VG418
An Investigation of Ascochyta and related diseases in processing peas

Dr Hoong Pung
Serve-Ag Research

Know-how for Horticulture™

VG418

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HORTICULTURAL RESEARCH & DEVELOPMENT CORPORATION

Partnership in horticulture

An investigation of *Ascochyta* and related diseases in processing peas

HRDC Project VG 418

Final Report

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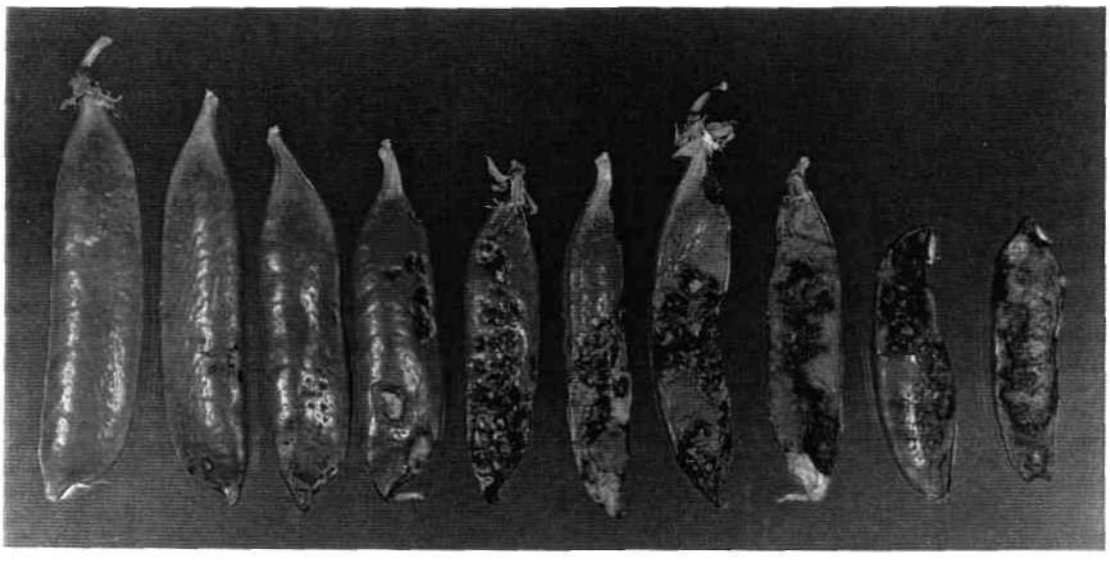
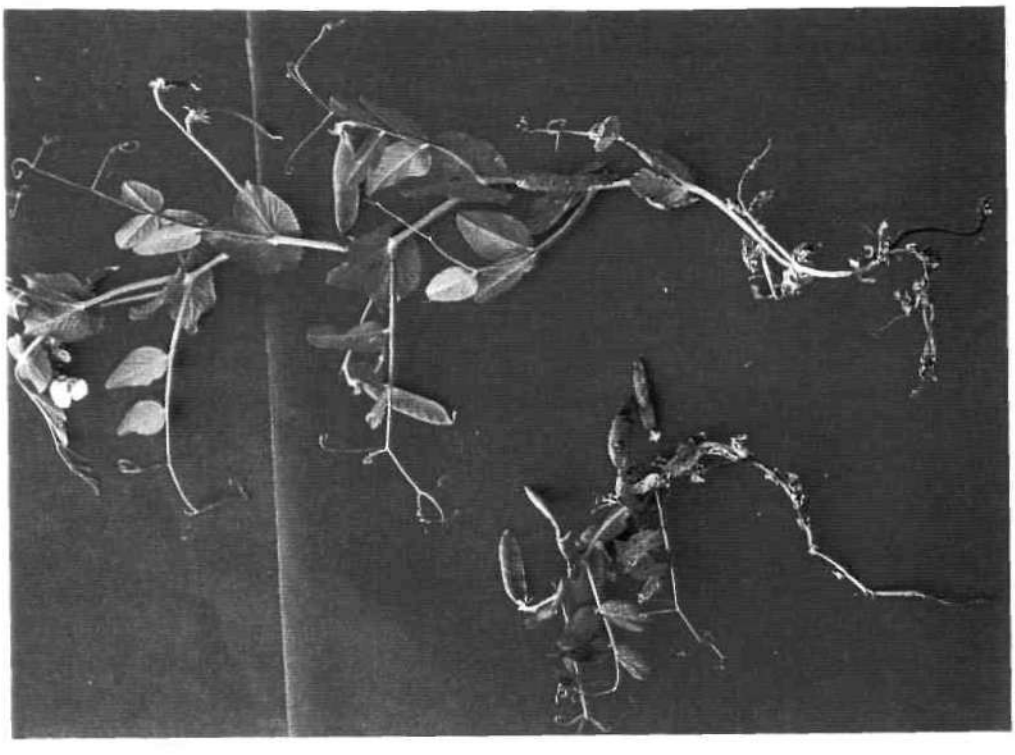
Ascochyta rot on peas

Ascochyta rot on pea pods.
Healthy pod on the left. Second from left to the right
show pods with increasing severity of *Ascochyta* infection.



Effect of severe _Ascochyta_ rot on plant growth.
Top: healthy plant. Bottom: plant with severe *Ascochyta* rot on stem, leaves and pods.



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Executive Summary

1. Collar rot disease:

- Stem canker or collar rot on peas is caused by a complex of *Ascochyta* pathogens. Two main species of *Ascochyta* pathogens isolated from collar rot on peas in Tasmania are:

    1. *Mycosphaerella pinodes* (*Ascochyta pinodes*)

    2. *Phoma medicaginis var. pinodella* (*Ascochyta medicaginis var. pinodella*)

- The main *Ascochyta* species associated with collar rot is *P. medicaginis var. pinodella*.

2. Seed infection and commercial seed treatments:

- *Ascochyta* infection of pea seed is an important source of the fungal pathogens.

    1. Seed test conducted in this project on commercial seed lines showed that *Ascochyta* infection could be both superficial and deep-seated, with most infection being superficial on the seed coat.

    2. The commercial standard for fungicide seed dressing (Apron & P-Pickel T) was shown to be effective in eradicating *Ascochyta* seedborne infection and may provide early protection to seedlings from field *Ascochyta* inoculum.

3. Field survey on disease incidence and distribution:

- Bioassay of field soils collected from 11 pea paddocks indicated that the *Ascochyta* rot pathogens were widespread and could persist in soil for at least 10 years between pea crops.

    1. This indicates that plants from seed free of *Ascochyta* infection will eventually become infected by soilborne *Ascochyta* inoculum in the paddocks.

    2. Field survey and soil bioassay studies conducted in this project seem to discount the belief that the use of infection free seed will prevent *Ascochyta* rot in crops sown in traditional pea production areas. *Ascochyta* rot on pea is widespread due to the persistence and widespread distribution of the field *Ascochyta* inoculum.

    3. With the effective control of seedborne *Ascochyta* infection, field inoculum that persists in soil is likely to become the main source of infection.

    4. Massive amount of conidia are produced by *P. medicaginis var. pinodella* in large number of pycnidia that developed on stem lesions, thereby enabling the disease to spread rapidly from infected plants in a moist environment. Leaves and pods may also become infected in secondary spread of the conidia.

    3. *P. medicaginis var. pinodella*, the main *Ascochyta* pathogen, has alternative plant hosts such as bean, clover, medic, and pyrethrum.

    4. Therefore, crop rotation based on years between pea crops only is not sufficient to reduce or prevent *Ascochyta* rot from field inoculum.

4. Herbicide effect on collar rot disease

- Field trials were conducted in 1994 and 1995 to assess the impact of metribuzin (Sencor, a post emergent herbicide) sprays on pea crops. This study was undertaken following observations by some growers that *Ascochyta* stem infection appeared to be worse after metribuzin application.

1. The research studies conducted showed that the use of metribuzin alone, under optimum growing condition, did not pre-dispose plants to severe *Ascochyta* collar rot nor affect yields.

2. Use of metribuzin could accentuate the *Ascochyta* rot problem only when peas were grown under stressful conditions brought about by other factors such as cold climate, poor drainage and poor soil structure.

5. Fungicide treatments to control soilborne infection:

- A trial with various fungicide seed dressings conducted to investigate the potential of extending the protection period to control field *Ascochyta* infection.

    1. Results indicated that the other alternative fungicides (Armour, Benlate, Saphire, Scala, Shirlan and Rovral) used produced poor emergence and low fresh weight in naturally *Ascochyta* infested field soil.

    2. Apron & P-Pickel T seed dressing gave the highest rate of emergence (90-100%) and fresh weight in comparison to all other fungicide treatments.

    3. None of the alternative fungicides tested is suitable for use as seed treatment in place of Apron & P-Pickel T.

- Five fungicide products (Benlate, Impact, Saphire, Shirlan, and Rovral) and three application methods were examined in a field trial for the control of soilborne *Ascochyta* pathogens.

    1. The three application methods examined were in furrow spray, sprayed onto fertilizer and applied into soil furrow, and applied as foliar sprays.

    2. Only Impact (applied in 5 foliar sprays) and Shirlan (applied into soil furrow at sowing) reduced the incidence of collar rot in the trial. No differences in collar rot could be found between the three application methods in the study.

- Field trials were conducted in 1996 to evaluate the efficacy of foliar fungicide applications in reducing disease severity by soilborne *Ascochyta* pathogens, and secondary spread of the disease.

    1. Two field trials (at Wesley Vale and Moriarty) to evaluate fungicide control strategies were conducted in the North-West coast of Tasmania. Fungicide treatments were Shirlan, Impact, Dithane + Bravo combination, Benlate and Rovral.

    2. In the first trial at Wesley Vale, only the Shirlan treated plants (3 sprays at week 6, 9 and 12 after sowing) produced significantly higher average fresh height, weight and pod number in comparison to the untreated plants. The crop at this site had severe *Ascochyta* leaf and stem infections. The field factors, poor soil structure and poor water drainage, in the paddock are likely to have contributed to the severe Ascochyta disease.

    3. In the second field trial at Moriarty, *Ascochyta* stem infection had no detrimental effect on plant growth or yield. In contrast to the Wesley Vale trial, there was little or no other field stress factors at the Moriarty site.

    4. Further laboratory tests conducted in 1996 at Serve-Ag showed that most of the fungicides used in the field trials above were capable of completely inhibiting *Ascochyta* spores from germinating.

    5. Tests conducted using coloured dye on fungicide sprays in the above fungicide field trials in the 1996 season indicated that the effectiveness of the fungicides may have been hampered by poor fungicide coverage on the target areas. The principal target areas, particularly the lower stems, received little or none of the fungicide sprays applied after crop canopy closure, possibly leading to inadequate disease control.

Technical Summary

Two species of *Ascochyta* pathogens, *Ascochyta pinodes* (*Mycosphaerella pinodes*) and *Ascochyta medicaginis var. pinodella* (*Phoma medicaginis var. pinodella*) have been isolated from stem or collar rot of processing peas in Tasmania. In the survey conducted, *Phoma medicaginis var. pinodella* was mainly isolated from collar rot affected plants, whereas *M. pinodes* was mainly isolated from leaf lesions. All the pea crops surveyed in this study were affected by collar rot, while leaf and pod spots were rare. Some pea crops are not irrigated in Tasmania, and the relatively dry conditions noted during the 1994 season when the survey was carried out may have limited the *Ascochyta* leaf infections. *Ascochyta* rot pathogens could be isolated on agar from stem bases about 2 weeks before collar rot became visible on the plants. Most collar rot was visible at 8 weeks after sowing.

Tests on field soils collected from 11 pea paddocks indicated that the *Ascochyta* rot pathogens were widespread and could persist in soil for at least 10 years between pea crops. *P. medicaginis var. pinodella* can both survive as chlamydospores and pycnidia on straw fragments and in the soil, and has also been recorded on other hosts like bean, clover, and pyrethrum in Tasmania. These alternative hosts of *P. medicaginis var. pinodella* indicates that some other crops or weeds in the paddock in the years between pea crops may assist in its long term persistence. Recommendation based on the years between pea crops alone appears to be inadequate for the management of collar rot in Tasmania. This also indicates that eradication and disease prevention from soilborne *Ascochyta* pathogens will be difficult to attain even at great expense.

In recent years, seed treatment has been widely used by the pea industry to control both seedborne fungal infection as well as damping off diseases. The commercial standard for fungicide seed dressing (Apron & P-Pickel T) was shown to be effective in eradicating seedborne infection and providing early protection to seedlings from field *Ascochyta* inoculum. No *Ascochyta* pathogens could be detected on the hypocotyls of 10 day old seedlings of 15 commercial seed lines that had been treated with Apron & P-Pickel T. Seed pathology test on one untreated commercial seed line showed both surface and internal seedborne *Ascochyta* infection, with surface sterilization reducing infection from 35% to 7.5%.

Studies conducted in this project discount the belief that the use of infection free seed will prevent *Ascochyta* rot in crops sown in traditional pea production areas. Even with effective control of seedborne *Ascochyta* infection with fungicide seed dressing, pea plants in the paddocks eventually became infected by soilborne *Ascochyta* inoculum.

Massive amount of conidia is produced by *P. medicaginis var. pinodella* in large number of pycnidia that developed on stem lesions, thereby enabling the disease to spread rapidly from infected plants in a moist environment. Leaves and pods may also become infected in secondary spread of conidia from the stem lesions.

Although the use of infected seed is undesirable, the production of pea seed lines that is completely free of *Ascochyta* infection will require sowing seed crops in new ground where no pea or related crops has been grown. The economics of shifting seed production from one area to another new area constantly is likely to be costly. The *Ascochyta* pathogens are also known to infect other types of plants. Good control of *Ascochyta* could be achieved through production of pea seed in dry regions that are not prone to severe *Ascochyta* disease, and with commercial seed treatments with fungicides.

Herbicide studies conducted in 1994 and 1995 indicate that seedling growth and vigour at the time of herbicide spraying are important determining factors on their susceptibility to herbicide damage and hence to further damage by collar rot. The studies conducted showed that the use of metribuzin alone under optimum growing condition did not pre-dispose plants to severe *Ascochyta* collar rot nor affect yields. Use of metribuzin could accentuate the *Ascochyta* rot problem only when peas were grown under stressful conditions brought about by other factors such as cold climate, poor drainage and poor soil structure.

