximity to the pea seed, using a Fiona drill. The treated fertiliser (N-P-K-S at 3-15-13-1 with molybdenum) was applied at the rate of 130kg/ha. Untreated fertiliser was used in treatments 3, 5, 6, 7 & 8. In treatment 3, nitrogen fertiliser (35 % ammonium nitrate) was treated with Impact in the same manner as described for NPKS above. The air-dried granular fertiliser was then broadcast evenly onto plots at week 8 after sowing.

Ascochyta *inoculation*

At 29 days after sowing, the two trials at Forth were inoculated with *Ascochyta pinodella*. The pathogen was cultured in a mixture of 200g autoclaved millet seed, 200g sand and 120ml distilled water. The inoculum mix was bulked to 6 times its weight with coarse grade sand, before being spread evenly onto the four centre rows of peas in each plot. Each plot had 40g of inoculum mix applied.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Assessments

An emergence count was conducted in Trial 3 to check for any adverse effects due to Impact in-furrow applications. Plant density was determined in a 1m^2 area in the centre of each plot.

At harvest, a disease assessment was conducted by collecting consecutive plants in the middle of each treatment plot and rating them for collar rot incidence and severity. In Trial 1, 20 plants per plot were assessed, and 30 plants per plot were assessed in Trials 2 and 3. The disease severity of collar rot and leaf spot was based on the percentage of plant length infected. Collar rot and leaf spot due to *Ascochyta* infections were confirmed with isolations of the fungus on agar medium.

Yield assessments were conducted on treatments that showed potential in the control of collar rot disease. In Trial 1, pea pods were handpicked and shelled, from 20 plants in each plot. In Trial 2, peas were harvested from 3 areas of 1m^2 per plot, and processed in a mechanical pea viner at the Forthside Vegetable Research Station for yield assessment.

Analysis

All data sets were tested for normality before analysis and, where appropriate, transformations applied to normalise the data. With the exception of the percentage of plants with leaf spots in Trial 2, an analysis of variance was performed using StatGraphics Plus 2.0. Comparisons were made of mean values using Duncan's Multiple Range Test.

Kruskall-Wallis Test was conducted on the data set of the percentage of plants with leaf spots in Trial 2, which could not be normalised. Consequently, comparison was made on the median values of the percentage of plants with leaf spots.

Results & Discussion

Trial 1

The first signs of collar rot were noted on a few plants at the 5-node growth stage, 8 weeks after sowing.

Fungicide treatments did not reduce collar rot incidence, with 100% of plants in the trial being infected. Oxine, Agrifos, Rovral and low rates of Shirlan (100 ml/ha) did not reduce collar rot severity at 80 and 130 days after sowing (Table 1.2.1).

Fungicide treatments did not reduce *Ascochyta* leaf incidence or severity at 80 days after sowing. *Ascochyta* leaf infection was not assessed at 130 days after sowing, due to the high incidence of downy mildew and *Septoria* leaf infections on all plants and in all treatments, making it impossible to visually separate their primary cause.

In the initial assessment, at 80 days after sowing, foliar sprays of Impact, Bravo, Kocide and Shirlan (Treatments 1, 3, 4, 5, 6, 7 and 8) significantly reduced collar rot severity at 80 days after sowing, compared to the untreated control. However, at 130 days after sowing, only Treatments 4 and 7, Shirlan at 500 ml/ha, and the Combined Bravo and Shirlan, significantly reduced collar rot severity, compared to the untreated control (Table 1.2.1). Although not significant, Bravo treated plants tended to have lower collar rot severity at 130 days after sowing than the untreated control.

Table 1.2.1: Treatment effects on disease severity, at 80 and 130 days after sowing (DAS)

No.	Treatment	Product rate/ha	Application schedule	% Leaf spot severity at 80 DAS	% Collar rot severity at 80 DAS	% Collar rot severity at 130 DAS
1	Impact	500ml	Weeks 10, 12 and 14 after sowing.	45.3 a	12.3 abcd	21.5 cd
2	Shirlan 100	100ml		48.4 a	14.4 cdef	21.7 cd
3	Shirlan 250	250ml		46.1 a	12.9 abcd	18.2 abc
4	Shirlan 500	500ml		43.8 a	9.7 a	14.8 a
5	Bravo 1.1	1.1L		45.4 a	11.2 abc	18.7 abcd
6	Bravo 1.6	1.6L		47.1 a	11.4 abc	18.3 abc
7	Bravo 1.1 + Shirlan 250	1.1L + 250ml		40.6 a	10.2 ab	16.5 ab
8	Kocide	2.2kg		53.6 a	13.5 abcde	22.0 cd
9	Oxine	483ml		51.3 a	17.1 ef	26.8 e
10	AgriFos	3L		47.7 a	15.2 def	23.4 de
11	Rovral	2L		42.2 a	13.7 bcdef	20.3 bcd
12	Untreated	N/a	N/a	50.8 a	17.3 f	22.3 cde

Within the same column, means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 1.2.2: Treatment effects on pod numbers and pea weight, at 130 days after sowing

No.	Treatment	Total no. of pods / 20 plants	Pea weight (g/20 plants)
4	Shirlan 500	105.3 c	170.9 b
5	Bravo 1.1	98.5 bc	158.2 ab
6	Bravo 1.6	101.0 c	168.2 ab
7	Bravo 1.1 + Shirlan 250	89.5 ab	160.8 ab
12	Untreated	87.0 a	144.9 a

Within the same column, means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

In the selective yield assessments, there was a significant increase in the number of pods from plants treated with 500ml/ha Shirlan, and the 1.1 and 1.6 L/ha Bravo treatments, compared to untreated plants (Table 1.2.2).

There was a significant increase in the weight of shelled peas from plants treated with 500ml/ha Shirlan. Plants treated with Bravo, and combined Bravo and Shirlan, showed a trend of higher yields, compared to the untreated control.

Trial 2

At the first spray application, a high incidence of downy mildew infection was observed on plants at the 5 to 6 node growth stage (7 weeks after sowing) in all plots. Collar rot appeared much later, at 8-node growth stage (10 weeks after sowing).

Table 1.2.3: Treatment effects on disease incidence and severity, at 112 days after sowing

No.	Treatment	Product rate/ha	Application schedule	% Collar rot severity *	% Plants with leaf spots #	% Leaf spot severity *
1	Impact 500	500ml	Weeks 7, 10 and 13 after sowing.	17.3 abcd	87 bc	63.3 bc
2	Shirlan 250	250ml		17.4 abcd	97 c	67.6 bc
3	Shirlan 500	500ml		20.2 d	83 bc	58.8 b
4	Bravo 1.1	1.1L		14.2 ab	50 ab	40.2 a
5	Bravo 1.6	1.6L		14.1 a	42 ab	38.6 a
6	Kocide 2.2	2.2kg		17.3 abcd	83 bc	60.6 b
7	Oxine 5 ppm	120ml		18.2 cd	93 c	72.9 bc
8	Oxine 20 ppm	483ml		17.1 abcd	97 c	83.2 c
9	AgriFos	3L		16.4 abc	100 c	76.5 bc
10	AgriFos + Kocide	3L 2.2kg		17.9 bcd	90 bc	65.6 bc
11	AgriFos + Oxine 20ppm	3L 483ml		17.2 abcd	100 bc	82.9 c
12	Untreated Control	N/a	N/a	17.2 abcd	97 c	73.6 bc

Within the same column, median values followed by a same letter are not significantly different at the 5% level according to Kruskall-Wallis Test.

* Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

As in Trial 1, all plants in the trial area were infected with collar rot, indicating that the fungicide treatments did not reduce collar rot incidence.

No significant differences in collar rot severity could be found between treatments (Table 1.2.3). This was partially due to high variability in the disease severity. Although not significant, plants treated with Bravo tended to have the lowest percentage of collar rot severity.

The Bravo treatments (1.1. and 1.6 L/ha), significantly reduced the percentage of plants with *Ascochyta* leaf spots, compared to the untreated control. Bravo applications also significantly reduced leaf spot severity, by preventing infection of the top half of plants.

Table 1.2.4: Treatment effects on pea yield, at 118 days after sowing

No.	Treatment	Pea weight $g/3m^2$	Pea weight g/m^2	Maturity Index (MI) *	Pea yield adjusted to MI235 (g/m^2)*
4	Bravo 1.1	879.4	305	339	256
5	Bravo 1.6	915.6	293	342	252
12	Untreated control	846.0	282	329	233

*Not significantly different at the 5% level according to analysis of variance.

Many of the softer seeds were crushed in the pea viner. Hence, the maturity index and yield was highly variable between replicates. As a result of the high variability, there was no significant difference between treatments, although it is interesting to note a trend of higher pea yields in the Bravo treatments (Table 1.2.4).

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Trial 3

Impact applied in-furrow had no adverse effect on seedling establishment (Table 1.2.5) in this trial. As in Trial 2, there was a high incidence of downy mildew and *Septoria* infection noted on plants at the 5 to 6 node growth stages in all treatment plots.

Table 1.2.5: Treatment effects on seedling density, disease incidence and severity, at 43 days after sowing (DAS)

No.	Treatment	Product rate/ha	Application method & schedule	Seedling density/m^2 *
1	Impact in-furrow 400	400ml	In-furrow soil application of Impact treated fertiliser	101.8
2	Impact in-furrow 800	800ml	As above	91.4
3	Impact top dressing 400	400ml	Impact treated fertiliser applied as a top dressing at week 8	96.4
4	Impact in-furrow 400 + foliar spray 500	400ml + 500ml	Impact in-furrow application, followed by one foliar spray at week 10	96.6
5	Impact foliar sprays 500	500ml	Foliar sprays at weeks 7, 10 and 13	98.6
6	Kocide early foliar spray	2.2kg	Foliar sprays at weeks 7, 10 and 13	95.2
7	Kocide late foliar spray	2.2kg	Late foliar sprays at weeks 13 and 15	91.4
8	Untreated	n/a	n/a	91.8

* Not significantly different at the 5% level according to analysis of variance.

Collar rot symptoms developed late (at 13 weeks after sowing), with most of the plants infected only at flowering stage. Impact, either in-furrow or foliar applications, did not reduce collar rot incidence or severity compared to the untreated control (Table 1.2.6). The lack of control by Impact in-furrow treatments may be due to the late development of collar rot in the trial area. The protective period for Impact in-furrow applications is not known.

None of the fungicide treatments reduced the percentage of plants with leaf spots (Table 1.2.6). As *Ascochyta* leaf infection occurred late in the plants' growth stage, only the late foliar application of Kocide (Treatment 7) resulted in significantly lower leaf spot severity than the untreated control (Table 1.2.6).

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Table 1.2.6: Treatment effects on leaf infections, at 115 days after sowing (DAS)

No.	Treatment	% Plants with collar rot *	% Collar rot severity *	% Plants with leaf spots *	% Leaf spot severity **
1	Impact in-furrow 400	100	13.8	100	96.3 b
2	Impact in-furrow 800	100	12.9	100	97.3 b
3	Impact top dressing 400	100	14.7	100	97.5 b
4	Impact in-furrow 400 + Foliar spray 500	100	12.8	100	95.6 ab
5	Impact foliar sprays 500	100	12.0	100	94.9 ab
6	Kocide early foliar spray	100	12.9	100	94.5 ab
7	Kocide late foliar spray	100	12.5	100	91.8 a
8	Untreated	100	13.1	100	97.6 b

* Not significantly different at the 5% level according to analysis of variance.

** Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Field trials conducted in Western Australia

Trial Details

	TRIAL 4	TRIAL 5	TRIAL 6
LOCATION	Kendenup WA	Kendenup WA	Mt Baker WA
VARIETY	Quantum	Quantum	Quantum
SOIL TYPE	Sandy Loam	Sandy Loam	Sandy Loam
REPLICATES	5	5	5
SOWING DATE	10 June 98	10 June 98	17 July 98
PLOT SIZE	2m x 6m	2m x 6m	2m x 6m
TRIAL DESIGN	Randomised complete block	Not completely randomised	Not completely randomised
PLANT DENSITY	30 plants m2	30 plants m2	30 plants m2
IRRIGATION	None	None	None

Materials & Methods

Fungicide application

All foliar sprays were applied using a pressurised hand sprayer fitted with a 1.5 metre boom and Hardi 4110-12 fan jets, at 500L/ha spray volume and 400 kPa pressure. Impact in-furrow was sprayed evenly onto a granular fertiliser, and air-dried before use. The treated fertiliser was drilled in proximity to the pea seed when sowing.

Assessment

Thirty plants from each plot were assessed for *Ascochyta* collar rot, and disease incidence was tabulated as a percentage of the total number of plants per plot infected. Disease severity was assessed according to the following ratings: 0 = no infection; 1 = up to 1cm rot; 2 = 1cm to 3cm rot; 3 = 3cm rot and above.

Analysis

In Trial 4, the collar rot disease severity rating was analysed using Kruskall-Wallis Test because the data set could not be normalised. Analysis was not conducted on Trials 5 and 6 due to incomplete randomised trial designs.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Results & Discussion

Trial 4

This trial was conducted in an area with high grass weed pressure. All plants, regardless of treatment, had *Ascochyta* collar rot (Table 1.2.7). Only two of the treatments, Bravo 1.6 L/ha and the combination of Bravo and Shirlan, reduced the collar rot severity ratings.

