



Management of downy mildew disease of pea crops and its possible resistance to metalaxyl

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Industry summary

Although metalaxyl seed treatment had been used successfully for many years for the control of downy mildew on pea seedlings, in recent years, poor crop establishment, severe crop infection and yield loss due to downy mildew on processing pea crops have become more frequent in Australia, and fungicide resistance in the downy mildew pathogen was suspected. This project, therefore, aimed to determine whether *Peronospora viciae* strains in Australia were resistant to metalaxyl; to identify suitable alternative seed treatments for the control of metalaxyl resistant downy mildew; and to develop affordable treatment methods for field downy mildew control. The research in this project was divided into three main areas, with the following major outcomes:

1. Sensitivity of *Peronospora viciae* to metalaxyl-M

- A total of 16 collections of *P. viciae* were obtained from pea crops at different sites in northern Tasmania for bioassay tests in 2001. Thirty-eight % of the collections were sensitive to metalaxyl, 31% were resistant and another 31% were partially resistant. This was consistent with similar resistance development in New Zealand. This is the first report of metalaxyl resistance following its use as a pea seed dressing for downy mildew control in Australia.

2. Seed and seedling infection control

- This project demonstrates the importance of seedborne infections and seedling pathogens, as well as the effectiveness of seed dressings with several active ingredients, in controlling several major pathogens and diseases of pea. Fungicide seed dressing is the most cost effective method of controlling seedborne infections and early seedling diseases. The fungicide seed dressings Apron + P-Pickel T, Aliette Super, and Wakil XL, generally gave the best results, consistently increasing the numbers of pea plants and seedling growth. With the establishment of metalaxyl-resistant isolates of *P. viciae* in Tasmania, fungicide resistance management strategies for seed treatment should include alternating metalaxyl or phenylamides with chemicals that have different modes of action, or using metalaxyl in mixtures with non-phenylamide chemicals such as cymoxanil or fosetyl-Al, which can protect seedlings from infection by metalaxyl-resistant isolates. Therefore, Aliette Super and Wakil seed treatments, which contains fosetyl-Al and cymoxanil, respectively, are suitable alternatives to the Apron + P-Pickel T seed treatment. In Apron + P-Pickel T, metalaxyl is the only active ingredient for downy mildew control. Treating seeds with Aliette Super or Wakil XL and storing them for almost 1 year gave no adverse effects on germination or seedling growth.

3. Field downy mildew control

- Downy mildew and *Ascochyta* collar rot are the two most common and important diseases of processing pea crop that impacts on pea yield and quality. Prior to this project, there was no effective or affordable control method for field downy mildew, hence, the impact of downy mildew field infection on pea yield was unknown. In this project, with effective field control, yield increases of 1 to 3 tonnes per hectare were recorded following improved downy mildew control. As for collar rot, yield increases of 1 to 2 tonnes per hectare were recorded following reduced collar rot severity with Bravo applications.
- This project identified three low cost fungicide products, chlorothalonil (Bravo), mancozeb (Penncozeb), and phosphorous acid (Agri-Fos), that provided effective control methods for field downy mildew on processing pea crops. The Agri-Fos + Penncozeb combination gave the best control of downy mildew, but had no effect on collar rot. However, Agri-Fos + Bravo, the second best treatment against downy mildew, was also effective in reducing collar rot severity. The optimum product rate for collar rot control was 1.8 L/ha Bravo. The optimum product rates for downy mildew control were 3.5 L/ha Agri-Fos, and 2.5 L/ha Penncozeb SC or 2.0 kg/ha Penncozeb DF. Agri-Fos or Penncozeb, applied on their own, had little or no effect on downy mildew incidence or severity.
- Two fungicide applications applied to plants at the growth stage of 4 and 8 nodes tended to give better downy mildew control than one application. However, for reducing collar rot severity, one spray application at 4 nodes was adequate. The timing of the fungicide applications was critical.

Early fungicide applications, before diseases occur, only protect plants for a short interval of 10 to 14 days. Therefore, for optimum downy mildew control, the fungicide application must be applied at the first sign of infection in a crop.

- Downy mildew field infections usually occur at the pea growth stage of 6 to 8 nodes, depending on sowing time and weather conditions. As collar rot tends to occur early in the crop, at about 4 nodes, the alternate applications of Agri-Fos + Bravo followed by Agri-Fos + Penncozeb 7-10 days later, could be a suitable program for reducing early collar rot severity as well as controlling downy mildew.