With effective control of seedborne *Ascochyta* infection, field inoculum that persists in soil is likely to become the main source of infection. In addition to seed treatment, follow-on fungicide applications may be required to manage the field inoculum in areas prone to severe *Ascochyta* rot. Fungicide application methods that were examined in this project included the fungicide applied directly in soil furrow at sowing, mixed into fertilizer as a carrier and applied in furrow at sowing, foliar sprays after sowing, and alternative fungicides for seed treatment.

The potential of alternative fungicides applied as seed treatment in extending the protection period provided by Apron & P-Pickel T mix for additional protection from field *Ascochyta* inoculum was evaluated. The fungicides Armour, Rovral, Saphire, Scala, and Benlate, which were found to be inhibitive to *M. pinodes* growth on fungicide treated agar, reduced seedling emergence when applied as fungicide seed treatment in a pot trial. Similar reduction in seedling emergence was also observed with the Shirlan treated seed. Apron & P-Pickel T seed treatment still gives the best result with improved seedling emergence on *Ascochyta* infested soil. None of the alternative fungicides tested improved disease control nor extends the protection period.

Five fungicide products (Benlate, Impact, Saphire, Shirlan, and Rovral) and three application methods were examined in a field trial for the control of soilborne *Ascochyta* pathogens. Three application methods were applied as in furrow spray, sprayed onto fertilizer and applied into soil furrow, and applied as foliar sprays. Only Impact (applied in 5 foliar sprays) and Shirlan (applied into soil furrow at sowing) reduced the incidence of collar rot in the trial. No differences in collar rot could be found between the three application methods in the study.

Two field trials were conducted at Wesley Vale and Moriarty in 1996 to evaluate foliar fungicide applications to reduce the disease severity by soilborne *Ascochyta* pathogens, and secondary spread of the disease. The fungicide treatments were Shirlan, Impact, Dithane + Bravo combination, Benlate, and Rovral. *Ascochyta* infection in the trial at Moriarty had no detrimental effect on plant growth or yield. In the trial at Wesley Vale, which had severe *Ascochyta* infection, Shirlan (applied at week 6, 9 and 12) treated plants had much lower pod infections than the control and other fungicide treatments, as well as bigger plants. The collar rot of the Shirlan treated plants however, was similar to the other treatments. This may be related to poor spray coverage of target areas when applying foliar spray to try to control infections. Some fungicides such as Benlate, Impact, and Shirlan, were inhibitive of *Ascochyta* growth from infected stems in vitro study. Nevertheless, when applied as low volume foliar spray (250 L/ha), no obvious reduction in collar rot could be found. Further test conducted in a spray coverage trial showed that higher spray volume and pressure (500L/ha and 700kPa) significantly increased the percentage coverage in comparison to the lower volume and pressure (200L/ha and 500kPa). The percentage coverage of spray applied also seems to decrease with increasing plant growth at the low spray volume and pressure but no difference is evident with the high volume and pressure spray.

In conclusion, *Ascochyta* rot disease management strategies must include consideration of interrelationships between paddock terrain, soil conditions, cultural practices, weather and disease pathogen. In this project, much progress has been made in obtaining a better understanding of the *Ascochyta* disease. These includes the types of *Ascochyta* pathogens involved, the persistence of *Ascochyta* pathogens, the distribution of collar rot incidence in soils influenced by pea crop rotation, onset of disease in the field, seed infection, seed treatment, and herbicide association with collar rot. Other significant findings of this project are on the potential fungicide efficacies, spray techniques and coverage of target areas. Further research studies are essential to build on this gain in knowledge of the disease to develop a cost effective management of *Ascochyta* rot from the widespread soilborne inoculum.

Recommendations

1. The use of fungicide seed dressing with Apron & P-Pickel T is recommended. The fungicide combination was shown to be effective in eradicating seedborne *Ascochyta* infection, and improves seedling emergence.

2. The suggestion of producing pea in new ground to obtain seed lines that is completely free of *Ascochyta* infection is not recommended. The economics of shifting seed production from one area to another new area constantly is likely to be very costly. Good control of *Ascochyta* could be achieved through production of pea seed in dry regions that are not prone to severe *Ascochyta* disease, and with commercial seed treatments with fungicides.

3. Recommendation based on the years between pea crops alone appears to be inadequate for the management of collar rot in Tasmania. *Ascochyta* rot pathogens are widespread in the traditional pea production areas in Tasmania, and could persist in soil for at least 10 years in the absence of pea crops. This indicates that collar rot will still occur on crops sown with treated commercial seed lines that are free of *Ascochyta* infection. This also indicates that eradication and disease prevention from soilborne Ascochyta pathogens will be difficult to attain even at great expenses.

4. Further studies are recommended to evaluate strategies for the management of *Ascochyta* rot due to field inoculum. The key to disease management of *Ascochyta* rot disease is likely to be in reducing disease severity to a level where infection is superficial and has no economic impact in pea production. Climatic and field conditions, seedling emergence and plant growth rate are inter-related and appears to be important determining factors on the plants susceptibility to severe disease infections. Investigations to identify risk factors in the field that will predispose pea crops to severe Ascochyta infection will assist in developing strategies to target high risk areas and minimise cost.

5. Field conditions that may affect plant emergence and growth rate must be considered when applying herbicides for weed control in pea crops. The studies conducted showed that the use of metribuzin, a post emergent herbicide, alone under optimum growing condition did not pre-dispose plants to severe *Ascochyta* collar rot nor affect yields. The use of metribuzin could accentuate the *Ascochyta* rot problem only when peas were grown under stressful conditions brought about by other factors such as cold climate, poor drainage and poor soil structure.

Extension

Conducted research forums in 1995 and 1996 to extend research findings to representatives from Simplot Australia, McCain Foods, growers, and agronomic consultants.

Copies of the project's executive and technical summary, and recommendations sent to field officers from Simplot Australia and McCain Food, pea growers, agronomic consultants, and extension officers

Project final report completed and sent to HRDC, Simplot Australia, McCain Foods, Tasmanian Farmers and Graziers Association, and Tasmanian Institute of Agricultural Research.

Presentations were made at Australasian Plant Pathology Conferences:

- Aldaoud, R., Macleod, I., Green, B., and Nielsen, P., 1995. An investigation of the epidemiology and control of *Ascochyta* diseases of peas in Tasmania. Seminar at the 10th APPS conference at Lincoln University, Christchurch, New Zealand.

- Pung, H., and Macleod, I., 1997. Control of *Ascochyta* rot on peas in Tasmania. Poster at the 11th APPS conference at Rendezvous Observation City Hotel, Perth, Western Australia.

Future studies

Further studies are being conducted in a new HRDC project, titled:

VG97051 *Ascochyta* rot on peas and its control

This project is a continuation of the completed project in this report. The aims of this new project will be to investigate suitable fungicides, and improve fungicide application techniques, rates and timing. As a result of this research, it is hoped that an effective control strategy can be developed. Field survey will also be conducted to investigate local factors in paddocks that can contribute to severe collar rot. A good understanding of risk factors in the field will assist in ensuring that fungicide usage is limited to high risk areas only.

Introduction

Collar and root rot diseases have been recognized as one of the main causes of yield and quality reduction of peas in Tasmania, where about 8000 Ha of peas are grown annually for processing into frozen peas. About 30% of the crop are believed to be influenced to some degree by the *Ascochyta* disease complex (D. Stirling, per. comm.). In severely affected areas (about 10% of the crop), a yield reduction of at least 30% resulted in an estimated loss of $360,000 per year.

Ascochyta diseases have been reported on peas in Tasmania since peas were introduced as a crop to this state (Wade, 1951). The most serious phase of the *Ascochyta* disease is the collar rot (Wade, 1951), where the affected collar area turns purplish black. Plants affected by collar rot are weakened and in severe cases causing premature senescence and hence severe losses in pea crops.

Three *Ascochyta* pathogens, *A. pisi* Lib., *Mycosphaerella pinodes* (Berk. And Blok.) Vesterg) (*Ascochyta* pinodes Jones) and *Phoma medicaginis* var. *pinodella* (Jones) Boerema (*Ascochyta pinodella* Jones, are associated with *Ascochyta* rot of peas. Two species of *Ascochyta*, *M. pinodes* and *P. medicaginis* var. *pinodella* have been identified in Tasmania (Sampson & Walker, 1982). *M. pinodes* is seed and soilborne and can attack all parts of the plant. The third species, A. pisi, has been isolated from infected and untreated pea seed lines (Williams, 1978 & 1980, unpublished Tas. DPIF reports) but appears to be rarely associated with collar rot of plants in Tasmania. Little is known of the main types of *Ascochyta* pathogens involved in the collar rots, their incidence or distribution in Tasmania.

Although crop rotation is commonly used as a mean of controlling *Ascochyta* diseases, little is known of how many years the pathogens can persist in soil. *P. medicaginis var. pinodella* is also believed to have a much wider host range. It is therefore important to establish the types of *Ascochyta* pathogens associated with collar rot in Tasmania, the persistence of the *Ascochyta* pathogens in soil, and the implications of soilborne inoculum in comparison to seedborne inoculum. A field survey was also conducted to investigate the type of *Ascochyta* pathogens, their incidence, distribution, and persistence in soil. The survey also includes the sampling of pea plants from paddocks over a period to determine the onset of *Ascochyta* disease in the field.

Seed infection of commercial seed lines is an important source of *Ascochyta* inoculum (Carter & Moller, 1960). It is generally believed that the use of infection free seed will prevent *Ascochyta* rot in crops. The production of pea seed that is completely free of *Ascochyta* infection will require sowing seed crops in new ground where no pea or related crops has been grown.

While severely infected seed show a visibly brown discoloration, most infected seed have no obvious symptom. In Tasmania, *M. pinodes* and *A. pisi* have been found on commercial seed lines (Williams, 1978 & 1980, unpublished Tas. DPIF reports). *M. pinodes* and *P. medicaginis var. pinodella* can both survive as thickened mycelia (sclerotia), chlamydospores, and pycnidia on straw fragments and in the soil (Lawyer 1984).

In recent years, seed treatment has been widely used by the pea industry to control both seedborne fungal infection as well as damping off diseases. The most widely used fungicides are Apron (metalaxyl) and P-Pickel T or P-Pickel T (a combination of thiram and thiabendazole). Metalaxyl is used to control Pythium damping off disease while both thiram and thiabendazole are effective on seedborne *Ascochyta* infections (Maude, 1966; Maude et al 1986). Studies were conducted in this project to determine the success of the industrial standard of using the two fungicide products, Apron and P-Pickel T, in controlling seedborne *Ascochyta* infections on commercial seed lines.

A pot trial was conducted in this project to confirm that *Ascochyta* pathogens isolated from infected plants were the cause of collar rot disease. The existence of different variability between isolates of M. pinodes and A. pisi on peas has been reported (Ali et al 1978). Therefore, the pot trial would also examine the pathogenicity of some isolates of the isolated *Ascochyta* pathogens. The isolates were also combined to determine whether they could increase disease severity in a disease complex.

Field observations indicate that the standard use of the herbicide, metribuzin, for weed control in pea crops appears to increase the severity of collar and root rot diseases. However, these observations are not always consistent and tend to vary from one crop to another. Several field trials were therefore conducted in this project, to investigate the relationship between metribuzin herbicide application and collar rot incidence.

With effective control of seedborne *Ascochyta* infection, infected pea crop residues from previous season crops is believed to be the main source of infection. High level of spores were still discharged from samples of infected straw that had been collected 2 years ago (Carter & Moller, 1960). Follow-on fungicide applications may be required to reduce infection or collar rot severity from the soilborne inoculum. Various control methods and fungicide products were evaluated in this project for the control of collar rot due to the soilborne inoculum.

1. Field Survey

1.1 Field sampling for incidence of collar rot

Aims

Ascochyta rots of peas have previously been reported in Tasmania (Wade, 1951; Sampson & Walker, 1982), but little is known of their incidence or distribution or of the main types of *Ascochyta* pathogens involved in the collar rots.

This study therefore aimed to conduct a field survey of pea crops in the north-west of Tasmania. Isolations were made to determine the species of *Ascochyta* pathogens involved in the collar rots. The incidence of collar rot as influenced by location, soil type and previous pea cropping history in commercial crops was also assessed.

Field sampling was also conducted in 1994 on commercial pea crops over time to assess for the onset of *Ascochyta* disease in the field. The sampling was conducted on crops produced from seed that had been commercially treated with the industry seed dressing, Apron & P-Pickel T at the ratio of 1:1.

Materials & Methods

Field sampling was conducted on eight paddocks (Table 1.1). Five sub-samples of 10 consecutive plants for a total of 50 plants were collected at random from each paddock at fortnightly intervals, beginning at four weeks to 18 weeks after sowing. Two types of assessments were conducted, visual assessment and fungal isolation assessment. The plant samples were visually assessed for presence of collar rot symptoms on the lower stems. Fungal isolations were conducted by cutting 1 cm length from lower stem containing both above and below soil parts, surface sterilized and plated out onto half strength potato dextrose agar. Plates were kept in the laboratory under 12 hours periodic fluorescent light at 22 - 24C°. Results were taken a week later by recording the numbers of specimens with colonies of *Ascochyta* species. Six representative pure cultures of *Ascochyta* spp. were sent to Michael Priest, NSW Dept. of Agriculture, to confirm their identity.