Table 1.2.7: Effects of foliar applications on disease incidence and severity

No.	Treatment	Product rate/ha	Application schedule	% Plants infected with collar rot	Severity rating
1	Shirlan 100	100ml	Weeks 6, 8 and 10	100	2 b
2	Shirlan 250	250ml		100	2 b
3	Shirlan 500	500ml		100	2 b
4	Bravo 1.1	1.1L		100	2 b
5	Bravo 1.6	1.6L		100	1 a
6	Bravo 1.1 + Shirlan 100	1.1L 100ml		100	1 a
7	Kocide 2.2 early spray	2.2kg		100	2 b
8	Kocide 2.2 late spray	2.2kg	Weeks 12 and 14	100	2 b
9	Untreated control	n/a	n/a	100	2 b

Within the same column, median values followed by a same letter are not significantly different at the 5% level according to Kruskall-Wallis Test.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Trial 5

This trial was located near a dam, and was prone to severe waterlogging after rainfall. As a result, seedling emergence, at 43 days after sowing, was highly variable, ranging from 0-100% in replicate plots. Therefore, the apparent differences in the percentage of emerged plants (Table 1.2.8) could not be attributed to treatment effects. Only one disease assessment was conducted in this trial, at 86 days after sowing, before it was terminated due to excessive damage caused by waterlogging. Like seedling emergence, disease incidence and severity were highly variable between replicate plots. In addition, the incomplete randomisation of replicate plots made it impossible to draw any conclusion from this trial.

Table 1.2.8: Effects of in-furrow and foliar applications at 86 days after sowing (04/09/98)

No.	Treatment	Product rate/ha	Application method	% Plants emerged	% Plants infected by collar rot	Severity rating
1	Impact in-furrow 400	400 ml	In-furrow soil application of Impact treated fertiliser	38	20	0.2
2	Impact in-furrow 800	800 ml		66	30	1.6
3	Impact with fertiliser - top dressing	400 ml	Impact treated fertiliser applied as a top dressing at week 6	60	16	1.6
4	Impact in-furrow & Foliar spray (week 9)	400 + 500 ml	Impact in-furrow application, followed by one foliar spray at week 9	37	24	1.2
5	Early Impact foliar sprays (week 6)	500 ml	Foliar sprays at weeks 6, 8 and 10	58	4	0.4
6	Late Impact foliar sprays (week 12)	500 ml	Foliar sprays at weeks 12 and 14	64	48	0.8
7	Untreated control	n/a	n/a	65	67	3

Statistical analysis was not conducted, as the trial design was not completely randomised.

1.2: Evaluation of foliar and in-furrow fungicide applications for disease control (Cont.)

Trial 6

Plants in this trial became severely affected by root-knot nematodes, resulting in very sparse and stunted plants. Nematode damage later became very severe in the trial area and hence no data was collected after 30th September 1998.

Collar rot disease in the trial area ranged from none to moderate. There appeared to be a trend of lower percentages of collar rot incidence and severity with fungicide treatments, when compared to the untreated control (Table 1.2.9). However, we need to be cautious in attributing the differences in collar rot incidence and severity to treatment effects, as nematodes were the main cause of damage in the trial area, and some damage in the lower stems may have been caused by wind damage on weak plants.

Table 1.2.9: Effects of in-furrow and foliar applications, at 49 and 75 days after sowing (DAS)

No.	Treatment	Product Rate/ha	Application Method	% Plants infected with collar rot		Severity rating	
				04/09/98 49 DAS	30/09/98 75 DAS	04/09/98 49 DAS	30/09/98 75 DAS
1	Impact in-furrow 400	400 ml	In-furrow soil application of Impact treated fertiliser	85	85	1.0	1.0
2	Impact in-furrow 800	800 ml		56	70	0.8	1.0
3	Impact in-furrow + foliar spray	400 ml + 500 ml	In-furrow soil application of Impact treated fertiliser, followed by one spray at week 9	48	60	0.8	1.0
4	Impact foliar spray	500 ml	Foliar spray at weeks 6, 8 and 10	4	20	0.8	2.0
5	Kocide Foliar spray	2.2 kg		55	55	1.6	1.6
6	Kocide + Shirlan foliar spray	2.2 g + 100 ml		80	80	2.8	2.8
7	Untreated control	n/a	n/a	100	100	3.0	3.0

Statistical analysis was not conducted on the data set, as the trial design was not completely randomised.

1.3: Refining fungicide application methods

Summary

All the field trials indicated that plants sprayed with Bravo tended to have lower collar rot severity by reducing the extent of the disease on the stem base. Bravo applications, however, did not reduce the percentage of plants infected.

A field trial conducted in Tasmania showed that 1 to 5 spray applications of Bravo reduced collar rot severity, only when applied early. In the early applications, the first spray was applied at 5-6 node growth stage, when the first signs of the disease became evident on infected plants. In the late spray applications, the first spray was applied at 7-8 node growth stage. Leaf infections usually occurred later in the crop stage, and hence the late spray application reduced the extent of leaf infections compared to the earlier sprays.

In processing pea production in Tasmania, leaf and pod infections are not considered to be important. However, they are important in snow pea production, where control of leaf and pod infections can minimize blemishes and distortion.

The trials also showed that fungicide sprays are economically beneficial only when applied to crops that were sown under less than ideal conditions. In Tasmania, grey sandy loam soils are less fertile and prone to water stress, compared to red ferrosol soil. Hence, crops sown in sandy loam soils tend to be slower to emerge, and when infected by collar rot, tend to result in reduced growth and yield. Trials 1 and 2, conducted in Tasmania on grey sandy loam soil, had severe collar rot. Under such conditions, the reduction in collar rot severity due to Bravo applications, may also bring about improved growth, reduced numbers of dead plants, and increased yields. When grown in red ferrosol soils, collar rot infected plants had greater tolerance for the disease, and this resulted in little or no impact on yield. Hence the reduction in collar rot severity in Trials 3 and 4 did not show any obvious improvement in yield.

Introduction

The purpose of these trials was to evaluate the efficacy of different types and rates of fungicides, applied as foliar applications, for the control of collar rot. These trials also examined the effects of the number of sprays and the timing of the spray applications.

1.3: Refining fungicide application methods (Cont.)

Field trials conducted in Tasmania

Trial Details

	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4
LOCATION	Wesley Vale (KA)	Forth (TP)	Forth (DP)	Forth (DB)
VARIETY	Small Sieve Freezer	Small Sieve Freezer	Small Sieve Freezer	Small Sieve Freezer
SOIL TYPE	Kurrosol; sandy loam	Kurrosol; sandy loam	Ferrosol; clay loam	Ferrosol; clay loam
REPLICATES	5	5	5	5
SOWING DATE	01 July 99	14 July 99	23 June 99	26 June 99
HARVEST DATE	17 Nov 99	22 Nov 99	24 Nov 99	15 Nov 99
PLOT SIZE	1.6m x 8m	1.6m x 8m	1.6m x 8m	1.6m x 8m
TRIAL DESIGN	Randomised complete block	Randomised complete block	Randomised complete block	Randomised complete block
PLANT DENSITY	100 seeds per m^2	100 seeds per m^2	100 seeds per m^2	100 seeds per m^2
IRRIGATION	Not irrigated	Not irrigated	Irrigated with travelling irrigator	Irrigated with travelling irrigator

Materials & Methods

Four field trials were set up in 1999 on the north-west coast of Tasmania. Foliar fungicide treatments were applied using a knapsack precision sprayer fitted with 1.5 metre boom, with TX8 hollow cone jets at 198 L/ha water volume and 500 kPa pressure.

Twenty plants were taken at random, at about 0.5m intervals, from the middle of each treatment plot for disease assessment. The disease severity of collar rot and leaf spot was based on the percentage of plant length infected.