Technical summary

Processing pea seeds used in Australia mainly come from New Zealand, where downy mildew is common. In both countries, metalaxyl seed treatment had been used for many years for the control of downy mildew on seeds and seedlings. However, in recent years, poor downy mildew control in New Zealand was attributed to the development of metalaxyl resistant strains of *Peronospora viciae*. In the late 1990s, poor crop establishment, severe crop infection and yield loss, due to downy mildew on processing pea crops, have become more frequent in Australia. Apart from metalaxyl seed treatment, there has been no cost effective method for controlling the disease in the field.

This project, therefore, aimed to determine whether *P. viciae* strains in Australia were resistant to metalaxyl; to identify suitable alternative seed treatments for the control of metalaxyl resistant downy mildew; and to develop affordable treatment methods for field downy mildew control. The major project outcomes are outlined below.

1. Sensitivity of *Peronospora viciae* to metalaxyl-M

- A total of 16 collections of *P. viciae* were obtained from pea crops at different sites in northern Tasmania for bioassay tests in 2001. Thirty-eight % of the collections were sensitive to metalaxyl, 31% were resistant and another 31% were partially resistant. This was consistent with similar resistance development in New Zealand. This is the first report of metalaxyl resistance following its use as a pea seed dressing for downy mildew control in Australia.

2. Seed and seedling infection control

- This project demonstrates the importance of seedborne infections and damping-off, as well as the effectiveness of seed dressings with several active ingredients in controlling several major pathogens and diseases. Fungicide seed dressing is the most cost-effective method of controlling seedborne infections and early seedling diseases.
- An indication of a good seed treatment is their consistency in performance over many trials, giving excellent crop establishment, with high seedling survival, improved seedling growth and early seedling disease control. Apron + P-Pickel T, Aliette Super, and Wakil XL are commercially formulated seed dressings, which generally gave the best performance, consistently increasing the number of plants and seedling growth. These fungicide seed dressings, each consisting of a mixture of three active ingredients, are all formulated to control downy mildew and *Ascochyta* infections on pea seeds as well as diseases that reduce seedling establishment.
- With the establishment of metalaxyl-resistant isolates of *P. viciae* in Tasmania, fungicide resistance management strategies for seed treatment should include alternating metalaxyl or phenylamides with chemicals that have different modes of action, or using metalaxyl in mixtures with non-phenylamide chemicals such as cymoxinil or fosetyl-AI, which can protect seedlings from infection by metalaxyl-resistant isolates. Therefore, Aliette Super and Wakil seed treatments, which contain fosetyl-AI and cymoxanil, respectively, are suitable alternatives to the Apron + P-Pickel T seed treatment. In Apron + P-Pickel T, metalaxyl is the only active ingredient for downy mildew control. Treating seeds with Aliette Super or Wakil XL and storing them for almost 1 year gave no adverse effects on germination or seedling growth.

3. Field downy mildew control

- Downy mildew and *Ascochyta* collar rot are the two most common and important diseases of processing pea crops that impact on pea yield and quality. Prior to this project, there was no identified effective or affordable control method for field downy mildew, hence, the impact of downy mildew field infection on pea yield was unknown. In this project, with effective field control, yield increases of 1 to 3 tonnes per hectare were recorded following improved downy mildew control. As for collar rot, yield increases of 1 to 2 tonnes per hectare were recorded following reduced collar rot severity with chlorothalonil.
- This project identified three low cost fungicide products, chlorothalonil (Bravo), mancozeb (Penncozeb), and phosphorous acid (Agri-Fos) that provided effective control for against field downy mildew on processing pea crops.
- In trials conducted over 3 years, and at different locations, Penncozeb + Agri-Fos and Bravo + Agri-Fos were the most consistent and effective foliar treatments for field control of downy mildew. Agri-Fos or Penncozeb alone, were shown to have little or no effect on collar rot. Agri-Fos or Penncozeb, applied on their own, also had little or no effects downy mildew incidence and severity. In contrast, Agri-Fos in a mixture with Bravo or Penncozeb reduced downy mildew incidence and severity on plants. This indicates a synergistic effect of the chemical mixture.
- The Agri-Fos + Penncozeb combination was the best treatment against downy mildew, but had no effect on collar rot. However, Agri-Fos + Bravo, the second best treatment against downy mildew, was also effective in reducing collar rot severity. The optimum product rate for collar rot control was 1.8 L/ha Bravo. The optimum product rates for downy mildew control were 3.5 L/ha Agri-Fos, and 2.5 L/ha Penncozeb SC or 2.0 kg/ha Penncozeb DF.
- Two fungicide applications applied to plants at the growth stage of 4 and 8 nodes tended to give better downy mildew control than one application. However, for reducing collar rot severity, one spray application at 4 nodes appeared to be adequate. The timing of the fungicide applications is critical. Early fungicide applications before diseases occur only protect plants for a short interval of 10 to 14 days. Therefore, for optimum downy mildew control, the fungicide application must be applied at the first sign of infection in crops.
- Downy mildew field infections usually occur at the pea growth stage of 6 to 8 nodes, depending on sowing time and weather conditions. As collar rot tended to occur early in crops, at about 4 nodes, the alternate applications of Agri-Fos + Bravo followed by Agri-Fos + Penncozeb at 7-10 days later, could be a suitable program for reducing early collar rot severity as well as controlling downy mildew.
- Among the different types of spray adjuvants examined in the trials, little or no advantage could be found with their addition to the fungicides.
- In two trials, plants treated with metalaxyl only, had similar downy mildew incidence and severity to the untreated plants. This poor control may have been due to the presence of metalaxyl resistant isolates of *P. viciae* in the crops.