Table 1.1 – Details of the commercial pea crops included in the field survey

Site	Grower	Location	Soil Type	Last Pea Crop	Sowing Date	Herbicide Application (1994)
1	Chaplin	Wesley Vale	Red Clay Loam	not known	28-June-94	Stomp, Lexone, Bladex
2	Addison	Moriarty	Red Clay Loam	1986	18-Aug-94	Lexone, Bladex, Basagran
3	Addison	Moriarty	Sandy Clay Loam	1993	10-Aug-94	Lexone, Bladex, Fusilade
4	Last	Kindred	Red Krasnozem	1990	9-Aug-94	Bladex, Sencor
5	Charleston	Kindred	Red Krasnozem	1990	20-Sep-94	Bladex, Sencor
6	Wright-1	Sassafras	Heavy Black Loam	1993	30-Aug-94	Basagran, Bladex
7	Parker Bros.	Don	Red Krasnozem	1991	1-July-94	Lexone, Bladex, Stomp
8	Parker Bros.	Don	Red Krasnozem	1992	18-July-94	Bladex, Stomp, Legumine

Results & Discussion

In the survey conducted, *P. medicaginis var. pinodella* was mainly isolated from collar rot affected plants, whereas *M. pinodes* was mainly isolated from leaf lesions. Although *Ascochyta pisi* had been found in commercial seed lines in early studies by Williams (1978, 1980, unpublished Tas. DPIF reports), it was not isolated from samples collected in this field survey. This was consistent with reports by Sampson & Walker (1982) that *P. medicaginis var. pinodella* and *M. pinodes* were mainly associated with *Ascochyta* infection on peas in Tasmania. *M. pinodes* is the main cause of crop blight and collar rot in New South Wales and South Australia (Carter & Moller, 1960 & 1961; Walker, 1961; Ali *et al*, 1978). However, in contrast to the finding of Wade (1951), *P. medicaginis var. pinodella* instead of *M. pinodes* is the frequently occurring

Ascochyta pathogen associated with collar rot of peas. *P. medicaginis var. pinodella* is believed to be the less aggressive pathogen of the two, and has been frequently isolated from other host plants (Sampson & Walker 1980).

Based on visual assessment, *Ascochyta* leaf infections did not appear to be a serious problem in the pea paddocks surveyed. The relatively dry conditions noted during the growing season in 1994 might have limited the *Ascochyta* leaf infections.

Ascochyta rot pathogens could be isolated on agar before collar and root rot became visible on the plants (Table 1.2). *Ascochyta* pathogens could be isolated in only a few plants at four weeks after sowing. An increased in the frequency of the fungal isolations on agar was made at 6 to 14 weeks after sowing. The collar rot symptom it caused became visible on the stem after about 10 weeks after sowing.

Table 1.2 – The onset and the progress of collar rot incidence in the commercial pea crops surveyed in the 1994 season.

Site		VISUAL DISEASE ASSESSMENT* % plants with visible collar rot at weeks after sowing*								FUNGAL ISOLATIONS** %plants that had *Ascochyta* pathogens isolated at weeks after sowing*					
	Week	4	6	8	10	12	14	16	18	4	6	8	10	12	14
1				1	2	5	18	34	70		6	32	32	54	52
2		0	0	0	2	11	27			0	8	8	0	6	14
3		0	0	0	0	8	70			0	0	0	4	6	30
4		0	0	0	0	9	81			2	14	28	18	30	
5		0	0	0	31					0	2	20	20		
6			0	0	0	2	23				2	10	4	6	2
7			0								22				
8			0				11				0				30

1.2 The Persistence of Ascochyta Pathogens in Field Soils

Aims

Ascochyta species that cause *Ascochyta* rot can survive as sclerotia, chlamydospores, and pycnidia on straw and in soil (Lawyer, 1984). Although crop rotation is usually recommended as a means of controlling the disease, little is known of the persistence of the *Ascochyta* pathogens in paddocks where peas have been grown previously.

A pot trial was therefore conducted to investigate the persistence of *Ascochyta* pathogens in field soils where pea crops had been sown previously.

Materials & Methods

Pots (20cm wide and 20cm deep) were filled to about two third of volume with pasteurized potting mix. Twenty surface sterilized seed were placed on the surface of the potting mix, then covered with 0.5 litre of field soil. Potting mix was used in place of field soil for the control treatment. The field soil used in the treatments were collected from different locations in the north-west of Tasmania (Table 1.3). Untreated pea seeds (Small Sieve Freezer variety) were surface sterilized with 0.5% sodium hypochlorite for 2 minutes before sowing. Seed pathology test conducted on the surface sterilized untreated seeds showed 7.5% seed infection by *Ascochyta* pathogens.

Trial design used was complete randomized block design with four replicates. The pots were kept in an open environment and watered by drip irrigation as required to maximum field capacity. The number of plants that emerged was recorded at 6 weeks after sowing (Table 1.3). A visual disease assessment was carried out at 8 weeks after sowing, by recording the number of plants with collar rot in each pot (Table 1.3). Analysis of variance was conducted using StatGraphic Plus 2.0. Before analysis, the collar rot incidence data was transformed to square root (%incidence) + 0.05 for normal distribution.

Results & Discussion

Collar rot incidence ranging from 25 to 93% occurred on plants grown in soils collected from 11 farm sites previously sown with peas (Table 1.3). There was no correlation between the period of time when the last pea crop had been sown (from 10 years to continuous pea cropping) and the level of collar rot incidence. This indicated that the *Ascochyta* rot pathogens appeared to be widespread in the intensively cultivated northern Tasmanian soils, and that these pathogens could persist in soil for at least 10 years in the absence of pea crops.

Table 1.3 – Collar rot incidence and crop emergence of plants grown in field soil according to their location, cropping history and soil type.

No.	Soil Source	Location	Last pea crop[1]	Years since the last pea crop	Soil Type	%Plant Emergence*	%Collar rot Incidence *
1	Yaxley	Don	1992	2	Krasnozem	75 abc	65 def
2	Charleston	Kindred	1990	4	Krasnozem	75 abc	44 cd
3	Last	Kindred	1990	4	Krasnozem	70 ab	44 bcd
4	Parker Bros.-1	Don	1991	3	Krasnozem	80 abc	51 de
5	Parker Bros.-2	Don	1992	2	Krasnozem	80 abc	45 cd
6	Lillico	Don	1984	10	Krasnozem	85 bc	64 de
7	Wright-1	Sassafras	1993	1	Black clay loam	65 ab	93 f
8	Wright-2**	Sassafras	1993	-	Black sandy loam	60 a	30 ab
9	Addison-2	Moriarty	1993	1	Sandy clay loam	90 bc	25 abc
10	Addison-1	Moriarty	1986	8	Clay loam	85 abc	84 ef
11	Chaplin	Wesley Vale	not known	n/a	Red clay loam	70 ab	53 de
12	Control		n/a	n/a	Sterile potting mix	100 c	12 a

* Sig. - Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test;
** No pea crop sown in 1994.

Figure 1.1: The relationship in the years between pea crops and collar rot incidence.

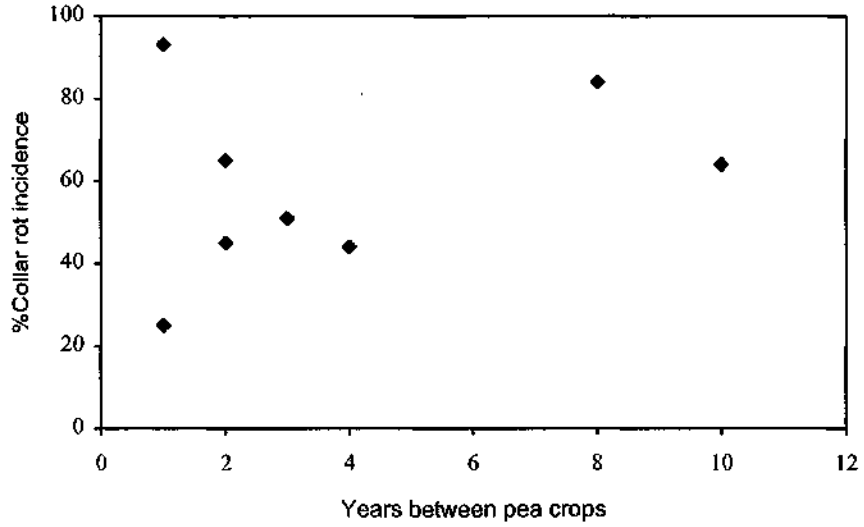
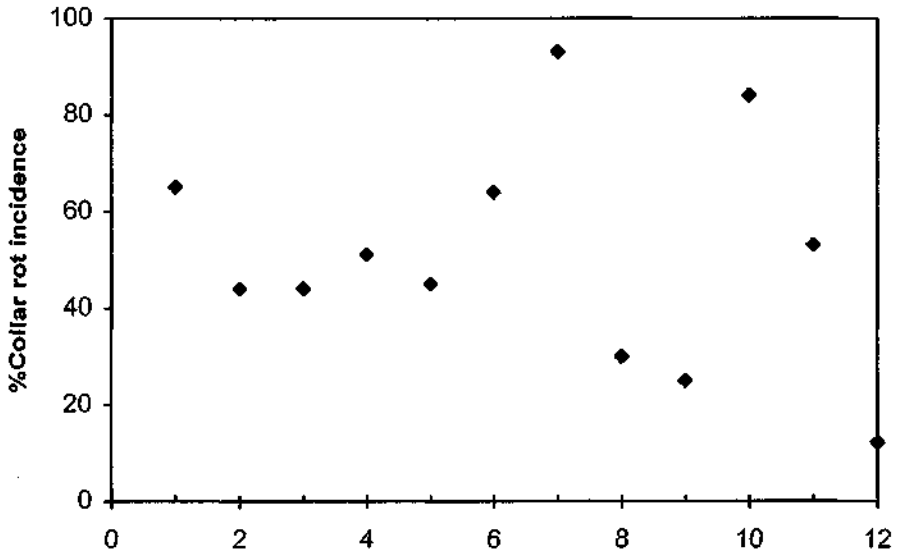


Figure 1.2: The relationship between soil type and collar rot incidence.



No obvious relationship could be observed between the pea crop rotation and collar rot (Figure 1.1) or between the soil type and collar rot (Figure 1.2). Apart from the red krasnozem soil, too few soils from the other soil types have been assessed to enable a proper comparison between the different soil types. It is noteworthy that two soil types collected in Wright's property at Sassafras caused a much higher collar rot incidence in the heavy black clay loam (93%) compared to that of the black sandy loam (30%). This appears to be consistent with growers and field officers observations that higher incidence and severity of collar rot disease on peas occur in heavier soils under very wet conditions. This indicated that soil types might have an indirect influence in association with water like poor drainage, which may increase plant susceptibility to severe *Ascochyta* disease.

No comparison could be made on the seedling emergence between treatments (other than with the control which contained only potting mix), due to the high variability in seedling emergence (Table 1.3). The low collar rot incidence (12%) observed in the control treatment, where only pasteurized potting mix was used, is likely to be due to seedborne *Ascochyta* infection of the untreated pea seed (Table 1.3). Seed pathology test conducted showed 7.5% seed infection.

2. Seedborne Infection

Introduction

The use of fungicide seed dressing has significantly improved seedling emergence and control of seed infection and damping off diseases caused by *Ascochyta*, *Pythium* and *Fusarium*. Commercially, most processing pea seed is treated with metalaxyl (Apron), thiram & thiabendazole (P-Pickel T or P-Pickel T) or the combination of the two products. Thiram and thiabendazole have been shown to provide effective control of seedborne *Ascochyta* infection (Maude 1966, Maude et al 1986), while metalaxyl is effective on *Pythium*. In this section, tests were conducted on commercial lines of pea seed and seedlings to validate the efficacy of the use of the commercial standard mixture of Apron & P-Pickel T in controlling seedborne *Ascochyta* pathogens.

Tests for seedborne infections

Aims

Laboratory testing was conducted to determine the level of seedborne *Ascochyta* infection, and the level of *Ascochyta* seed infection on seedlings produced from seed that had been treated with Apron and P-Pickel T fungicide mixture.

Material & Methods

Test on non-fungicide treated seed

Forty seed from one untreated seed lot (Small Sieve Freezer variety) were plated onto half strength potato dextrose agar. Another forty seed from the same lot were surface sterilized with 0.5% sodium hypochlorite and 10% ethanol for 2 minutes, rinsed with sterile water, dried on filter paper and then plated onto half strength potato dextrose agar (PDA). After one week, the seed on agar plates were examined for fungal infection (Table 2.1).

Test on fungicide treated seed

Germinated seedlings (10 days old) from 15 different seed lots of fungicide treated seed were supplied by Simplot Australia to test for *Ascochyta* infection (Table 2.2). Seedling hypocotyl sections (1cm in length) were cut, surface sterilized in 0.5% sodium hypochlorite for 2 minutes, rinsed in sterile water and plated onto half strength PDA. In each seed lot, 16 to 25 seedlings were tested.

Results & Discussion

While seed infection can be superficial or internal, surface sterilization reduced *Ascochyta* infection from 35% to 7.5% (Table 2.1), indicating that the infection was mostly superficial on the seed coat.

Table 2.1: Ascochyta infection of non-fungicide treated seed

Treatments	Seed infected
Untreated seed	35%
Surface -sterilized seed	7.5%

No *Ascochyta* pathogens could be detected on the hypocotyls of 10 day old seedlings, which germinated from Apron, & P-Pickel T treated seed (Table 2.2). Disease assessments conducted in the field survey studies showed that the *Ascochyta* pathogens were first detected at four weeks after sowing (Table 1.2). This indicated that the seed treatment of Apron & P-Pickel T fungicide mixture seems to provide effective control of seedborne as well as early protection from soilborne *Ascochyta* pathogens.

Table 2.2 –Ascochyta infection on seedling that had been treated with Apron & P-Pickel T

Seed Lot	%Seedlings infected*	Seed Lot	%Seedlings infected**
		A4256 SSF	0
90-44 CPT SSF	0	ZP 54966 HORIZON	0
ZP 54986	0	P54988 HORIZON	0
D 9259 SOMERSET	0	ZPA8024 RESAL	0
ZP 54972 BOUNTY	0	ZP44982 HORIZON	0
ZP 549883 HORIZON	0	ZP549911 BOUNTY	0
ZP 549451 HORIZON	0	ZP579882 HORIZON	0
ZP 549711 BOUNTY	0	AP549882 HORIZON	0

*Test conducted on 16 seedlings; **Test conducted on 25 seedlings

3. Pathogenicity of Ascochyta Pathogens

Aims

Three species of *Ascochyta* pathogens, *A. pisi, M. pinodes*, and *P. medicaginis var. pinodella*, are associated in diseases of field and processing peas (Jones 1927). In Tasmania, only two *Ascochyta* species, *M. pinodes* and *P. medicaginis var. pinodella*, have been implicated in leaf, stem and pod lesions, and foot rot of processing peas (Sampson & Walker 1982). This was confirmed in the field survey and sampling conducted in this project (Section 1).