Yield assessments were conducted only on treatments that showed significant differences in the control of collar rot disease. Peas were harvested from plants in a $1m^2$ area from the centre of each plot.

All data sets were tested for normality before analysis, and where appropriate, transformations applied to normalise the data. An analysis of variance was performed using StatGraphics Plus 2.0. Comparisons of mean values were made using Duncan's Multiple Range Test.

1.3: Refining fungicide application methods (Cont.)

Results & Discussions

Trial 1

This trial was conducted within a commercial crop in a poor sandy loam soil area. The early fungicide treatments were first applied at the 6-node growth stage (5 weeks after sowing), when about 40% of the plants had initial collar rot symptoms.

Table 1.3.1: The effects of different spray timings of 3 applications of 1.8L/ha Bravo, on the severity of collar rot infections in Trial 1, at 103 and 140 days after sowing (DAS)

No.	1st spray (weeks after sowing [WAS] and plant growth stage)	2nd spray (days after 1st spray)	3rd spray (days after 1st spray)	Total length of plant at 103 DAS	% Collar rot at 103 DAS*	Total length of plant at 140 DAS*	% Collar rot at 140 DAS*
1	5 WAS, 6 nodes	Nil	Nil	58 b	10 a	83 ab	14 cd
2	5 WAS, 6 nodes	10	Nil	58 b	10 a	80 ab	12 abc
3	5 WAS, 6 nodes	10	20	58 b	9 a	85 b	11 ab
4	5 WAS, 6 nodes	5 sprays at 10 days interval		59 b	10 a	83 ab	11 ab
5	6 WAS, 6 nodes	10	20	57 b	10 a	82 ab	13 bcd
6	8 WAS, 7-8 nodes	10	20	52 a	14 b	75 a	16 de
7	N/a	N/a	N/a	52 a	13 b	79 ab	18 e

* Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

When assessed at 103 and 140 days after sowing, all plants in the trial area had collar rot, confirming the findings of field trials conducted in previous seasons, that Bravo treatments did not reduce collar rot incidence.

At 103 days after sowing, plants treated with early spray applications (Treatments 1 to 5), were bigger and had less severe collar rot, when compared to plants treated with late spray applications (Treatment 6) or the untreated plants (Table 1.3.1). At harvest, 140 days after sowing, the mean lengths of the treated plants were similar to the untreated plants. However, the collar rot severity in Treatment 6 and the untreated control remained higher than for plants that were treated early.

The reduction in collar rot severity at 103 days after sowing was similar with 1, 2, 3 or 5 sprays for plants treated with early spray applications. However at 140 days after sowing (harvest), an increase in the number of sprays from 1 to 3 resulted in a greater reduction in collar rot severity. There was no difference in the level of disease control between 3 and 5 sprays.

1.3: Refining fungicide application methods (Cont.)

Table 1.3.2: The effects of different spray timings of 3 applications of 1.8L/ha Bravo, on the extent of leaf spots in Trial 1, at 103 and 140 days after sowing (DAS)

No.	1st spray (weeks after sowing [WAS], plant growth stage)	2nd spray (days after 1st spray)	3rd spray (days after 1st spray)	% Leaf spot at 103 DAS^*	% Leaf spot at 140 DAS^*
1	5 WAS, 5-6 nodes	Nil	Nil	28 c	63 c
2	5 WAS, 5-6 nodes	10	Nil	25 bc	62 c
3	5 WAS, 5-6 nodes	10	20	22 a	60 bc
4	5 WAS, 5-6 nodes	5 sprays at 10 days interval		17 a	46 a
5	6 WAS, 5-6 nodes	10	20	24 abc	58 bc
6	8 WAS, 7-8 nodes	10	20	27 c	54 b
7	N/a	N/a	N/a	33 d	64 c

* Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

^ Based on % of plant length affected by *Ascochyta* leaf spots.

At 103 days after sowing, even though all the plants assessed had *Ascochyta* leaf spots, Bravo spray applications had reduced the extent of leaf infections, when compared to the untreated control (Table 1.3.2). At 140 days after sowing, only Treatments 4 and 6, which included late spray applications, had significantly reduced the extent of leaf infections, compared to the control and other treatments, indicating that leaf infections occurred later in the growth stage.

Although leaf spot and pod infections of processing peas are not considered to be important, in snow peas an increase in leaf spots often leads to pod infections, which could reduce the quality of the pods or make them unmarketable.

1.3: Refining fungicide application methods (Cont.)

Table 1.3.3: The effects of different spray timings of 3 sprays of 1.8L/ha Bravo, on the pea yield in Trial 1

No.	1st spray (weeks after sowing [WAS] and plant growth stage)	2nd spray (days after 1st spray)	3rd spray (days after 1st spray)	Standard deviation of adjusted yield (Adjusted yield range)	Yield corrected to standard maturity index of 235 (g/m2)
1	5 WAS, 6 nodes	Nil	Nil	109 (354-597)	469
2	5 WAS, 6 nodes	10	Nil	112 (177-552)	453
3	5 WAS, 6 nodes	10	20	142 (304-641)	475
4	5 WAS, 6 nodes	5 sprays at 10 days interval		96 (345-606)	495
5	6 WAS, 6 nodes	10	20	113 (342-610)	457
6	8 WAS, 7-8 nodes	10	20	76 (293-462)	382
7	N/a	N/a	N/a	14 (317-348)	329

The yield of pea seeds obtained from plants within a 1m^2 area of each replicate plot was highly variable (Table 1.3.3), as many less mature and softer peas were crushed during the harvest and extraction process. The high variability in the yield range in Treatments 1 to 6 showed that many pods and plants in those treatments were still maturing. Untreated plants, however, appeared to have reached full maturity and hence had low standard deviation and yield range. When the yields were adjusted to a standard maturity index of 235 for comparison, there was a trend of higher yields in plants treated with early fungicide sprays compared to the untreated plants and plants treated with late fungicide sprays.

1.3: Refining fungicide application methods (Cont.)

Trial 2

This trial was conducted within a commercial crop in a sandy loam area. All plants in the trial area had both collar rot and downy mildew. Downy mildew was widespread, affecting almost all plants in all the treatments. There was no obvious difference in the incidence or severity of downy mildew between the treatments. At the flowering stage, many plants became stunted due to severe water stress as a result of low rainfall, no irrigation, and poor water retention in the sandy loam soil. This crop was not harvested commercially due to the poor growth of peas and the high weed pressure.