Extension to industry

- A poster was presented at the 8th International Congress of Plant Pathology, in Christchurch, New Zealand, on 3-7 February 2003. Copies of the poster were provided to Horticulture Australia and voluntary contributors.
- Results of this project were presented to the meeting of the National Vegetable Pathologists Working Group and State Industry Development Officers, at Adelaide on 21-23 April 2004.
- A poster was presented to South Australian growers at the Virginia Horticultural Centre, South Australia, on 22 April 2004. Printed flyers of the poster were also made available to growers.
- Many of the project's findings have already been adopted by the processing pea industry in Tasmania during the project in 2002 and 2003. The use of alternative seed treatments, as well as Agri-Fos + Penncozeb or Agri-Fos + Bravo, are already industry standards for downy mildew management.
- Project findings will be extended nationally to related pea crop producers (e.g. garden pea, snow pea and sugar snap pea) with the production of a flyer, which will be circulated through the vegetable IDOs' network as well as posted on the web site.

Recommendations

Seed and seedling infection control

- This project established that a significant proportion of isolates of *P. viciae* from pea crops in northern Tasmania had become partially resistant or resistant to metalaxyl. Therefore, the strategies for seed treatment should include alternating metalaxyl or phenylamides with chemicals that have different modes of action, or using metalaxyl in mixtures with non-phenylamide chemicals such as cymoxanil or fosetyl-AI, which can protect seedlings from infection by metalaxyl-resistant isolates.
- Aliette Super and Wakil seed treatments, which contain fosetyl-AI and cymoxanil, respectively, are therefore suitable alternatives to the Apron + P-Pickel T seed treatment. In Apron + P-Pickel T, metalaxyl is the only active ingredient for downy mildew control.
- The active ingredient fosetyl-AI in Aliette Super, is converted into phosphorus acid, which is active against downy mildew. Therefore, if phosphorus acid (Agri-Fos) is also used as foliar spray applications for field downy mildew control, there is a potential for fungal strains to develop resistance from the over-reliance on the use of phosphorus acid.
- The two alternative pea seed dressings, Aliette Super and Wakil, are registered for use in New Zealand, but not in Australia. As almost all processing pea seeds are imported from New Zealand, and seeds could be treated there before shipment to Australia. There is no plan by the seed-dressing manufacturers to register the seed treatment products in Australia. This arrangement, while satisfactory, is not ideal, as some pea seeds produced in Australia could not be treated with these alternative seed dressings.
- Alternative commercial seed dressings already registered for use on broad acre crops such as cereals and canola in Australia should also be evaluated for possible extension of use on pea seeds.