This pot trial was conducted to confirm the ability of *M. pinodes* and *P. medicaginis var. pinodella* that were isolated in Section 1 to cause collar rot on peas. This study also investigated the pathogenicity of two different isolates each of *M. pinodes* and *P. medicaginis var. pinodella*, alone and in combinations that had been isolated from infected pea stems in the field survey conducted earlier.

Materials & Methods

Pots (20cm wide x 20cm deep) were filled to two thirds with steam pasteurised potting mix and the appropriate spore suspension was sprayed onto the soil surface to give even coverage. Untreated pea seed (Small Sieve Freezer variety) were sown (20 seed per pot), and covered with 0.5 litre potting mix. The top surface was again sprayed with the spore suspension.

For treatments 1-4, the spore suspension inoculum consisted of four plates of each isolate that had been grown on full strength PDA for 10 days, then homogenised in 1 litre of sterile water (Table 3.1). For treatments 5-10, two plates of each isolate were used, and for treatment 11, only one plate of each isolate was used. All the *Ascochyta* inoculum suspension was adjusted to 1.0×10^6 conidia/ml. For the control in treatment 12, four plates of uninoculated PDA was used instead.

The pot trial was conducted in an open environment and watered by drip irrigation as required. The trial design was complete randomized block with 4 replicate pots per treatment. The number of pea seedlings that emerged was recorded at 2 and 4 weeks after sowing. The number of plants with collar rot and/or root rot was recorded at 10 weeks after sowing.

Seed pathology test was conducted on 40 untreated seed by plating them onto half strength PDA, and incubated under 12 hour periods of fluorescent light at 22-24°C, and assessed 10 days later for the presence of seedborne *Ascochyta* infection. No *Ascochyta* colonies could be found.

Results and Discussion

Application of spore inocula of the different isolates of *P. medicaginis* and *M. pinodes*, either alone or in combinations, had no significant effect on seedling emergence (Table 3.1). Collar rot disease symptoms caused *by P. medicaginis* and *M. pinodes* were similar and cannot be separated visually. High incidence of collar rots (ranging from 95 to 100%) was observed on plants grown in *Ascochyta* inoculated soil at 10 week after sowing (Table 3.1, Figure 3.1). Collar rot was observed on plants from the untreated control (Table 3.1, Figure 3.1). No *Ascochyta* infection could be found in the pea seed line used in this study. This indicated that the low level of collar rot found in the untreated control is likely to be due to spread of Ascochyta inoculum from the inoculated treatments in adjacent pots.

The collar rot disease observed on *P. medicaginis* and *M. pinodes* inoculated plants in the pot trial tended to be superficial and has little or no obvious detrimental effects on pea growth or vigour. The lack of adverse detrimental effects on pea plants infected by the *Ascochyta* pathogens in the pots may be due to the pots being maintained under relatively dry conditions with drip irrigation. It appeared that under non-conducive conditions, the *Ascochyta* pathogens were mainly weak pathogens capable of invading and infecting superficial cortical tissues on the collar regions. It seems that other pre-disposing environmental conditions that can weaken the plants to severe *Ascochyta* rots must also be considered when evaluating the potential of *Ascochyta* pathogens to cause severe damage on pea crops.

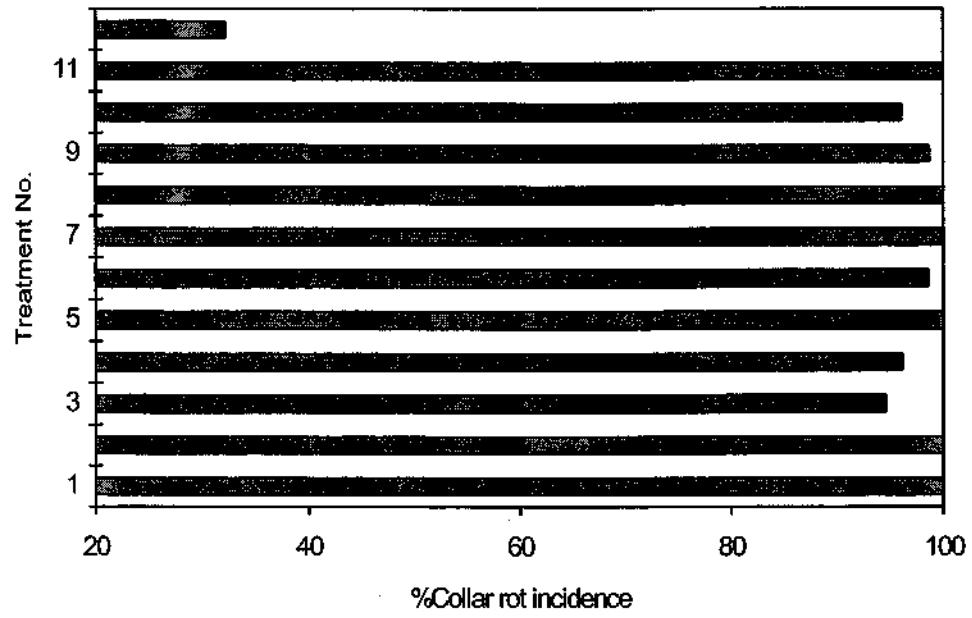
Root rot incidence was low but highly variable between replicates (ranging from 1.3 to 10.3%), and no significant differences could be found either between inoculated treatments nor with the control (Table 3.1). Visually, a few plants with root rot on the entire root system tended to be small and unthrifty.

Table 3.1- The effects of isolates of two *Ascochyta* species and their combinations on pea seedling emergence and disease incidence of collar rot and root rot.

NO.	TREATMENT	MEAN %EMERGENCE 2 Weeks after sowing	4 Weeks after sowing	% DISEASE INCIDENCE Collar rot	Root rot
1	*P. medicaginis* - isolate a	90	90	100 b	1.4 a
2	*P. medicaginis* - isolate b	85	90	100 b	4.2 a
3	*M. pinodes* - isolate c	95	95	94.6 b	4.1 a
4	*M. pinodes* - isolate d	95	95	96.2 b	1.3 a
5	a + b	90	90	100 b	1.5 a
6	a + c	90	90	98.6 b	2.9 a
7	a + d	90	90	100 b	10.8 a
8	b + c	95	95	100 b	10.3 a
9	b + d	90	95	98.7 b	7.8 a
10	c + d	100	100	96.1 b	3.9 a
11	a + b + c + d	90	90	100 b	9.3 a
12	untreated	95	100	32.1 a	5.1 a

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

Figure 3.1: The effect of Ascochyta inoculated treatments on collar rot incidence.



4. Effects of Herbicide Application

Aims

The post-emergent herbicide, Sencor (metribuzin) is often used in pea crops to control weed such as nightshade, radish and pinkweed, which are common in Tasmania. Many growers observed that the use of metribuzin for weed control in pea paddocks appears to increase the severity of collar rot disease. Therefore, several field trials were conducted under varying conditions at different locations to investigate whether post emergent herbicide applications, especially metribuzin could increase the disease severity.

Materials & Methods

Three field trials were conducted in 1994 and 1995 at Deloraine, Northdown and Kindred (Table 4.1). Plot size was 2m x 10m. The trial designs were complete randomized blocks with four replicates. Herbicide was applied using pressurised knapsack precision sprayer fitted with a 2m boom and 6502 fanjets. The volume applied was 250L/ha at 280kPa.

Table 4.1: Details of the field sites where the trials on the effect of herbicides on collar rot were conducted.

Details	Trial 1	Trial 2	Trial 3
Location	Deloraine	Northdown	Kindred
Soil type	Krasnozem	Krasnozem	Krasnozem
Sowing Date	21 September 1994	8 July 1995	24 August 1995
Harvest Date	30 November 1994	5 December 1995	21 December 1995
Days from sowing to harvest	Disease assessment at 70 days after sowing	150	119
Pre-emergent herbicides	nil	2.5L/ha Agaprop & 3.0L/ha Stomp	3.0L/ha Stomp
Other factors	Good weed control	Cleavers was a serious problem in the pea crop. The herbicide 1.5L/ha Basagran was applied throughout the paddock including the trial site.	Good weed control.

Field trial 1 (1994)

The first trial was conducted at Deloraine (G. Cresswell's property) in a commercial pea crop (sown at 21 September 1994) (Table 4.1). Only Sencor (480g/L metribuzin), applied at the 3 nodes growth stage, was evaluated and compared with untreated plants (Table 4.2).

Fifty plants from each replicate plot were assessed visually for collar rot incidence at 11 weeks after planting. Another 25 plants from each replicate plot were assessed for *Ascochyta* infection by cutting 1 cm length of their stem just above the soil level, surface sterilized and plated out onto half strength potato dextrose agar.

Field trials 2 & 3 (1995)

Two trials were conducted in 1995 at two locations in commercial pea crops in the north-west of Tasmania (Table 4.1). One was an early sown crop (sown at 8 July 1995) at Northdown (Alan Duff's property) (Table 4.3). The other was sown later in 24 August 1995 at Kindred (Langmaid's property) (Table 4.4). Both sites were sown with the Small Sieve Freezer seed variety. The post-emergent herbicides used in this study was Sencor (480g/L metribuzin), Basagran (480g/L bentazone), Bladex (500g/L cyanazine) and MCPA (500g/L MCPA). The treatments for the two trials are listed in Table 4.3 (Northdown) and Table 4.4 (Kindred).

Disease assessment was conducted about 2 weeks and one week after the last application, at Northdown and Kindred respectively. The assessment was carried out by removing five samples of ten consecutive plants per plot. The numbers of plants with collar rot were recorded. Plant vigour was also rated 1 to 5 according to the following criteria: 1=dying; 2=small, stunted & yellow; 3=reduced growth with slight yellowing; 4=reduced growth but no yellowing; 5=healthy

Yield assessment was conducted by harvesting 1 m^2 per plot except for very sparse plots where 2 m^2 were harvested instead. Harvested plants were processed at Simplot Australia, Devonport for yield of peas and their maturity index. Adjusted yields were tabulated using maturity index and raw yield of peas for an equivalent yield at the maturity index average for the trial.

Results

Field trial 1

The herbicide spray application using metribuzin (Sencor at 500ml/ha) did not significantly increase collar rot incidence when applied on a pea crop at a growth stage of 3 node in this field trial. However, while not significant, there seems to be a trend towards higher collar rot incidence on metribuzin treated pea plants in comparison to the untreated pea plants (Table 4.2).

Table 4.2 - The effects of Sencor application on Ascochyta Rot incidence at 11 weeks after planting

Treatment	Product Rate	Visual Assessment# %Plants with obvious collar rot disease	Fungal isolation# %Plants with *Ascochyta* infection
Untreated Control	nil	44	20
Sencor	500 ml/ha product applied at 3 node growth stage	54	29

No significant differences between the two treatments according to analysis of variance.

Field trial 2

The field trial at Northdown showed that herbicide applications appeared to have adverse effects on collar rot incidence and plant vigour. Collar rot incidence on herbicide treated plants generally tended to be higher than those observed on untreated control plants (Table 4.3).

Table 4.3: The effects of herbicide applications at Northdown on collar rot incidence and plant vigour at 82 days after sowing, and on maturity index and yield at 150 days after sowing.

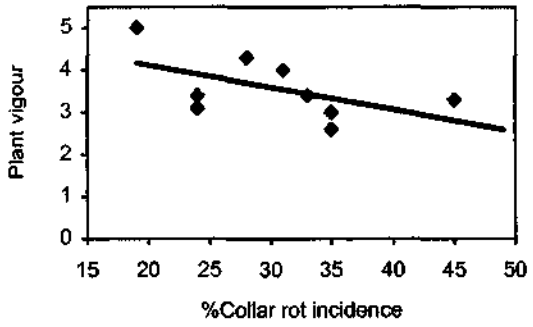
No.	Product	Product Rate per Ha	Application Timing at week after sowing (plant growth stage)	%Collar rot incidence *	Plant Vigour (1-5)	Maturity Index	Raw Yield g/m^2	Adjusted Yield * (g/m^2)
1	Sencor	500 ml	Week 6 (1-2 node)	24 ab	3.1	104	465	441.2
2	Sencor	500 ml	Week 9 (2-4 node)	35 bcd	3.0	104	443	491.0
3	Sencor	500 ml	Week 10 (4 node)	28 ab	4.3	110	471	438.9
9	Sencor	1L	Week 4 (1-2 node)	33 abc	3.4	95	490	522.2
4	Sencor	1 L	Week 6 (1-2 node)	35 abcd	2.6	91	327	429.6
5	Sencor	1 L	Week 9 (2-4 node)	45 cd	3.3	100	499	497.0
6	Sencor	1 L	Week 10 (4 node)	31 abc	4.0	108	507	466.2
7	Basagran + Bladex	2 L + 2 L	Week 6 (1-2 node)	49 d	2.6	96	393	405.9
8	MCPA	1L	Week 6 (1-2 node)	24 ab	3.4	88	477	564.5
10	Untreated	n/a	n/a	19 a	5.0	102	488	473.9

* Means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.
# No significant differences between the two treatments according to analysis of variance.

Basagran & Bladex as well as Sencor treated plants at the 2-4 node stage appeared to increased collar rot incidence (Table 4.3). All the herbicide treatments appeared to cause detrimental effect on plant vigour as well as higher incidence of collar rot in comparison to the untreated control. This indicated collar rot tend to

increase with a decrease in plant vigour due to herbicide sprays in unthrifty crop (Figure 4.1). It should be noted that the entire crop including all the trial treatments was sprayed with 1.5 L/ha Basagran.

Figure 4.1: Relationship between plant vigour and collar rot incidence.



Although not significant, collar rot incidence tended to be higher with an increase in application rate of Sencor from 500ml to 1litre per ha (Table 4.3). This indicated that timing of the Sencor herbicide application as well as its rate might be critical in minimising any adverse effects.

Adjusted yield of peas ranged from 406 to 565g/m^2 (Table 4.3). The mean maturity indices ranged from 91 to 110 and the mean of raw yield ranged from 327 to 507 g/m^2. There was no significant difference in the adjusted yield of peas between all treatments due to high variability of the maturity index and raw yield between replicate plots. As a result of this high variability, large differences between treatments are required before significant difference could be detected. A high level of cleaver weed in this trial site is likely to be a contributing factor to yield variability as well as low yields. Similarly, due to the variability, no obvious relationship could be observed between the adjusted yield and plant vigour or collar rot incidence.