Table 1.3.4: The effects of different fungicide treatments on the severity of collar rot infections in Trial 2, at 132 days after sowing

No.	Product & Rate (L/ha)	1st spray (plant growth stage)	2nd spray (days after 1st spray)	3rd spray (days after 1st spray)	Length of plant	% Collar rot	% Dead plants
1	1.1L/ha Bravo	5-6 nodes	10	20	57 a	28 a	1 a
2	2.5L/ha Ridomil (2.5kg/ha)	5-6 nodes	10	20	54 a	38 b	3 a
3	350g/100L Aliette	5-6 nodes	10	20	52 a	23 a	4 a
4	1.8L/ha Bravo	5-6 nodes	10	Nil	54 a	20 a	0 a
5	1.8L/ha Bravo	5-6 nodes	10	20	54 a	19 a	1 a
6	1.8L/ha Bravo	5-6 nodes	20	Nil	58 a	26 a	0 a
7	1.8L/ha Bravo	5-6 nodes	20	30	53 a	29 a	1 a
8	Untreated control	N/a	N/a	N/a	48 a	44 b	22 b

Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

At 132 days after sowing, although the mean plant lengths were not significantly different between treatments (Table 1.3.4), plants treated with Bravo or Aliette had lower collar rot severity compared to the untreated plants or those treated with Ridomil. There was also a trend of lower collar rot severity when Bravo was applied at the higher rate of 1.8L/ha, compared to 1.1L/ha. This observation was consistent with the findings in Trial 1.

There were higher numbers of dead or desiccated plants in the untreated control, compared to those treated with fungicides (Table 1.3.4). This indicated that, apart from poor growing conditions, ie. poor soil and drought, diseases like collar rot and downy mildew might have placed additional stress on the untreated plants.

1.3: Refining fungicide application methods (Cont.)

Trial 3

This trial was conducted in a commercial crop in a ferrosol, clay loam soil type. At 103 days after sowing, the crop, which was irrigated regularly, looked healthy even though all plants had collar rot. At harvest, there were no differences in plant length between the untreated control and any of the treatments (Table 1.3.5). The untreated plants, however, had a higher collar rot severity rating than fungicide treated plants. The use of Shirlan with Bravo, either in alternation or combined, did not reduce collar rot severity compared to Bravo applied alone.

Table 1.3.5: The effects of different treatments in Trial 3 on the severity of collar rot infections, at 140 days after sowing

No.	Treatments	Total length of plant (cm)	% Collar rot
1	1.1L/ha Bravo	81 a	13 a
2	1.8L/ha Bravo	80 a	12 a
3	Alternate 1.8L/ha Bravo & 0.1L/ha Shirlan	82 a	12 a
4	Alternate 1.8L/ha Bravo & 0.2L/ha Shirlan	83 a	11 a
5	Alternate 1.8L/ha Bravo & 0.3L/ha Shirlan	81 a	12 a
6	Combined 1.1L/ha Bravo + 0.1L/ha Shirlan	80 a	11 a
7	Combined 1.1L/ha Bravo + 0.2L/ha Shirlan	80 a	12 a
8	Combined 1.8L/ha Bravo + 0.2L/ha Shirlan	79 a	11 a
9	Untreated control	83 a	17 b

Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

As in Trial 1, yields from each of the replicate plots were highly variable (Table 1.3.6), and many less mature and softer peas were crushed in the mechanical extraction process. When yields were adjusted to a standard maturity index of 235 for comparison, there was a trend of higher yields in the untreated plants compared to fungicide treated plants. This difference may be related to the greater pod maturity observed on untreated plants compared to those on treated plants.

Table 1.3.6: The effects of different treatments in Trial 3 on pea yield, at 154 days after sowing

No.	Treatments	Yield corrected to std 235 MI (g/m2)	Standard deviation (Yield range) deviation
1	1.1L/ha Bravo	438	130 (285-636)
2	1.8L/ha Bravo	490	71 (387-567)
8	Combined 1.8L/ha Bravo + 0.2L/ha Shirlan	502	90 (366-597)
9	Untreated control	557	57 (479-629)

1.3: Refining fungicide application methods (Cont.)

Trial 4

This trial was conducted within a commercial crop in a ferrosol, clay loam soil. The pea crop appeared to be healthy, with excessive shoot growth and an average plant height of 125cm at harvest. Collar rot was first noted at 79 days after sowing, on less than 1% of plants in the trial area, indicating that the disease incidence was low. At harvest, all plants assessed had collar rot, although the disease severity was low, ranging from 4 to 7% of the lower stem length infected. While the fungicide treatments reduced collar rot severity compared to the untreated control, there were no differences in the collar rot severity between the different fungicide treatments (Table 1.3.7).

While the fungicide treatments reduced collar rot severity compared to the untreated control, no yield assessment was conducted, as there were no obvious differences in plant growth and pea pod production between treatments.

Table 1.3.7: The effects of different fungicide treatments in Trial 4 on the severity of collar rot infections, at 140 days after sowing.

No.	Product & Rate (L/ha)	1st spray (plant growth stage)	2nd spray (days after 1st spray)	3rd spray (days after 1st spray)	% Collar rot incidence	Length of plant (cm)	% Collar rot severity
1	1.1L/ha Bravo	6 nodes	10	20	84 a	125 a	5 a
2	Combined 1.1L/ha Bravo + 0.1L/ha Shirlan	6 nodes	10	20	91 a	128 a	4 a
3	Alternate 1.8L/ha Bravo & 0.1L/ha Shirlan	6 nodes	10	20	98 a	126 a	5 a
4	1.8L/ha Bravo	6 nodes	10	Nil	99 a	125 a	6 a
5	1.8L/ha Bravo	6 nodes	10	20	92 a	123 a	6 a
6	1.8L/ha Bravo	6 nodes	20	Nil	86 a	125 a	4 a
7	1.8L/ha Bravo	6 nodes	20	30	91 a	124 a	5 a
8	Untreated control	N/a	N/a	N/a	98 a	122 a	7 b

Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

1.3: Refining fungicide application methods (Cont.)

Field trials conducted in Western Australia

Trial Details

	TRIAL 5	TRIAL 6
LOCATION	Kendenup WA (DDP)	Kendenup WA (DDP)
VARIETY	Quantum	Quantum
SOIL TYPE	Sandy Loam	Sandy Loam
REPLICATES	5	5
SOWING DATE	21 June 99	21 June 99
HARVEST DATE	22 November 99	22 November 99
PLOT SIZE	1.6m x 8m	1.6m x 8m
TRIAL DESIGN	Randomised complete block	Randomised complete block
PLANT DENSITY	30 plants m^2	30 plants m^2
IRRIGATION	None	None

Materials & Methods

Two field trials were set up in 1999, in the Kendenup region of Western Australia. The treatments in the two trials are given in Tables 1.3.8 and 1.3.9.

All foliar sprays were applied using a pressurised hand sprayer fitted with 1.5 metre boom and Hardi 4110-12 Fan Jets, and sprayed at 400L/ha spray volume and 300 kPa pressure. The first spray was applied at 6-node growth stage. Some growers in Western Australia apply Bavistin to control collar rot, so this fungicide was included in the evaluations.

In both trials, ten consecutive plants in the middle of each treatment plot were removed and assessed for *Ascochyta* rot incidence and severity. The disease severity of collar rot and leaf spot was based on the percentage of plant length infected.

Yield assessments were not conducted in either trial, as there were no obvious differences noted between the treatments.

All data sets were tested for normality before analysis and, where appropriate, transformations applied to normalise the data. Analysis of variance was performed using StatGraphics Plus 2.0.

Results & Discussion

In the 1998/1999 season, *Ascochyta* collar rot was not considered to be a threat to pea production in the Kendenup region, as its incidence and severity were considered to be low and appeared to have little or no impact on yield. For the first time, downy mildew was noted to be widespread in most pea crops, but appeared to have no obvious impact on yield.