Field downy mildew control

- Agri-Fos + Penncozeb + and Agri-Fos + Bravo, have been shown to be the most consistent and effective foliar treatments for field downy mildew control. Each product on its own had little or no effect on the disease. The product mixture provides growers with a cost effective and affordable method for managing field infections of the two major pea diseases. Chlorothalonil (Bravo™) and mancozeb (Penncozeb™) are already registered for use on peas. Phosphorous acid (Agri-Fos™) is also a fertiliser and therefore chemical residue on plants from its use is not an issue.
- Agri-Fos + Penncozeb gave the best control of downy mildew, but had no effect on collar rot. However, Agri-Fos + Bravo, the second best treatment against downy mildew, was also effective in reducing collar rot severity.
- The optimum product rate for collar rot control was 1.8 L/ha Bravo. The optimum product rates for downy mildew control were 3.5 L/ha Agri-Fos, and 2.5 L/ha Penncozeb SC or 2.0 kg/ha Penncozeb DF. A maximum of two spray applications is recommended at the first sign of infection at the 4 to 8 nodes growth stages to reduce disease severity and improve yield.
- If downy mildew is the only disease, or is the dominant disease, Agri-Fos + Penncozeb should be used for optimum downy mildew control and yield improvement.
- Downy mildew and *Ascochyta* collar rot are the two most common and important diseases of processing pea crops that impact on pea yield and quality. Many crops have both diseases, and therefore the ability to control both is critical for pea disease management. Agri-Fos + Bravo should be used for control of both downy mildew and *Ascochyta* collar rot. Alternatively, an alternate spray program of Agri-Fos + Bravo followed by Agri-Fos + Penncozeb at 7-10 days later, could be used to optimize both collar rot and downy mildew disease management. This is because

collar rot tended to occur early in the crop at about the 4 node stage, followed by downy mildew later.

Introduction

Background

In Australia, processing peas (*Pisum sativum*) are mainly produced in northern Tasmania, for processing into frozen vegetables by McCain Foods and Simplot Australia. Small scale processing pea production is also carried out near Kendenup in Western Australia. Downy mildew of pea is caused by the fungus *Peronospora viciae*. The disease is very common in pea crops grown in cool temperate regions of the world, including northern Tasmania and New Zealand (Dixon 1981, Falloon et al 2000). Severe downy mildew infections cause severe stunting of seedlings and may kill them, while less severe infection reduces plant vigour and pea yield (Dixon 1981, Stegmark 1988). The pathogen can infect pods and seeds, which can then transmit downy mildew to subsequent crops. Most processing pea seed used in Tasmania and Western Australia come from New Zealand, where cool and humid conditions are sometimes conducive to downy mildew epidemics. Seed treatment with the systemic fungicide metalaxyl is commonly used in Australia and New Zealand for the control of downy mildew on seeds and seedlings. Apart from downy mildew, metalaxyl also controls seed rot and damping off caused by *Pythium* spp. that are common in soil. In the late 1990's, poor crop establishment, severe crop infection and yield loss due to downy mildew have become more frequent in processing pea crops in northern Tasmania.

Studies conducted in New Zealand in 1996 established that a high proportion of *P. viciae* strains were resistant to metalaxyl as a result of the sole reliance on metalaxyl for downy mildew control on seeds (Falloon et al. 2000). Downy mildew developed in young pea crops from metalaxyl-treated seeds as a result of insensitivity to the fungicide in strains of *P. viciae* after several years of use. In Australia, Apron SD + P-Pickel T, has been the standard fungicide seed dressing used on pea seeds over a number of years. This seed dressing mixture consists of metalaxyl in Apron, plus thiram and thiabendazole in P-Pickel T. Since the mixture relied on metalaxyl for downy mildew control, similar development of fungicide insensitivity may have also occurred in Australia, or gave poor control of resistant strains carried on seeds from New Zealand. It was not known if the current use of metalaxyl seed treatment still provided adequate downy mildew control or whether resistant strains of *P. viciae* had developed or had been introduced into Australia. As the metalaxyl seed treatment constitutes a significant proportion of the pea seed cost, adding about 10% to the total seed cost to the industry, these questions need to be addressed. Research in New Zealand has identified several alternative seed dressing products that could be used successfully to control the downy mildew pathogen, including metalaxyl resistant strains.

Apart from metalaxyl seed treatment, there was also no cost-effective method for controlling the disease in the field. Downy mildew can also survive in soil as oospores, and the pathogen is widespread in major pea-producing regions. Although mancozeb and chlorothalonil are registered for downy mildew control in Australia, disease control by the fungicides is poor. As processing peas are considered to be relatively low value crops compared to other crops such as grapes and opium poppy in Tasmania, there has been little incentive for fungicide manufacturers to optimize control methods or to evaluate new fungicides. Any foliar fungicide applications developed for use on pea crops must also be cost-effective and result in better return for growers.