Field trial 3

Sencor applications in the trial at Kindred had no adverse effects on plant vigour. The qualitative assessment on plant vigour showed that the pea plants were vigorous in growth and healthy looking in all treatments (Table 4.4). Collar rot incidence on Sencor treated plants tended to be higher than those observed on untreated control plants (Table 4.4). The untreated plants had the lowest mean collar rot incidence (12%) in comparison to Sencor treated plants (ranging from 19 to 26%).

Table 4.4 – The effects of herbicide applications at Kindred on collar rot incidence, plant vigour, maturity index and yield at 11 weeks after sowing

No.	Product	Rate per Ha	Application Timing at week after sowing (growth stage)	Mean %Plants with collar rot*	Mean Plant Vigour (1-5)	Mean Maturity Index	Mean Raw Yield g/m^2	Adjusted Yield # g/m^2
1	Sencor	500 ml	Week 3 (emergence)	23 ab	5	208	882	898.7
2	Sencor	500 ml	Week 4 (1-2 nodes)	24 b	5	222	859	878.4
3	Sencor	500 ml	Week 7 (4 nodes)	25 b	5	194	857	897.0
4	Sencor	500 ml	Week 9 (6 nodes)	24 b	5	225	992	974.4
5	Sencor	500 ml	Week 10 (8-9 nodes)	21 ab	5	208	814	829.7
6	Sencor	1L	Week 3 (emergence)	24 b	5	198	859	884.0
7	Sencor	1L	Week 4 (1-2 nodes)	26 b	5	168	785	904.1
8	Sencor	1L	Week 7 (4 nodes)	23 ab	5	214	851	864.7
9	Sencor	1L	Week 9 (6 nodes)	24 b	5	220	957	955.1
10	Sencor	1L	Week 10 (8-9 nodes)	19 ab	5	229	811	816.9
11	Untreated	n/a	n/a	12 a	5	165	878	1037.5

*- Means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.
No significant differences between the two treatments according to analysis of variance.

It is noteworthy that although the Sencor treatments generally increased the collar rot incidence in comparison to the control treatment, plants vigour was not affected by the increase in the disease incidence (Table 4.4). The collar rot disease observed on plants in this trial was mostly superficial. There were no significant differences in the level of collar rot incidence between the different application rate and timing of Sencor at 500ml/ha and 1L/ha (Table 4.4).

Adjusted yield of peas ranged from 816.9 to 1037.5 g/m^2 (Table 4.4). The mean maturity indices ranged from 165 to 229 and the mean of raw yield ranged from 785 to 992 g/m^2. There was no significant difference in the adjusted yield of peas between all treatments due to high variability of the maturity index between the replicate plots.

While not significant, the adjusted yield for the untreated control tended to be higher compared to the Sencor treatments. The adjusted yield takes into account the low maturity index of peas from the untreated control plants. This indicates that the untreated plants were still growing and with smaller peas in the maturing pods.

Discussion

This study indicates that seedlings growth and vigour at the time of the herbicide spraying are important determining factors on their susceptibility to herbicide damage and hence to further damage by collar rot disease. Climatic conditions may also be important as factors such as temperatures and rainfall will influence plant growth and vigour. Field trials showed that with early winter sown crop at Northdown during the cool and wet winter period, the rate of pea emergence and plant growth was much slower than the later sown crop at Kindred. The pea crop sown at Northdown was harvested at 150 days after sowing in comparison to the crop at Kindred, which was harvested at 119 days after sowing. Raw yield of peas from the Northdown's crop was about double that from the Kindred's crop.

Incidence of collar rots tends to be higher on herbicide treated plants in early winter sown crop at Northdown compared to those from later sown crops at Deloraine and Kindred. Significant plant damages due to herbicide was found only on the slow growing crop at Northdown but not on the crops at Deloraine or Kindred. This indicates that slow rate of emergence and growth of seedlings with early winter sown crop is more likely to pre-dispose the plants to post-emergent herbicide spray damage than late winter sown crop. Under such conditions, herbicide rate and timing of spray applications may be critical in causing crop damage, and hence pre-dispose them to disease. The rates and timing of the post-emergent Sencor applications was critical only with the early sown crop at Northdown.

5. Chemical Control

Introduction

P. medicaginis var. pinodella can survive in soil for many years, and seems to be widespread in major pea production areas in Tasmania. While the use of seed produced in dry areas and/or seed treatment is the best way of preventing seedborne infection from *Ascochyta* spp., most crops in the paddocks still eventually become infected by field *Ascochyta* inoculum. Therefore, in this section, studies were conducted to investigate the use of different fungicide products and fungicide application methods for the control of soilborne *Ascochyta* infections. This includes a study to evaluate the potential of alternative fungicides for use in seed treatment to extend the protective period from field *Ascochyta* inoculum.

5.1 Seed treatments

Aims

This study was conducted to evaluate the potential of alternative fungicides for use in seed treatment to extend the protective period from *Ascochyta* infections. In a laboratory test, a range of fungicides was first screened on agar at different concentrations for inhibitory activity against one of the *Ascochyta* pathogen, *M. pinodes*. After the fungicide screening test, a pot trial was then set up to evaluate the use of the fungicides in seed treatments in controlling collar rot.

Materials & Methods

Chemical Screening on Agar

The fungicide screening was conducted in three separate tests (Table 5.1). Various fungicides were incorporated into PDA at three concentrations (Table 5.1). Agar plugs (1cm diameter) of *M. pinodes* cultures that had been grown on PDA for 14 days were placed at the centre of the fungicide treated agar medium. Each treatment was replicated 3 times. After 7 days incubation at 20-22C, the radial growth of *M. pinodes* on each plate was recorded. Fungal inhibition was tabulated according to the following formula: %Inhibition = 100 x (a –b)/a, where a is the radius of the fungal colony on the control agar medium and b is the radius of the fungal colony on the fungicide treated agar medium.

Fungicide seed treatments

Pea seed were treated by mixing 100g seed (Small Sieve Freezer variety) with the appropriate fungicide and 0.6ml of water in a 500ml glass flask (Table 5.2). Pots (20cm wide x 20cm deep) were filled to two thirds volume with pasteurized potting mix. Twenty treated seed were sown in each pot, and then covered with 0.5L naturally infected field soil (collected from Wright site-1). In the control treatment, untreated seed were covered with sterile soil instead.

Trial design was complete randomized block design with four replicate pots for each treatment. Pots were kept in an open environment and watered by drip irrigation as required. The number of pea seedlings that emerged were recorded at 4 weeks after sowing. At 10 weeks after sowing, plants were removed from the pots. A visual assessment was carried out by counting the numbers of plants with collar rot in each pot. Plant shoot weights were measured.

Seed pathology test was conducted on 40 untreated seed as described in section 3 (p16).

Results

Chemical Screening on Agar

The fungicides, Armour, Rovral & Saphire at 10 & 100ppm, Scala at 1, 10 & 100ppm,and Benlate at 100ppm were very effective, causing greater than 80% growth inhibition to *M. pinodes* mycelial growth on agar (Table 5.1, Figure 5.1, 5.2 & 5.3). Folicur and Ronilan were less effective, causing only 68% and 52% growth inhibition at 10ppm.

Table 5.1 – Percentage inhibition of fungicides on mycelial growth of *M. pinodes*.

No.	Product	Active Ingredient	Conc. a.i. (ppm)	Radial Growth (mm)	%Inhibition*
	Screening 1				
1	Saphire	Fludioxonil	1	17.3	66b
2	Saphire	Fludioxonil	10	4.7	91a
3	Saphire	Fludioxonil	100	5.3	89a
4	Scala	Pyrimethanil	1	9.7	81ab
5	Scala	Pyrimethanil	10	10	80ab
6	Scala	Pyrimethanil	100	5.7	89a
7	Untreated Control			50.3	0c
	Screening 2				
1	Armour C	Flutriafol	1	9	79b
2	Armour C	Flutriafol	10	0	100a
3	Armour C	Flutriafol	100	0	100a
4	Untreated Control			43	0c
	Screening 3				
1	Rovral	Iprodione	1	38.7	50cd
2	Rovral	Iprodione	10	0	100a
3	Rovral	Iprodione	100	4.8	94a
4	Ronilan	Vinclozolin	1	71	8f
5	Ronilan	Vinclozolin	10	37	52c
6	Ronilan	Vinclozolin	100	33	57c
7	Benlate	Benomyl	1	62.3	19e
8	Benlate	Benomyl	10	37.7	51c
9	Benlate	Benomyl	100	5	94a
10	Folicur	Tebuconazole	0.1	56.3	27e
11	Folicur	Tebuconazole	1	44.3	42d
12	Folicur	Tebuconazole	10	24.7	68b
13	Untreated Control	0	0	77	0f

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

Figure 5.1: Screening 1

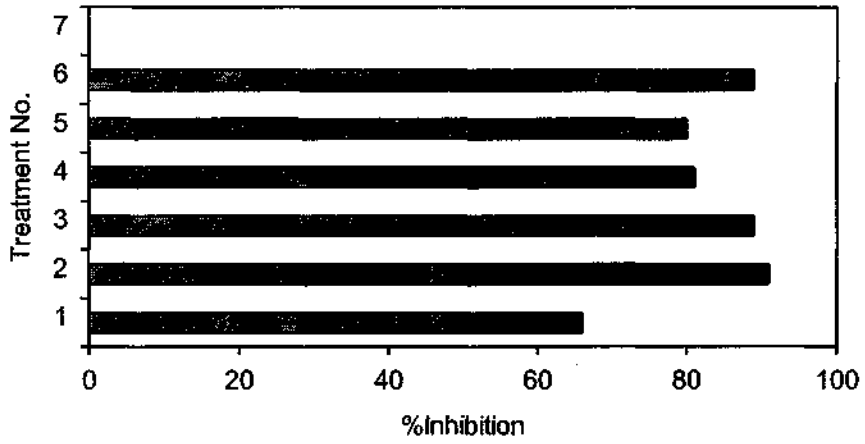


Figure 5.2: Screening 2

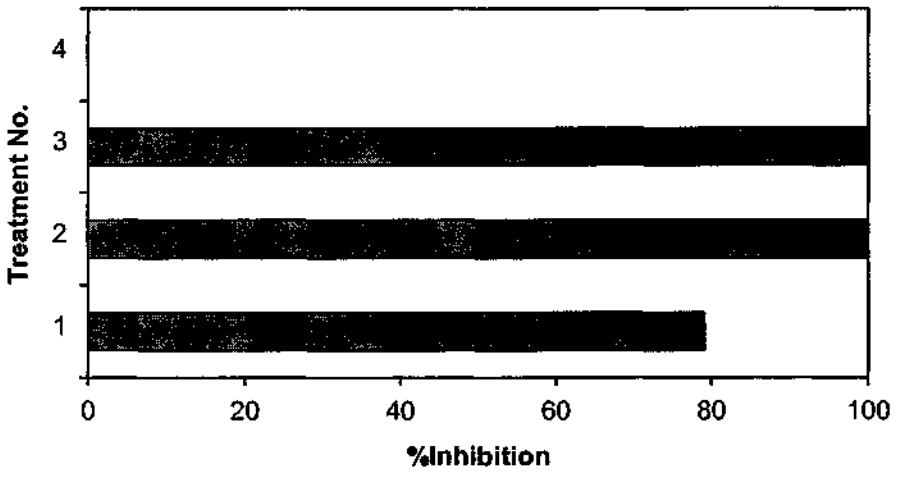
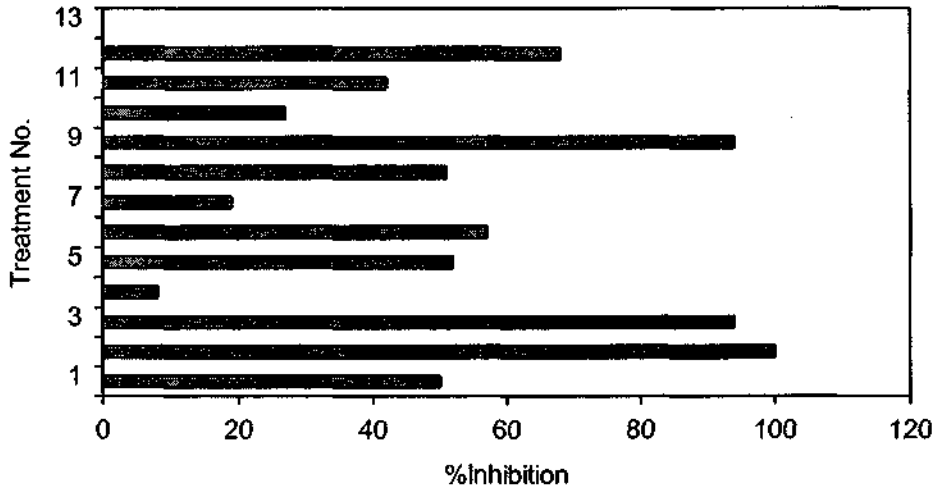


Figure 5.3: Screening 3



Fungicide seed treatments

All the treatments inoculated with naturally infested field soil had high levels of collar rot incidence (Table 5.2), but no significant difference was found between the fungicide treatments. With an exception of Apron & P-Pickel T seed dressing, all the other fungicides seemed to reduce seedling emergence (Figure 5.4). Similarly, with Shirlan, a relatively new fungicide, also tend to cause lower seedling emergence in comparison to Apron & P-Pickel T. There also appeared to be a similar pattern of reduced fresh weight of pea plants (Table 5.2).

Note that the untreated control used sterile soil instead of infested soil. In retrospect, the use of non-sterile infested field soil for the untreated control would have been more appropriate, enabling comparison with the seed treatments. Even so, relatively high level of collar rot was recorded on the untreated control plants. This may be due to seedborne infection on the untreated seed. Seed test conducted on the untreated seed batch showed that 35% had *Ascochyta* infection. The high collar rot incidence (69%) found at the end of the trial showed that the fungal could spread easily from infected plants.