Trial 5

Table 1.3.8: The effects of different fungicide treatments on the severity of collar rot in Trial 1, at 104 and 122 days after sowing (DAS)

No.	Product & Rate (L/ha)	Spray Schedule	% Collar rot severity at 104 DAS	% Collar rot severity at 122 DAS
1	Bravo 1.1	1st spray at 6 node plant stage, then 3 sprays at 10 day intervals	10 a	16 a
2	Bravo 1.8		11 a	15 a
3	Alternate Bravo 1.8 & Shirlan 0.1		9 a	13 a
4	Alternate Bravo 1.8 & Shirlan 0.2		11 a	14 a
5	Alternate Bravo 1.8 & Shirlan 0.3		15 b	28 b
6	Combined Bravo 1.1 + Shirlan 0.1		10 a	15 a
7	Combined Bravo 1.1 + Shirlan 0.2		11 a	15 a
8	Combined Bravo 1.8 + Shirlan 0.2		12 ab	16 a
9	Bavistin 1.5		12 ab	16 a
10	Untreated control	N/a	12 ab	18 a

Within the same column, means followed by a same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

In this trial, although all plants assessed had collar rot, the disease severity was considered to be mild to moderate. As a result of low collar rot severity, there was no significant reduction in collar rot severity by the fungicide treatments, when compared to the untreated control (Table 1.3.8).

The collar rot severity of plants in Treatment 5, where alternate sprays of 1.8L/ha Bravo and 0.1L/ha Shirlan were applied, was higher compared to both untreated plants and other fungicide treatments. No explanation could be determined for this phenomenon.

1.3: Refining fungicide application methods (Cont.)

Trial 6

In this study, the roots of most of the pea plants in the trial area were infested by root-knot nematodes, thereby causing poor growth. No conclusive results could be drawn from this trial due to this damage. However, it is interesting to note that the untreated plants tended to have more severe collar rot, when compared to the fungicide treated plants (Table 1.3.9).

Trial 1.3.9: The effects of different spray timings of 3 sprays of 1.8L/ha Bravo, on the severity of collar rot infections in Trial 6, at 104 days after sowing

No.	Product & Rate (L/ha)	1st spray (plant growth stage)	2nd spray (days after 1st spray)	3rd spray (days after 1st spray)	% Collar rot severity
1	Bravo 1.8	6	10	Nil	11
2	Bravo 1.8	6	10	20	14
3	Bravo 1.8	6	20	Nil	11
4	Bravo 1.8	6	20	30	12
5	Bravo 1.8	6	5 sprays at 10 days interval		10
6	Untreated control	N/a	N/a	N/a	16

SECTION 2: OTHER FACTORS AFFECTING COLLAR ROT INFECTION

2.1: The effects of late fertiliser applications on crops affected by severe collar rot

Summary

Three trials were conducted during 1997 and 1998 to evaluate the effects of late fertiliser applications on crops affected by severe collar rot. Late nitrogen fertiliser applications or fungicide applications did not reduce disease severity or improve plant vigour in any of the trials conducted.

Introduction

Ascochyta collar rot tends to increase in severity between flowering and pea maturity, affecting water and nutrient uptake. Nitrogen based fertiliser has been applied as a top dressing near the end of plant maturity by some growers, to try to alleviate nutrient deficiency due to severe collar rot. The benefits of this practice have not been proven and it remains a contentious issue. This study, therefore, aimed to investigate the benefits of late fertiliser applications on unthrifty crops that have collar rot.

Trial Details

	Trial 1 (1997)	**Trial 2 (1997)**	**Trial 3 (1998)**
LOCATION	Wesley Vale (DD)	East Devonport (GD)	Moriarty (LM)
VARIETY	Small Sieve Freezer	Small Sieve Freezer	Small Sieve Freezer
SOIL TYPE	Ferrosol	Ferrosol	Ferrosol
REPLICATES	4	4	3
SOWING DATE	25 June 97	7 July 97	18 June 98
HARVEST DATE	21 November 97	28 November 97	23 November 98
PLOT SIZE	20m x 3m	14m x 3m	3m x 5m
TRIAL DESIGN	Randomised complete block	Randomised complete block	Randomised complete block
PLANT DENSITY	100 plants per m^2	100 plants per m^2	100 plants per m^2
IRRIGATION	None	None	Irrigated with travelling irrigator
PLOT BUFFER	2m inter-rows plus 5 metre buffer within rows	2m inter-rows plus 3 metre buffer within rows	Nil
COMMENTS	Site was selected due to pea crop planted in previous season.	Plants were small and sparse at the time the trial was set up.	Stunted plants with very severe collar rot at the 13-node growth stage on 12 October 98, when this trial was set up.

2.1: The effects of late fertiliser applications on crops affected by severe collar rot (Cont.)

Materials & Methods

Product Formulations

• Nitram	-	fertiliser	-	35 % ammonium nitrate
• Impact	-	fungicide	-	250 g/L flutriafol
• Kocide	-	fungicide	-	500 g/kg copper hydroxide
• Wuxal	-	fertiliser		9.9 %nitrogen, 4.3 % phosphorus, 6.1 % potassium, 0.16 % magnesium and trace elements

Trials 1 & 2

Two trials were set up within commercial pea crops located at Wesley Vale, in Tasmania. The treatments were applied at 9 to 10 node growth stage (Tables 2.1.1 & 2.1.2). For Treatments 1 to 3, the fertilisers were broadcast evenly throughout each treatment plot using a hand-held hopper. Wuxal, a liquid fertiliser, was applied using a precision knapsack sprayer with 1000 L/ha water.

Trial 3

Treatments in Trial 3 were applied at 116 days after sowing (week 17 after sowing), in a commercial crop with severe collar rot infection. In Treatment 1, Nitram (35 % ammonium nitrate) was broadcast evenly onto the appropriate plots. In Treatment 2, Impact was sprayed onto Nitram, air-dried and then broadcast evenly within the appropriate plots. Kocide spray was applied using a precision knapsack sprayer, with TX26 hollow cone jet, at 400 kPa and 483 L/ha.

Assessments

Disease assessments were conducted 1 to 2 days prior to commercial harvest. Twenty consecutive plants from the middle of each treatment plot were removed and assessed for collar rot incidence and severity. The disease severity was based on the percentage of plant nodes infected.

Pea yield and maturity were also assessed in trials conducted in Trial 1 and 2. In Trial 1, pods and their pea seeds were removed from 20 plants that were assessed for disease. In Trial 2, plants within a 1m^2 area were harvested, and pea seeds were separated mechanically. In Trial 3, as there were no obvious differences in collar rot severity, or improvement in plant growth in the trial area, no yield assessment was conducted at harvest.

2.1: The effects of late fertiliser applications on crops affected by severe collar rot (Cont.)