This project, in collaboration with researchers in New Zealand, would establish whether metalaxyl resistant strains of *P. viciae* are also present in Tasmania, and to identify and help introduce the most suitable pea seed treatments for use in Australia. The project would also evaluate the efficacies of foliar applications of chlorothalonil, mancozeb, and other potential fungicides to pea crops, and to optimize foliar application methods for field downy mildew control.

Aims

This project aimed to determine whether *Peronospora viciae* strains in Australia are resistant to metalaxyl; to identify suitable alternative seed treatments for the control of metalaxyl resistant downy mildew; and to develop affordable treatment methods for field downy mildew control. Therefore, the research studies conducted in this project could be divided into three main areas of studies: 1) Sensitivity of *P. viciae* to metalaxyl-M in order to determine whether there are metalaxyl resistant strains in Australia; 2) Fungicide seed treatments to identify suitable seed dressings for the control of downy mildew on seeds and seedlings; 3) Foliar fungicide applications for field downy mildew control to evaluate the efficacy of foliar fungicide treatments for the control of downy mildew from field inoculum.

General Discussion

Nine field trials were conducted from 2000 to 2004, within commercial pea crops, to evaluate and optimize foliar fungicide application methods to control downy mildew from field inoculum of *P. viciae*. As peas are considered to be low value crop, mainly low cost fungicide products such as chlorothalonil (Bravo), mancozeb (Penncozeb), and phosphorous acid (Agri-Fos) were used in the trials. The fungicides were also applied in combinations with products (Agri-Fos, Bion and Micro-Gyp (calcium sulfate) that may stimulate or induce systemic acquired resistance in plants.

2000 trials

In 2000, in two preliminary field trials with two spray applications were carried out. The first spray was applied at 2-3 node growth stage before downy mildew occurred in the crops. These fungicide treatments did not reduce downy mildew incidence or severity, where the disease occurred at approximately 1 month after the second spray application. This indicates the importance of spray timing and the crop protection period by the fungicides for disease control.

2001/02 trials

In two trials carried out in 2001, the first spray was applied at the onset of downy mildew on lower leaves of plants. These trials demonstrated that Penncozeb SC + Agri-Fos, was the most effective treatment for field downy mildew control. Two foliar sprays of Penncozeb SC + Agri-Fos at the 4-5 node plant stage, consistently reduced downy mildew and increased pea yields. Among the other treatments evaluated, Bravo + Agri-Fos, followed by Penncozeb + Bion, were the second and third most effective treatments for downy mildew control. Penncozeb + Bion was more effective, if applied early, before most infection occurred and under low disease pressure. Penncozeb alone, applied in four sprays had no effect on downy mildew. As Bion is unlikely to be commercially available, subsequent trials conducted in 2002 to 2004 were focused on treatments with Agri-Fos, Bravo, and Penncozeb.

Plants treated with Apron or metalaxyl alone had similar downy mildew incidence and severity to the untreated plants. This poor control may have been due to the presence of metalaxyl resistant isolates of *P. viciae* in the crop.

A third trial in 2001/02 indicated that 5.0 L/ha of Agri-Fos 400 is likely to be more effective than 2.5 L/ha. Therefore, an equivalent of 5.0 L/ha Agri-Fos 400 (i.e. 2 kg active/ha) were used in trials conducted in 2002 to 2004, at 3.0 L/ha and 3.5 L/ha Agri-Fos 600, a new formulation (i.e. 1.8 kg and 2.1 kg active/ha).

2002 – 2003/04 trials

Four trials were conducted in 2002 to 2004, in order to optimize fungicide application methods for both downy mildew and collar rot control. These are the two most common and important diseases impacting on processing pea crops yield and quality. In some trials, even when downy mildew or collar rot was considered to be relatively mild, they could still adversely affect pea yield when crops are subjected to water stress. Most crops have both diseases, and therefore the ability to control both is critical for pea disease management. Even though one disease is usually dominant in a crop, it can be difficult to predict which will become the major disease. Where it is possible to determine which disease is of major concern in a crop, it is important that the effective fungicide application is used. Bravo was consistently shown to be effective in reducing collar rot severity in this project and in a previous study on collar rot (Pung & Cross 2000).

Agri-Fos or Penncozeb alone, were shown to have little or no effect on collar rot. Agri-Fos or Penncozeb, applied alone, also had little or no effects on downy mildew incidence and severity. In contrast, Agri-Fos, in a mixture with Bravo or Penncozeb, reduced downy mildew incidence and severity on plants. This indicates a synergistic effect by the spray mixture of these two products.