Table 5.2 – The effects of fungicide seed dressing on plant emergence, fresh weight and collar rot incidence

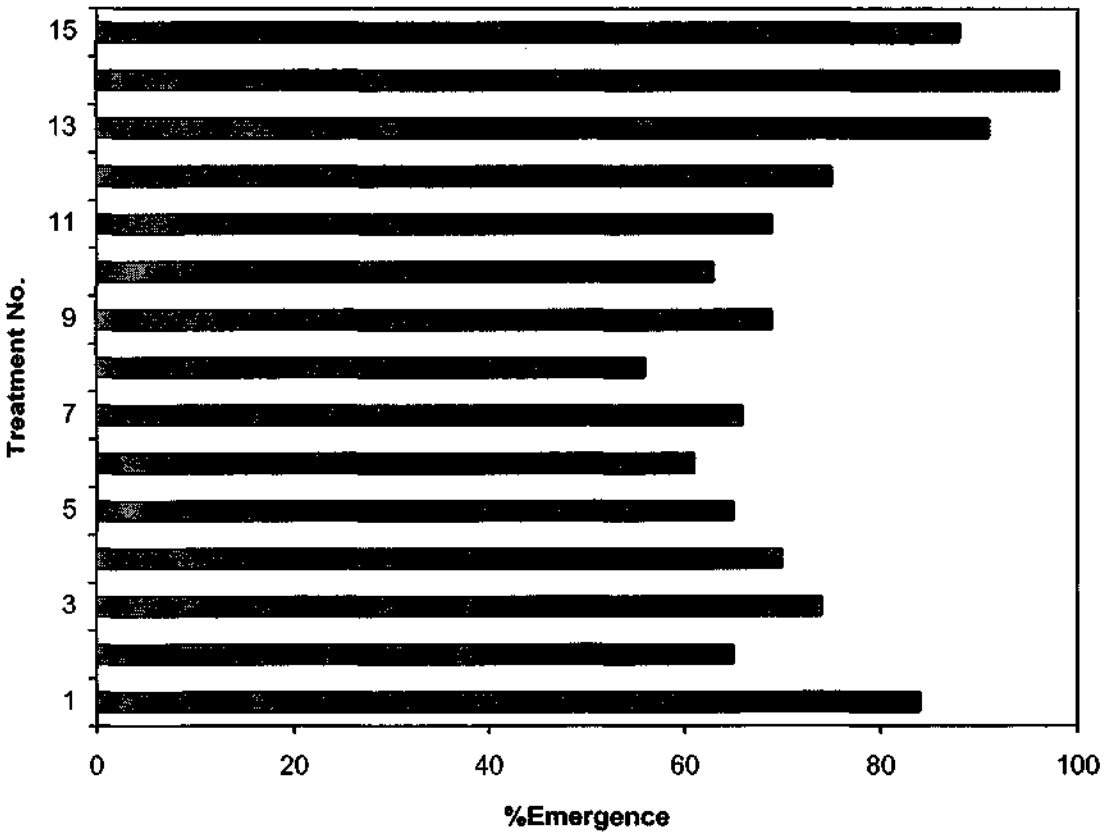
No.	Product	Active Ingredient (a.i.)	a. i. concn per 100g seed (ppm)	%Emergence [1,2]	Fresh Weight [1] per plant (g)	Collar Rot %Incidence [3]
1	Saphire	Fludioxonil	100	84 bcde	9.5 a	85.0
2	Saphire	Fludioxonil	200	65 ab	10.9 ab	74.4
3	Scala	Pyrimethanil	50	74 bcde	10.8 ab	93.1
4	Scala	Pyrimethanil	100	70 ab	10.0 ab	85.3
5	Armour C	Flutriafol	100	65 ab	11.0 ab	93.2
6	Armour C	Flutriafol	200	61 a	12.1 ab	91.2
7	Rovral	Iprodione	2000	66 ab	11.4 ab	78.9
8	Rovral	Iprodione	4000	56 a	10.9 ab	85.2
9	Benlate	Benomyl	100	69 ab	10.1 ab	87.6
10	Benlate	Benomyl	200	63 ab	12.2 ab	93.7
11	Shirlan	Fluazinam	500	69 abc	10.7 ab	91.2
12	Shirlan	Fluazinam	1000	75 abcd	9.8 a	89.4
13	Apron / P-Pickel T	Metalaxyl / Thiabendazole & Thiram	525 / 720 & 400	91 de	13.1 ab	81.2
14	Apron / P-Pickel T	Metalaxyl / Thiabendazole & Thiram	2100 /2880 & 1576	98 e	12.1 ab	91.1
15	Untreated**		n/a	88 cde	13.6 b	69.7

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

2 Statistical analysis conducted on square root of (% emergence) + 0.05;

3 No significant differences between the two treatments according to analysis of variance.

Figure 5.4: The effect of fungicide seed dressing on plant emergence.



5.2 Fungicide Applications Methods

Aims

Field trials were conducted to evaluate different fungicides and application methods for the control of collar rot due to field *Ascochyta* inoculum.

Materials & Methods

The trial was conducted at Kindred (Dudley Russell's property) within a commercial pea crop in krasnozem soil. The pea variety sown was Resal. Fungicide treatments were applied using 3 application methods (Table 5.3) as follow:

(1) Foliar Spray - fungicide sprayed onto plants;
(2) In-Furrow Spray - fungicide sprayed onto soil in-furrow as seed were sown;
(3) Fertiliser - fungicide sprayed onto fertiliser, mixed, then applied in-furrow as seed were sown.

The foliar fungicide was applied using a pressurised knapsack precision sprayer, hollow cone jets at 250 L/ha and 480 kPa. The trial design was complete randomized block with four replicate plots. Each plot size was 2m x 10m.

Disease assessments were conducted at 85 days (12 weeks) after sowing by removing 5 sub-samples of ten consecutive plants for a total of 50 plants per plot. The number of plants with collar rot was recorded. Plant vigour was also rated 1 to 5 according to the following description: 1=dying; 2=small, stunted & yellow; 3=reduced growth with slight yellowing; 4=reduced growth but no yellowing; 5=healthy

After 15 weeks, 1 m^2 per plot was harvested, and processed at Simplot Australia, Devonport for yield and maturity index. Adjusted yields tabulated using maturity index and raw yield of peas for an equivalent yield at the maturity index average for the trial.

Results

Table 5.3 – The effects of fungicide applications on Ascochyta collar rot and plant vigour at 12 weeks after sowing

No.	Product	Active ingredient	Product Rate/ha	Application Timing (weeks after sowing)	Application Method	%Collar rot Incidence*	Plant Vigour (1-5)
1	Impact	Flutriafol	0.4 L	5 weeks	Foliar spray	40 abc	5
2	Impact	"	0.4 L	7 weeks	Foliar spray	50 abc	5
3	Impact	"	0.4 L	10 weeks	Foliar spray	46 abc	5
4	Impact	"	0.4 L	11 weeks	Foliar spray	47 abc	5
5	Impact	"	0.4 L	13 weeks	Foliar spray	40 abc	5
6	Impact	"	0.4 L	5, 7, 10, 11, 13 weeks	Foliar sprays	31 a	5
7	Shirlan	Fluazinam	2 L	at sowing	In-Furrow	32 ab	5
8	Saphire	Fludioxonil	1.5 L	at sowing	In-Furrow	50 abc	5
9	Impact	Flutriafol	0.4 L	at sowing	In-Furrow	50 abc	5
10	Rovral	Iprodione	2 L	at sowing	In-Furrow	41 abc	5
11	Benlate	Benomyl	2 kg	at sowing	In-Furrow	45 abc	5
12	Impact	Flutriafol	0.4 L	at sowing	Fertiliser	45 abc	5
13	Rovral	Iprodione	1 L	at sowing	Fertiliser	53 bc	5
14	Benlate	Benomyl	1 kg	at sowing	Fertiliser	47 abc	5
15	Untreated		n/a	n/a	n/a	58 c	5

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

Only Impact (0.4L, multiple foliar sprays at 5, 7, 10, 11 & 13 weeks) and Shirlan (2L, in-furrow application at sowing) significantly reduced the incidence of collar rot from 58% in the untreated to about 30% (Table 5.3). No differences could be found on the collar rot between the three application methods for Impact, Rovral and Benlate.

Although collar rot incidence ranging from 31% to 58% was recorded (Table 5.3), the collar rot disease noted in the field crop was mostly superficial. Consistent with this observation was that plants from all the treatments have the highest rating of 5 for plant vigour regardless of the collar rot incidence (Table 5.3).

Table 5.4 - Effect of Fungicide applications on pea yield at harvest

No.	Product	Rate per ha	Timing	Application Method	Maturity Index	Raw Yield per m^2	Adjusted Yield g/m^2*
1	Impact	0.4L	5 weeks	Foliar spray	286	845	893.0 abcd
2	Impact	0.4L	7 weeks	Foliar spray	272	990	1060.3 cd
3	Impact	0.4L	10 weeks	Foliar spray	332	927	948.0 abcd
4	Impact	0.4L	11 weeks	Foliar spray	318	847	872.1 abcd
5	Impact	0.4L	13 weeks	Foliar spray	258	792	849.9 abc
6	Impact	0.4L	5, 7, 10, 11, 13 weeks	Foliar sprays	293	901	933.1 abcd
7	Shirlan	2 L	at sowing	In-Furrow	271	793	837.9 abc
8	Saphire	1.5L	at sowing	In-Furrow	435	738	738.0 a
9	Impact	0.4L	at sowing	In-Furrow	392	887	890.8 abcd
10	Rovral	2 L	at sowing	In-Furrow	288	715	753.0 a
11	Benlate	2 kg	at sowing	In-Furrow	297	854	894.4 abcd
12	Impact	0.4L	at sowing	Fertiliser	302	772	793.4 ab
13	Rovral	1L	at sowing	Fertiliser	262	1006	1080.2 d
14	Benlate	1 kg	at sowing	Fertiliser	280	965	1016.7 bcd
15	Untreated	n/a	n/a	n/a	235	946	995.3 bcd

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

The adjusted yield of peas for all the treatments were highly variable between replicate plots. No significant improvement in the adjusted yield among all the fungicide treatments could be detected compared to the control treatment. The two treatments, Saphire (1.5L) and Rovral (2L) both with in-furrow application at sowing gave a significantly lower adjusted yield in comparison to the untreated control adjusted yield (Table 5.4). As no differences could be observed on disease incidence or plant vigour, it is possible that other factors may be involved.

5.3 Foliar Fungicide Applications

Aims

Two field trials were conducted to investigate the use of fungicides applied as foliar sprays at different timings, and number of applications. A laboratory test was also conducted to evaluate the efficacy of the field trial fungicides in controlling *Ascochyta* growth. A third field trial was conducted to evaluate the influence of spray volume, pressure, and wetting agent on spray coverage.

Materials & Methods

Field trials on foliar fungicide applications

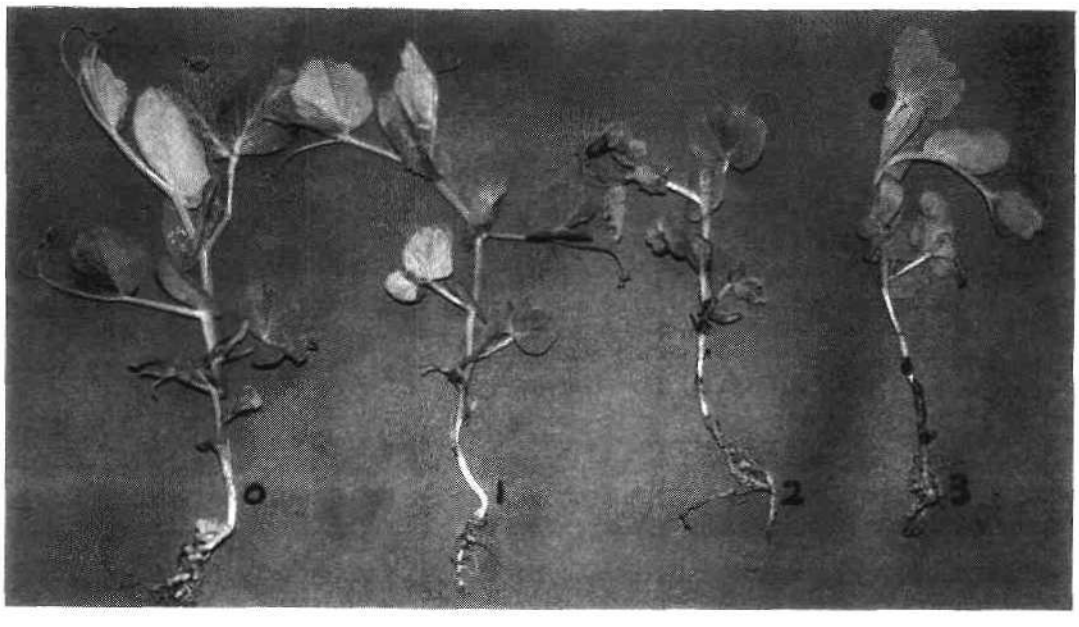
The trials were conducted on early winter sown crops at Wesley Vale (Derrick Dick's property) and Moriarty (David Chaplin's property) in krasnozem soil (Table 5.5). The pea variety sown was Small Sieve Freezer.

The appropriate fungicide (Table 5.6 & 5.7) was applied using a pressurised knapsack precision sprayer, hollow cone TX8 jets at 250 L/ha and 450 kPa. The post-emergent herbicide, Sencor, was applied in all the treatments except for the untreated control-2 treatment. The trial design was complete randomized block with four replicate plots. Each plot size was 2m x 8m.

Table 5.5: Details of the trial sites at Wesley Vale and Moriarty.

	Trial 1	Trial 2
Location	Wesley Vale, near coastal area	Moriarty
Sowing Date	8 July 1996	16 July 1996
Harvest Date	28 November 1995	9 December 1997
Growth period from sowing to harvest	143 days	146 days
Field factors	The field was on level ground, very prone to water logging, and has poor soil structure; slow emergence, field was water logged between sowing and seedling stage; very weedy.	The trial site was level, located at base of sloping field; ground prone to water-logging with heavy rain; has good soil structure

At week 9 and 12 after sowing, 20 plants were removed from each trial plot prior to fungicide applications and assessed for collar rot incidence and severity. Disease severity at the stem base was rated 0 to 3: 0=no lesion, 1=small lesion less than 1cm, 2=1 to 2cm lesion; and 3=necrosis around the stem (see Plate 1 below).