Results & Discussions

Table 2.1.1: The effects of late fertiliser applications on collar rot severity and yield of peas in Trial 1

No	Treatment	Crop Stage	Rate (Kg/ha)	Collar rot severity (%)*	Weight of pea seeds in 20 plants (g) *
1	Nitram	9-10 node	125	46	171
2	Nitram	9-10 node	250	44	184
3	Nitram, Triphos, Muriate	9-10 node	125, 95, 80	44	179
4	Wuxal	9-10 node	0.59	46	153
5	Untreated control	9-10 node	N/a	48	163

*Not significantly different at the 5% level according to analysis of variance.

No significant differences in collar rot severity or yield of peas were found in Trials 1 and 2 (Tables 2.1.1 & 2.1.2). No visible differences in growth response were noted in field observations. The 1997/98 season was unusually dry, and the two crops where Trials 1 and 2 were conducted were not irrigated. Collar rot incidence was 100% on all the plants assessed.

Table 2.1.2: The effects of late fertiliser applications on collar rot severity and yield of peas in Trial 2

No	Treatment	Crop Stage	Rate (Kg/Ha)	Collar rot severity (%)*	Weight of peas per m^2 (g)*	Maturity index*
1	Nitram	9-10 node	125	50	875	392
2	Nitram	9-10 node	250	50	823	392
3	Nitram Triphos Muriate	9-10 node	125, 95, 80	50	809	380
4	Wuxal	9-10 node	0.59	53	808	378
5	Untreated control	9-10 node	N/a	48	797	380

*Not significantly different at the 5% level according to analysis of variance.

2.1: The effects of late fertiliser applications on crops affected by severe collar rot (Cont.)

No significant differences in collar rot severity were found in Trial 3 (Table 2.1.3). Collar rot incidence was 100% and the disease severity remained high, with approximately 50% of plant stems affected by collar rot. No improvement in plant vigour was observed. This showed that the late nitrogen fertiliser application or fungicide applications did not reduce disease severity or improve plant vigour.

Table 2.1.3: The effects of fertiliser applications on collar rot severity in Trial 3

No.	Product	Product Rate/ha	Schedule	% Plants with collar rot*	% Collar rot severity*	% Leaf spot severity*
1	Nitram	100 kg	Week 17	100	47.60	84.24
2	Nitram + Impact	100 kg + 800 ml	Week 17	100	48.08	81.61
3	Kocide	2.2 kg	Weeks 17, 18 and 20	100	48.03	85.56
4	Control	N/a	N/a	100	47.66	77.70

* Not significantly different at the 5% level according to analysis of variance.

2.2: The effects of field conditions on collar rot infection

Objectives

A field survey was conducted in Tasmania in 1997 and 1998 to investigate field conditions and cultural practices that may contribute to severe collar rot infection in commercial crops.

Field Inspections

A total of 20 pea crops were investigated in the field survey in the 1997 season. The field survey included sites that were prone to waterlogging or were in locations with previous history of severe *Ascochyta* rot problem. However, due to unusually dry and warm conditions, *Ascochyta* disease did not pose a threat to most of the crops investigated. All the areas prone to waterlogging were dry during most of the season due to very low rainfall. Water stress, due to lack of water, was an important factor in yield reduction on some of the crops surveyed. Therefore, further field studies were conducted in 1998, with a total of 10 pea crops being investigated during the season.

Information on the crops, such as seed treatments, varieties, weed problems, herbicide applications, soil preparations, soil conditions, previous crop history, previous crop trash, paddock profile, and drainage were examined in relation to *Ascochyta* rot disease, and yield.

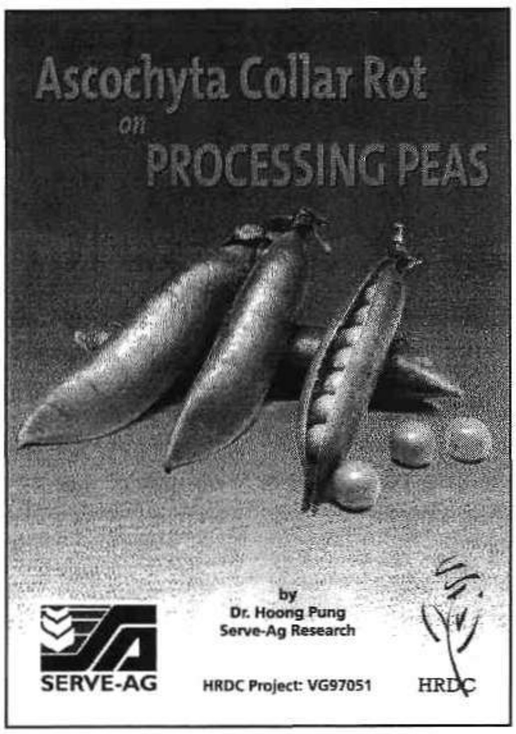
Many photographic records were also taken during these field studies, for use in an information booklet on collar rot management.

Outcomes

The field inspection findings were compiled in an information booklet titled "*Ascochyta* collar rot on processing peas", outlining the impact of cultural practices and field conditions on collar rot severity. A copy of the booklet is in Appendix iv.

Other information presented in the booklet includes details of pathogens, disease symptoms, disease cycle, favourable conditions, and methods for managing the disease.

This booklet was published and circulated to the processing pea industry in August 2000.



2.3: The effects of herbicides on plant susceptibility to collar rot

Summary

All treatments with post-emergent herbicide sprays increased collar rot severity of plants when compared to the untreated control. Herbicide treatments consisting of only pre-emergent herbicide sprays of Command and Frontier gave good weed control with good plant tolerance, and did not increase collar rot severity. The post-emergent herbicides Basagran, Bladex and Lexone, appeared to pre-dispose plants to severe collar rot.

Introduction

Field observations have indicated that applications of post-emergent herbicides often lead to severe collar rot. In a previous project on collar rot (HRDC Project VG418, Final Report), field trials showed that the post-emergent herbicides Basagran + Bladex, and Sencor could predispose plants to severe collar rot. This field study was aimed at evaluating the effects of new and potential pre- and post-emergent herbicides that are currently being screened for weed management in pea crops.

Materials & Methods

This study was conducted as part of a herbicide screening trial in 1998 at Forth, on the north-west coast of Tasmania. Collar rot affected this crop, so a disease assessment was conducted on potential new herbicide treatments, as well as herbicides that are currently being used, to determine if any of these herbicides were pre-disposing plants to infection by collar rot pathogens.

The treatments in the trial are given in Table 4.1. All the herbicide applications were applied using a knapsack precision sprayer fitted with 2.0 metre boom, with System Sprayer 11002 fan jets, at 220 L/ha water volume and 280 kPa pressure. The pre-emergent herbicides were sprayed on 26th June 1998, 8 days after sowing and before pea seedling emergence. The post-emergent herbicides were applied on 24th August 1998, at the 6-7 node pea growth stage, 67 days after sowing.

At 75 days after sowing, treatment plots were rated for the level of weed control and crop tolerance to the herbicide sprays. Weed control and crop tolerance were rated according to the European Weed Rating Scale (EWRS) (Appendices i & ii).

At 104 days after sowing, 20 plants were taken at random, at about 0.5m intervals from the middle of each treatment plot, for disease assessment. The collar rot severity was based on the number of nodes infected from the base of the plant.