The Agri-Fos + Penncozeb in combination gave the best control of downy mildew, but had no effect on collar rot. However, Agri-Fos + Bravo, the second best treatment against downy mildew, was also effective in reducing collar rot severity.

Two fungicide applications applied on to plants at the growth stage of 4 and 8 nodes gave better downy mildew control than one application. However, for reducing collar rot severity, one spray application at 4 nodes appeared to be adequate.

Where the two major pea diseases were present, and collar rot was the dominant disease, Agri-Fos + Bravo treatment reduced severity of both collar rot and downy mildew. The optimum product rate of

Bravo for collar rot control was 1.8 L/ha. However, if downy mildew was the only disease or was the dominant disease, Agri-Fos + Penncozeb tended to give better downy mildew control and yield improvement. The optimum product rates for downy mildew control were 3.5 L/ha Agri-Fos, and 2.5 L/ha Penncozeb SC or 2.0 kg/ha Penncozeb DF.

Early fungicide applications before diseases occur only protect plants for a short interval of 10 to 14 days. Therefore, for optimum downy mildew control, the fungicide application must be applied at the first sign of infection in the crop. As collar rot tends to occur early in the crop, the alternate applications of Agri-Fos + Bravo followed by Agri-Fos + Penncozeb could be a suitable program for optimum collar rot and downy mildew control. In many crops, the onset of field downy mildew infection tended to occur later. Pea fungicide seed treatments could also protect seedlings from early infection.

The spray mixture containing the dry flowable formulation of Penncozeb (Penncozeb DF) also reduced collar rot severity compared to untreated experimental controls or the mixture containing the suspension concentrate formulation (Penncozeb SC). Apart from formulation, the differences between the two Penncozeb products may also be related to the lower rates of mancozeb in the Penncozeb SC formulation compared with Penncozeb DF.

Among other fungicides also examined, Apron and BAS 518 had little or no effect on downy mildew, while Agri-Fos + Acrobat was only as effective as Agri-Fos + Bravo.

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Appendix i - Product Formulations

Product	Active Ingredient (a.i.)	Concentration of a. i.	Formulation
Acrobat MZ690	Mancozeb + Dimethomorph	600 g/kg + 90 g/kg	Wettable powder
Agri-Fos Supa 400	Phosphoric acid	400 g/L	Liquid
Agri-Fos Supa 600	Phosphoric acid	600 g/L	Liquid
Aliette Super	Fosetyl-Al + thiram + thiabendazole	528 g/kg + 172 g/kg + 129 g/kg	Wettable powder
Amistar	Azoxystrobin	500 g/kg	Water dispersible micro-granules
Apron 350SD	Metalaxyl	350 g/kg	Wettable powder
Bavistin	Carbendazim	500 g/L	Soluble concentrate
Bion 50WG	Acibenzolar-S-methyl	500 g/kg	Water dispersible granules
Bravo 720	Chlorothalonil	720 g/L	Suspension concentrate
Captan	Captan	800 g/kg	Water dispersible micro-granules
Elexa	Chitosan	4 %	Suspension liquid
Fongarid 250WP	Furalaxyl	250 g/kg	Wettable powder
Maxim	Fludioxinil	100 g/L	Suspension concentrate
Penncozeb 750DF	Mancozeb	750 g/kg	Dry flowable
Penncozeb 420SC	Mancozeb	420 g/L	Suspension concentrate
P-Pickel T	Thiram + thiabendazole	360 g/L + 200 g/L	Soluble concentrate
Raxil	Tebuconazole + cypermethrin	25 g/kg + 4 g/kg	Suspension concentrate
Serenade	Bacillus subtilis	5 X 10 ⁹ cfu/g	Wettable powder
Wakil XL	Cymoxinil + metalaxyl + fludioxinil	100 g/kg + 175 g/kg + 50 g/kg	Water dispersible granules

Photographs

Downy mildew infected leaves (Photograph 1), and constrictions of lower stems due to the black Ascochyta collar rot (Photograph 2)



Photograph 1



Photograph 2

Patchy and unthrifty pea plants due to poor downy mildew control (Photograph 3), and dense and healthy pea plants with effective downy mildew control by chlorothalonil + phosphorous acid spray application (Photograph 4)



Photograph 3



Photograph 4