At maturity, just before the commercial harvest, plants in two half m^2 area were harvested, and assessed for total shoot weights. Plant height, number and weight of matured and immature pods, and number of diseased pods were determined from 30 plants taken at random from the 2 x half m^2 harvest. The percentage of immature and diseased pods were tabulated. In the second trial at Moriarty, harvest assessment was conducted only on the Shirlan and untreated control treatments due to very low disease severity and lack of any visible differences in disease levels or plant growth between all treatments in the field.

Fungicide effect on Ascochyta growth

Ascochyta infected pea plants (12 weeks after sowing) were collected from the paddock at Wesley Vale (Derrick Dick's property). The infected lower stem pieces of about 1.5cm in length were cut, treated with the appropriate fungicide by soaking in the fungicide suspension for 1min and 30 min, removed and air dried in the laminar flow. The treated stem pieces were then transferred into half strength potato dextrose agar. The same fungicide concentrations used for fungicide sprays in the field trials were used in this study. Ten stem pieces were used for each treatment. The plates were incubated at 20-22C, mycelial growth from the infected stem pieces was measured, and the percentage fungal inhibition by the fungicide treatments was tabulated. Analysis of variance was carried out to analyse both the fungicide and timing of the fungicide dipping effects using StatGraphic Plus 2.0 program.

Field trial on spray coverage

This trial was conducted at Moriarty (Paul Badcock's property) within a commercial pea crop sown in krasnozem soil. The pea variety, Resal was sown in 19 November 1996 and harvested in 3 February 1997.

Fungicide was applied using a pressurised knapsack precision sprayer. Different application volumes, pressures, and spray nozzles were used in the fungicide applications (Table 5.6). Pulse, a wetting and penetrating agent, was used at the rate of 200ml/ha in some of the treatments to see if its usage will improve spray coverage. The trial design was complete randomized block with five replicate plots. Each plot size was 2m x 10m.

Table 5.6: Treatment details.

No.	Fungicide	Active Ingredient	Product Rate/ha	Application methods Spray volume, pressure, nozzle	Spray timing (weeks after sowing)
1	Calixin	tridemorph	0.5L	200L/ha; 500kPa; Tx6	6 & 9
2	Calixin	"	0.5L	500L/ha; 700kPa; Tx18	6 & 9
3	Calixin	"	0.5L + 200ml Pulse	200L/ha; 500kPa; Tx6	6 & 9
4	Calixin	"	0.5L + 200ml Pulse	500L/ha; 700kPa; Tx18	6 & 9
5	Shirlan	fluazinam	0.5L + 200ml Pulse	200L/ha; 500kPa; Tx6	6 & 9
6	Untreated	nil	nil	n/a	n/a

Spray coverage was assessed at each spray application by placing water sensitive paper strips (paper strip size - 75 x 25 mm) adjacent to the base of the main stems at ground level. Spray droplets on each of the paper strips were scanned and coverage area tabulated on computer using the program SigmaScan.

Unfortunately, all plants in the trial plots suffered from severe water stress due to soil compaction, poor water retention, and poor soil structure. As a result of very poor growth and premature plant death, there was no canopy closure between rows. There was only about one pod per plant at harvest time. Since no differences could be observed due to treatments, this trial was aborted.

Results

Field trials on foliar fungicide applications

Table 5.7: The effect of foliar applications of fungicide on collar rot incidence in the trials at Wesley Vale and Moriarty.

Product	Active ingredient	Product Rate/ha	Application Time (Week)	%Collar rot Incidence # Wesley Vale Week 9	Wesley Vale Week 12	Moriarty Week 9	Moriarty Week 12
Shirlan (6)	Fluazinam	0.5 L	6	94	100	18	96
Shirlan (12)	Fluazinam	0.5 L	9	100	100	31	97
Shirlan (6, 9 & 12)	Fluazinam	0.5 L	6,9 & 12	100	100	22	97
Impact	Flutriafol	0.5 L	6,9 & 12	100	100	17	88
Dithane + Bravo	Mancozeb + chlorothalonil	1.5kg+1.5L	6,9 & 12	95	100	23	94
Benlate	Benomyl	2 kg	6,9 & 12	100	100	19	92
Rovral	Iprodione	1.5 L	6,9 & 12	99	100	17	91
Untreated - 1	Nil	n/a	n/a	100	100	14	95
Untreated - 2	Nil	n/a	n/a	100	100	11	94

No significant differences between the treatments down the column according to analysis of variance.

No significant differences could be found in the collar rot incidence or severity between all treatments in the two trials at Wesley Vale and Moriarty. However, the collar rot was consistently much higher in incidence and more severe on plants in the Wesley Vale trial site in comparison to those at the Moriarty trial site (Tables 5.7 & 5.8). Almost all plants at the Wesley Vale trial site have both *Ascochyta* collar rot and leaf spots, whereas little or no *Ascochyta* leaf spot occurred on the plants at the Moriarty trial site. An increased in disease incidence and severity was noted as plant age increased at both sites (Tables 5.7 & 5.8). There was a delay in seedling emergence at the Wesley Vale crop due to very poor drainage and water logging. There was also little or no Rhizobium nodulation in the root system at this site. In contrast, the crop at Moriarty showed no delay in seedling emergence, and plant growth was vigorous with lots of nodulation in the root systems.

Table 5.8: The effect of foliar applications of fungicide on collar rot severity in the trials at Wesley Vale and Moriarty.

Product	Product Rate/ha	Collar rot severity rating (0-3) # Wesley Vale Week 9	Wesley Vale Week 12	Moriarty Week 9	Moriarty Week 12
Shirlan (6)	0.5 L	2.04	2.92	0.24	2.24
Shirlan (9)	0.5 L	2.38	2.93	0.53	2.08
Shirlan (6, 9 & 12)	0.5 L	2.41	2.89	0.41	2.1
Impact	0.5 L	2.09	3.00	0.27	1.91
Dithane + Bravo	1.5kg+1.5L	2.54	2.90	0.39	1.81
Benlate	2 kg	2.07	2.91	0.28	1.63
Rovral	1.5 L	2.41	2.95	0.30	2.00
Untreated - 1	Nil	2.57	2.96	0.25	2.01
Untreated - 2	Nil	2.11	2.91	0.16	2.17

No significant differences between the treatments down the column according to analysis of variance.

In the trial at Wesley Vale, only fluazinam treated plants sprayed at week 6, 9 and 12, produced significantly bigger plants, and lower disease incidence on pods in comparison to untreated plants (Table 5.9). Maturity of the pods was highly variable, but no significant differences could be found in the %immature pods between all the treatments.

Table 5.9: The effect of foliar fungicide treatments on shoot weights, pod numbers and weights, plant size, and *Ascochyta* disease incidence on pods in the trial at Wesley Vale.

Product	Product Rate/ha	Shoot & pod wt (kg/m^2)	Total pod no./30 plants.	Pod weight (g/30 plants)	%Immature pods	%Diseased pod*	Shoot height *(cm)
Shirlan (6)	0.5 L	3.7	148.2	510.0	41.9	19.6ab	59.4 b
Shirlan (12)	0.5 L	3.7	172.0	572.8	34.3	14.8 bc	62.8 b
Shirlan (6, 9 & 12)	0.5 L	4.2	183.2	580.1	28.7	6.0 c	72.3 c
Impact	0.5 L	3.2	169.8	556.1	36.2	26.4ab	53.1ab
Dithane + Bravo	1.5 kg +1.5 L	3.8	158.2	515.3	23.7	19.4ab	52.5ab
Benlate	2 kg	3.4	158.6	564.1	22.5	20.7ab	56.0ab
Rovral	1.5 L	3.3	146.8	539.6	25.1	26.9ab	50.4a
Untreated1	n/a	3.3	191.6	596.2	23.3	24.8ab	48.8a
Untreated2	n/a	3.6	181.6	597.6	24.2	24.9ab	52.8ab

* Means followed by the same letter in the columns are not significantly different at the 5% level according to Duncan's Multiple Range Test; # No significant differences between the treatments down the column according to analysis of variance, p>0.5.

In the trial at Moriarty, no significant differences could be found in the shoot and pod weights, and pod numbers and weights between all the treatments (Table 5.10). Although not significant, Shirlan treated plants tended to be lower in yield and plant size compared to the untreated plants. No explanation could be given for this observation. No *Ascochyta* lesions could be observed on the pea pods.

Table 5.10: The effect of foliar fungicide treatments on shoot weights, pod numbers and weights, and plant size in the trial at Moriarty

Product (Spray timing)	Product Rate/ha	Shoot & pod wt (kg/m2)	Total no. pod/30 plants	Total pod wt. (g/30 plants)	Shoot height per plant (cm)
Shirlan (6)	0.5 L	5.12	202.00	1021.26	77.20
Shirlan (9)	0.5 L	5.40	173.80	856.82	70.64
Shirlan (6,9 & 12)	0.5 L	5.10	168.50	789.08	78.63
Untreated - 1	n/a	5.95	215.75	1032.38	84.53

No significant differences between the treatments down the column according to analysis of variance, p>0.5 for all the yield assessment data.

Fungicide effect on Ascochyta growth

Benlate and Calixin showed the greatest inhibition, followed by Impact and Shirlan. The protectant mix Dithane/Bravo showed no significant inhibition, but seemed to stimulate fungal growth instead.

Table 5.11: The effect of fungicide dip treatments on Ascochyta mycelial growth from infected stems.

Treatments	Product concn	Product Rate/ha	%Fungal inhibition (1.0min dip)	%Fungal inhibition (30min dip)	Mean of %Fungal inhibition [1,2]
Benlate	8g/L	2 kg	49.0	95.7	72.4a
Calixin	2ml/L	0.5 L	76.4	77.1	76.8a
Impact	2ml/L	0.5 L	36.8	62.9	49.8 b
Rovral	6ml/L	1.5 L	3.8	20.0	11.9 cd
Shirlan	2ml/L	0.5 L	29.2	14.3	21.6 c
Dithane/Bravo	6g/L	1.5kg+1.5L	3.8	-51.4	-23.7 e
Control	nil	nil	0	0	0 d

1 Mean of %fungal inhibition of measurements taken from both 1 and 30 minute dip treatments;
2 Means followed by the same letter in the columns are not significantly different at the 5% level according to Duncan's Multiple Range Test

Field trial on spray coverage

Tests conducted using water sensitive papers during spray applications indicated that water volume and pressure used in the applications would affect the spray coverage (Table 5.12, Plate 2). Unfortunately, the effect of spray coverage as affected by crop canopy could not be evaluated due to very poor plant growth at the trial site. Although the crop was irrigated, plants still suffered from severe water stress due to soil compaction and poor soil structure. As a result of poor growth and plant premature plant death prior to harvesting time, no proper disease or harvest assessment could be carried out. There was no canopy closure between the rows. Each plant has only 1 to 2 pods with about 1 to 2 pea seed in the pod.

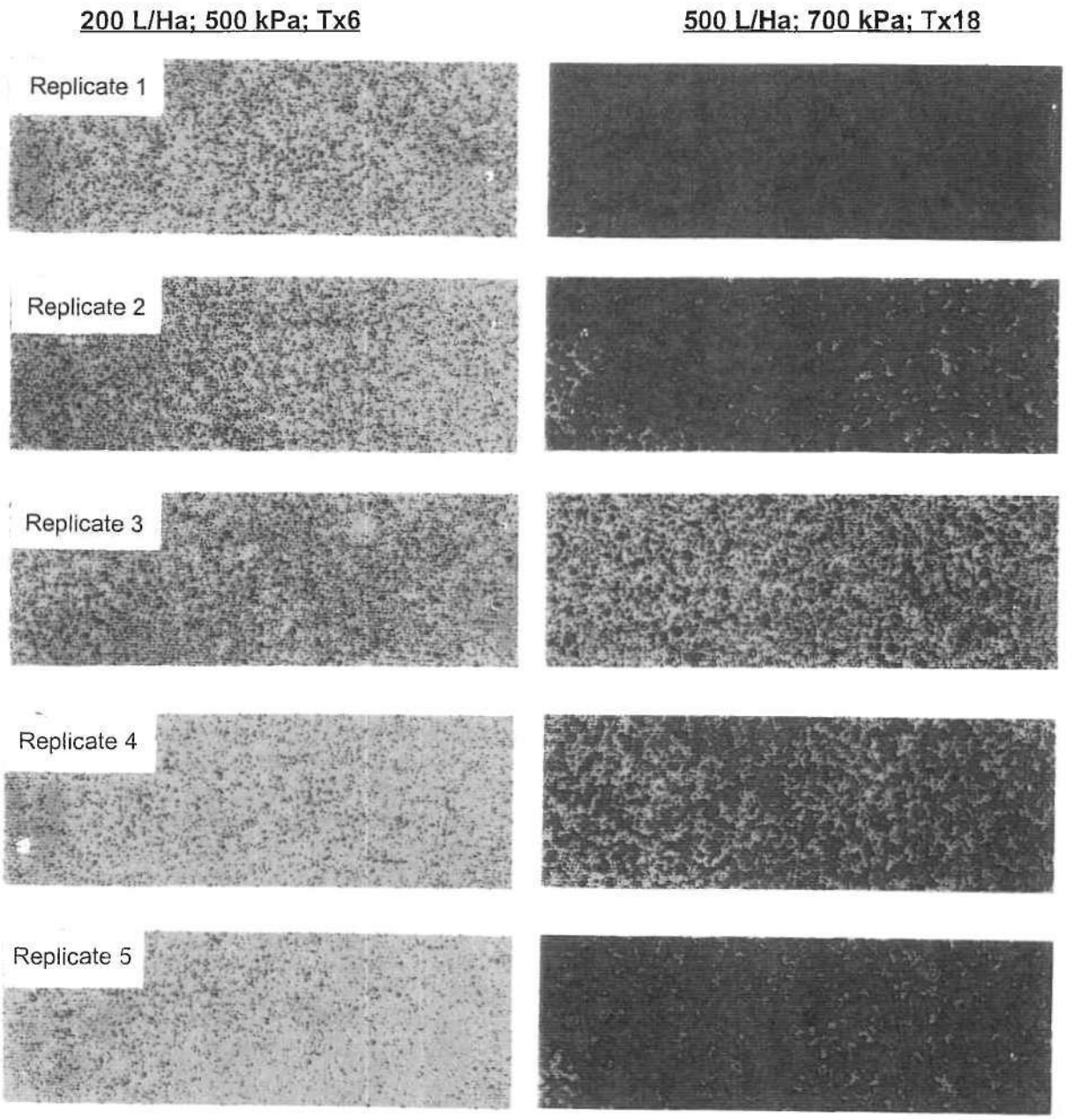
The higher spray volume and pressure (500L/ha and 700kPa) significantly increased the percentage coverage as measured by the water sensitive paper ($p<0.00001$), in comparison to the lower volume and pressure (200L/ha and 500kPa) (Table 5.13). There was also a significant reduction on the percentage coverage of spray applied at week 9 in comparison to week 6 ($p<0.05$), at the low spray volume and pressure. Percentage coverage of the high volume and pressure spray was similar for both spray timing.