2.3: The effects of herbicides on plant susceptibility to collar rot (Cont.)

Table 2.3.1: Pre- and post-emergent herbicide treatment list

TREATMENT						
No.	**Pre-Emergence**			**Post-Emergence**		
	Product Name	**Product Rate / Ha**	**Active Ingredient Rate / Ha**	**Product Name**	**Product Rate / Ha**	**Active Ingredient Rate / Ha**
1	Command	500ml	240g	Basagran + Activator	2L 100ml/100L	960g
2	Command + Frontier	500ml 1.5L	240g 1350g			
3	Stomp	3L	990g	Basagran + Activator	2L 100ml/100L	960g
4	Command	250ml	120g	Lexone + Bladex	300g 1.5L	225g 750g
5	Command	250ml	120g	Lexone	300g	225g
6				Lexone + Bladex	300g 1.5L	225g 750g
7				Basagran + Bladex	2L 1.5L	960g 750g
8	Untreated Control					

Results & Discussions

The dominant weeds at this site were wild poppy (*Papaver* spp.), and hogweed (*Polygonum aviculare*). Pinkweed (*Fumaria* spp.) was common, while shepherds purse *(Capsella bursa-pastoris*) was sporadically distributed across the site. All of the plants assessed for collar rot were infected.

Table 2.3.2: The effects of pre- and post-emergent herbicides on collar rot severity, at 104 days after sowing

No.	TREATMENT TIMING		Collar rot severity - No. nodes infected	
	Pre-Emergence	Post-Emergence	Collar rot	Sig*
1	Command 500ml	Basagran 2L + Activator 100ml/100L	6.40	bc
2	Command 500ml + Frontier 1.5L	None	5.13	ab
3	Stomp 3L	Basagran 2L + Activator 100ml/100L	6.77	c
4	Command 250ml	Lexone 300g + Bladex 1.5L	7.13	c
5	Command 250ml	Lexone 300g	7.43	c
6	None	Lexone 300g + Bladex 1.5L	6.07	bc
7	None	Basagran 2L + Bladex 1.5L	7.37	c
8	Untreated Control		4.37	a

* Means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

All treatments with post-emergent sprays had significantly greater collar rot severity than the untreated control (Table 2.3.2). However collar rot severity in Treatment 2, which consisted of only pre-emergent herbicide sprays of Command and Frontier, was not significantly greater than the untreated control. This treatment also gave good weed control with good plant tolerance (Table 2.3.3). Note that herbicide combinations currently used by the pea industry, Treatments 3, 6 and 7, significantly increased collar rot severity (Table 2.3.2).

It appears that the pre-emergent products, which are generally safer on the crop, do not lead to increased collar rot severity, as opposed to post-emergent products such as Basagran, Bladex.and Lexone.

2.3: The effects of herbicides on plant susceptibility to collar rot (Cont.)

Table 2.3.3: The effects of pre- and post-emergent herbicides on weed control and crop vigour, at 75 days after sowing

No.	TREATMENT TIMING		Crop & Weed Assessments (1/9/98) WHOLE PLOT RATINGS	
	Pre-Emergence (Applied 26/6/98)	**Post-Emergence (Applied 24/8/98)**	**Crop**	**Weed**
1	Command 500ml	Basagran 2L + Activator 100ml/100L	3.25	2.25
2	Command 500ml + Frontier 1.5L		2.25	2.25
3	Stomp 3L	Basagran 2L + Activator 100ml/100L	3.50	3.50
4	Command 250ml	Lexone 300g + Bladex 1.5L	2.75	2.75
5	Command 250ml	Lexone 300g	2.00	6.50
6	None	Lexone 300g + Bladex 1.5L	2.50	4.75
7	None	Basagran 2L + Bladex 1.5L	2.75	5.25
8	Untreated Control		1.00	9.00

Extension of project studies

Technology Transfer

- Presentation of project findings at the 11th Biennial Australian Plant Pathologists Society Conference held in Perth, Western Australia, in 1997. Title of the presentation - "Control of *Ascochyta* rot on peas in Tasmania".
- Presentation and discussion with processing pea growers in Kendenup, Western Australia, on 30th September 1998. Topics included an introduction on *Ascochyta* pathogens, their survival and disease epidemiology, as well as conditions that may pre-dispose plants to severe infection.
- Project findings were presented at Tasmanian vegetable extension days held at Burnie on 28th May 1998 and at Ulverstone on 27th July 1999. These were well attended by Tasmanian growers, industry representatives and researchers.
- A field day was held at Wesley Vale, Tasmania, on 11th October 1999, to demonstrate Bravo treatment differences to industry representatives.
- Facilitation of the purchase and distribution of copies of "Pea Disease Identification Guide", printed by New Zealand Crop & Food Research, to field officers in processing companies, consultants and processing pea growers in Tasmania and Western Australia. This guide is now out of stock and is unavailable until a decision is made to reprint. A copy of this publication is available from Serve-Ag Research, if required.
- An information package on *Ascochyta* disease management for growers and field staff was prepared, published and distributed to processing companies field officers, consultants, process growers, industry development officers, and HRDC program managers.

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Appendices

Appendix i - EWRS Scale for Crop Tolerance

RATING	% EFFECT	
1	0	Healthy plant
2	0.1 - 2	Very mild symptoms
3	2.1 - 5	Mild but clearly recognisable symptoms
4	5.1 - 10	More severe symptoms without necessarily an effect on yield
	--------------	Limit of commercial acceptability
5	10.1 - 18	Reduction in yield expected
6	18.1 - 30	
7	30.1 - 45	Heavy damage to total kill
8	45.1 - 70	
9	70.1 - 100	

Appendix ii - EWRS Scale for Weed Control

RATING	% EFFECT	
1	100	Complete weed kill
2	99.9 - 98	
3	97.9 - 95	
4	94.9 - 90	
	------------	Limit of commercial acceptability
5	89.9 - 82	
6	81.9 - 70	
7	69.9 - 55	
8	54.9 - 30	
9	29.9 - 0	Little to no effect on weeds

Appendix iii - Avcare Fungicide Grouping

Fungicide activity grouping list based on mode of action (Developed by Avcare)

Fungicide group	Activity group	Chemical group
A	Benzimidazole	Benzimidazole
B	Dicarboximide	Dicarboximide
C	DMI	Imidazole Piperazine Pyrimidine Triazole
D	Phenylamide	Acylamine Oxazolidinone
E	Morpholine	Morpholine
F	Phosphoro-thiolate	Organo-phosphorous
G	Oxathun	Anilide
H	Hydroxy-pyrimidine	Pyrimidinol
I	Anilinopyrimidine	Anilinopyrimidine
J	Hydroxyanilide	Hydroxyanilide
K	Strobilurin	Strobilurin
Y	Multi-site activity	Carbamate Phosphonate Inorganic Dithiocarbamate Phthalimide Chlorophenyl Quinone Hydroxyquinoline Pyradinaminae Cyclic imide
X	(Unspecified)	Cinnamic acid derivative Sulfamide Dinitrophenyl Organophosphate Guanidine Thiadiazole Quinoxaline

Appendix iv - Information Booklet