Table 5.12: The effect of spray volume and pressure on percentage coverage of water sensitive paper placed on ground adjacent to plant stem bases.

Fungicide	Product Rate/ha	Application methods	%Spray Coverage		
		Spray volume, pressure, nozzle	6 Week	9 Week	mean [1,2]
Calixin	0.5L	200 L/ha; 500 kPa; Tx6	50.4	31.8	41.1a
Calixin	0.5L	500 L/ha; 700 kPa; Tx18	87.2	81.2	84.2 b

1 The combined mean of %spray coverage measurement of the sprays applied at 6 and 9 week after sowing;
2 Means followed by the same letter in the columns are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Plate 2: The influence of spray volume, pressure and nozzle on spray coverage of paper strips placed adjacent to the stem base of pea plants at week 9.



Discussion

The fungicides, Armour, Rovral, Saphire, Scala, and Benlate were found to be very inhibitive to *M. pinodes* mycelial growth on fungicide treated agar medium. However, they did not reduce collar rot incidence in comparison to the industry standard of Apron & P-Pickel T mixture used for pea seed treatment. The percentage seedling emergence of seed treated with these fungicides also tended to be lower compared to the Apron & P-Pickel T treated seed. Similar effect was also observed on the Shirlan treated seed. It is not clear whether the lower seedling emergence was due to improved control of fungal infections by the Apron & P-Pickel T treatment or due to phytotoxicity of the other fungicides. In conclusion, the studies indicates that Apron & P-Pickel T seed treatment still gives the best result with improved seedling emergence on *Ascochyta* infested soil. None of the alternative fungicides tested improved disease control nor extends the protection period.

Only Impact (0.4L, applied in 5 foliar sprays) and Shirlan (2L, applied into soil furrow at sowing) appear to reduce the incidence of collar rot in the field trial conducted to evaluate 5 different fungicides and 3 application methods for the control of soilborne *Ascochyta* rot. While no differences could be found in this study between the three application methods, the advantage of the soil-in-furrow and fertiliser applications are that these are applied at sowing making them attractive methods for a low maintenance crop like pea. However, with additional cost of fungicide applications, fungicide usage is likely to be attractive only when the crop productivity is obviously threatened by severe disease problems. The use of foliar spray with an effective fungicide could be an option in such occasions.

In the two foliar fungicide trials conducted at Wesley Vale and Moriarty, the collar rot incidence and severity was consistently much higher on plants at the Wesley Vale trial site in comparison to those at the Moriarty trial site. Nevertheless, no significant differences could be found in the collar rot incidence or severity between all the fungicide treatments and the untreated control in both trials. At harvest, only the trial at Wesley Vale, which had severe *Ascochyta* infection, showed significant differences. The leaf and pod infections of Shirlan (applied at week 6, 9 and 12) treated plants was much lower in comparison to the control and other fungicide treatments, even though their collar rot incidence and severity were not reduced.

Some fungicides used in the foliar fungicide application trials at Wesley Vale and Moriarty, i.e. Benlate, Impact, and Shirlan are inhibitive of *Ascochyta* growth from infected stems in *in vitro* study. But, when applied as low volume foliar sprays (250 L/ha and 450 kPa), no obvious reduction in collar rot could be found. This may be due to poor spray coverage. Tests with coloured dye on plants at 9 weeks after sowing, showed that little or no fungicide droplets reached the lower leaves and stems, where the *Ascochyta* infection frequently occurs.

Subsequently, further test conducted in a spray coverage trial showed that higher spray volume and pressure (500L/ha and 700kPa) significantly increased the percentage coverage in comparison to the lower volume and pressure (200L/ha and 500kPa). The percentage coverage of spray applied also seems to decrease with increasing plant growth at the low spray volume and pressure but no differences is evident with the high volume and pressure spray.

The interpretation of pea yield is complex due to the interrelationship between yield and pea maturity. In this study, the pea yield was adjusted to an equivalent yield at the maturity index average for the trial. However, it should be noted that vigorous growing plants tend to grow for a longer period and hence lower maturity in comparison to less thrifty plants, which mature faster. Consequently, the benefit of disease control in producing vigorous growing plants and loss of potential yield increase of these plants that are still producing pods are difficult to assess. The formula used to tabulate the equivalent yield based on the average maturity index for the trial did make some allowance on the projected yield according to pea seed maturity. Even so, significant differences are difficult to obtain unless very large and obvious yield differences occur. In addition to yield and maturity, consistency in pea maturity between plants is equally important especially in terms of quality.

Different harvest yield assessment methods used in the 1996 trials gave some indications on the plant growth through the shoot height, and consistency in pod maturity through the percentage immature pods. Field observations indicate that plants with severe *Ascochyta* infections tend to mature faster compared to healthy or minor infected plants. These observations could be verified by longer shoot length with healthy plants compared to severely infected plants.

General discussion

Although three *Ascochyta* pathogens are associated with *Ascochyta* rot of peas, only two species, *M. pinodes* and *P. medicaginis* var *pinodella* have been identified in the field survey conducted in this project. This was consistent with reports by Sampson & Walker (1980) that *P. medicaginis var. pinodella and M. pinodes* were mainly associated with *Ascochyta* infection on peas in Tasmania. The third species, *A. pisi,* has been isolated previously from commercial pea seed lines (Williams 1978, 1980 – unpublished Tas. DPIF reports) but has not been isolated from plants or soil bioassays in the field survey studies. This is not surprising as *A. pisi* is a weak saprophyte and relies on seedborne infection for carry-over (Lawyer 1984), and good control can be achieved through production in drier climates and seed treatment.

In the survey conducted, *P. medicaginis var. pinodella* was mainly isolated from collar rot affected plants, whereas *M. pinodes* was mainly isolated from leaf lesions. All the pea crops surveyed in this study were affected by collar rot, while leaf and pod spots were rare. In contrast to the finding of Wade (1951), fungal isolations conducted in this study showed that *P. medicaginis var. pinodella* instead of M. pinodes was the most widespread *Ascochyta* species associated with collar rot of peas. This is in contrast to South Australia and New South Wales, where *M. pinodes* is the most widespread and destructive species (Carter & Moller 1960, Walker 1961, Ali *et al*, 1978).

Some pea crops are not irrigated in Tasmania, and the relatively dry conditions noted during the 1994 season when the survey was carried out may have limited the *Ascochyta* leaf infections. *Ascochyta* rot pathogens could be isolated on agar on stem bases about 2 weeks before collar rot became visible on the plants. Most collar rot was visible at 8 weeks after sowing.

No obvious relationships could be found in the years between pea crops and *Ascochyta* rot incidence or severity. *P. medicaginis var. pinodella* was found to be widespread in the areas where peas are grown for processing in Tasmania. The fungus could persist in soil for at least 10 years in the absence of pea crops. This indicates that collar rot will still occur on crops sown with treated commercial seed lines that are free of *Ascochyta* infection.

P. medicaginis var. pinodella can survive both as chlamydospores and pycnidia, on straw fragments, and in the soil (Lawyer 1984). This fungal pathogen has also been isolated and recorded on other host plants like bean, clover, medicago, pyrethrum, and lentil (Sampson & Walker 1980, Farr et al 1995). The fungus may also colonize other host crops without showing any obvious symptoms. The alternative hosts of *P. medicaginis var. pinodella* indicates that some other crops or weeds in the paddock in the years between pea crops may assist in its long term persistence. Recommendation based on the years between pea crops alone appears to be inadequate for the control of the pathogen in Tasmania. A good record of all previous crops sown in paddocks would be essential for investigations in relation to crop rotations.

In recent years, seed treatment is widely used by the pea industry to control both seedborne fungal infection as well as damping off diseases. The most widely fungicides are Apron and P-Pickel T. Apron is used to control Pythium damping off disease while both thiram and thiabendazole are effective on seedborne *Ascochyta* infections (Maude, 1966; Maude et al 1986). A laboratory study conducted in this project showed that the combined Apron & P-Pickel T seed treatment provide good control of seedborne *Ascochyta* pathogens. No *Ascochyta* pathogens could be detected on the hypocotyls of 10 day old seedlings of 15 commercial seed lines that had been treated with Apron & P-Pickel T. Before the use of seed treatments, seed infection was a major source of *Ascochyta* infection (Carter & Moller 1960). Seed pathology test on one untreated commercial seed line showed both surface and internal seedborne *Ascochyta* infection, with surface sterilization reducing infection from 35% to 7.5% infections.

Studies conducted in this project seem to discount the belief that the use of infection free seed will prevent *Ascochyta* rot in crops sown in traditional pea production areas. Although the use of infected seed is undesirable, the production of pea seed lines that is completely free of *Ascochyta* infection will require sowing seed crops in new ground where no pea or related crops has been grown. This is likely to be costly and the success of producing completely *Ascochyta* infection free seed is by no means guaranteed. The *Ascochyta* pathogens are also known to be able to persist for long period of times in the soil and can also

infect other types of plants. Good control of *Ascochyta* could be achieved through production of pea seed in drier climates or in regions that are not prone to severe *Ascochyta* disease, and with commercial seed treatments with fungicides.

The different isolates of *P. medicaginis* and *M. pinodes*, either alone or in combinations, had no effect on seed germination, emergence and disease incidence. Collar rot symptoms caused *by P. medicaginis var. pinodella* and *M. pinodes* were similar and cannot be separated visually, with incidence ranging from 95 to 100%. Low collar rot severity observed on all the inoculated treatments may be due to the relatively dry conditions as a result of using drip irrigation and well-drained soil. The existence of different pathotypes between isolates of *M. pinodes* and *A. pisi* but not of *P. medicaginis var. pinodella* on peas had been reported (Ali et al 1978).

Herbicide studies conducted in this project indicate that seedling growth and vigour at the time of herbicide spraying are important determining factors on their susceptibility to herbicide damage and hence to further damage by collar rot. Pea crops sown in early winter are more susceptible to herbicide damage due to slow emergence and growth rate during the cold and wet winter period. Under such conditions, post-emergent herbicides tend to cause plant injury, and the weakened plants are likely to become more susceptible to severe collar rot. Field observations indicate that in addition to sowing time and herbicide applications, other factors such as paddock conditions and previous crop trash may contribute to collar rot susceptibility and severity. Variability in field conditions may explain why some paddocks had severe collar rot and not others although they were sown about the same time and use the same herbicide.

With effective control of seedborne *Ascochyta* infection, field inoculum that persists in soil is likely to become the main source of infection. Infected straw could still discharge spores after 2 years (Carter & Moller, 1960). In Tasmania, most pea crops are sown in 1 to 6 year rotations with other crops. In addition to seed treatment, follow-on fungicide applications may be required to manage the field inoculum in areas prone to severe *Ascochyta* rot.

Follow-on fungicide application methods examined in this project included the fungicide applied directly or mixed into fertilizer as a carrier and applied in furrow at sowing, foliar sprays after sowing, and alternative fungicides for seed treatment.

The potential of alternative fungicides in extending the protection period provided by Apron & P-Pickel T mix for additional protection from field *Ascochyta* inoculum was evaluated. The fungicides Armour, Rovral, Saphire, Scala, and Benlate, which were found to be inhibitive to *M. pinodes* growth on fungicide treated agar, reduced seedling emergence when applied as fungicide seed treatment in a pot trial. Similar reduction in seedling emergence was also observed with the Shirlan treated seed. It is not clear whether the lower seedling emergence was due to improved control of fungal infections by the Apron & P-Pickel T treatment or due to phytotoxicity of the other fungicides. Apron & P-Pickel T seed treatment still gives the best result with improved seedling emergence on *Ascochyta* infested soil. None of the alternative fungicides tested improved disease control nor extends the protection period.

Only Impact (applied in 5 foliar sprays) and Shirlan (applied into soil furrow at sowing) reduced the incidence of collar rot in the field trial conducted to evaluate 5 different fungicides and 3 application methods for the control of soilborne *Ascochyta* rot. No differences could be found in this study between the three application methods. In field studies of MacLeod et al (1997), reduction in disease severity was recorded with Impact treated fertilizer on black spot on garden peas caused by *Ascochyta* infection. The advantage of the soil-in-furrow and fertilizer applications are that these are applied at sowing making them attractive methods for a low maintenance crop like peas.

However, with additional cost of fungicide applications, fungicide usage is likely to be attractive only when the crop productivity is obviously threatened by severe disease problem. The use of foliar spray with an effective fungicide could be an option in such occasions. In the trial at Wesley Vale, which had severe *Ascochyta* infection, Shirlan (applied at week 6, 9 and 12) treated plants had much lower pod infections than the control and other fungicide treatments, as well as bigger plants. The collar rot of the Shirlan treated plants however, was similar to the other treatments. This may be related to poor spray coverage of target areas when applying foliar spray to try to control infections. Some fungicides such as Benlate, Impact, and Shirlan, are inhibitive of *Ascochyta* growth from infected stems in vitro study. Nevertheless, when applied as low volume foliar spray (250 L/ha), no obvious reduction in collar rot could be found. Further test

conducted in a spray coverage trial showed that higher spray volume and pressure (500L/ha and 700kPa) significantly increased the percentage coverage in comparison to the lower volume and pressure (200L/ha and 500kPa). The percentage coverage of spray applied also seems to decrease with increasing plant growth at the low spray volume and pressure but no difference is evident with the high volume and pressure spray.

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