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PRACTICAL SECTION FOR GROWERS

Commercial benefits of the project.

This project has identified those varieties of vining peas which appear to have a high level of tolerance to downy mildew. This offers greater security for pea producers in the absence of an effective foliar treatment for control and also provides useful information for organic producers. The project also highlighted the increased resistance of downy mildew to metalaxyl seed treatments and allowed the evaluation of replacement products which have given consistently good control of primary seedling infection.

Background

Downy mildew has been a particular problem in vining peas in recent years. Seed of all varieties is routinely treated with fungicides to reduce mildew infection, but the level of control has been variable, possibly due to the development of metalaxyl resistant populations of the fungus. There was insufficient information on varietal resistance and no approved foliar applied fungicides.

The project was aimed at evaluating the relative field resistance of current varieties of vining peas, comparing the effectiveness of seed treatments and screening foliar applied chemicals for activity against downy mildew.

Work completed in previous years (1998 -1999)

Varietal resistance

In the first year of the project, 13 commercially available vining pea varieties were evaluated in field trials and in an inoculated polythene tunnel for their relative resistance to downy mildew. The field evaluations were conducted at three sites in commercial crops of vining peas in fields with a long history of vining pea production and with a potentially high soil-borne inoculum of oospores of *Peronospora viciae.* The varieties were drilled as early in the season as possible to allow maximum infection to develop. In addition to the field trials, the varieties were also planted in artificially inoculated soil in a polythene tunnel. The humidity was kept high throughout the test period. In all trials, disease assessments were made on the plants at one, two or three occasions and the mean infection calculated and expressed as % leaf infection. Of the varieties, Sigra, Colana and Saturn showed the lowest levels of infection compared with the susceptible standard variety Avola.

The trials were repeated in 1999 at different field sites with 18 varieties, including most of the ones tested in 1998. Results indicated that Barle, Kermit and Pinnacle showed the lowest levels of infection.

Seed treatment trials

Comparisons of seed treatments were made in both 1998 and 1999 in field trials at three sites in each year. The susceptible variety Avola was treated with either Apron Combi, Aliette plus HyTL (Triple Pea Treatment), Apron Elite or HyTL and disease infection levels recorded during the year. In each year, Apron Combi, which contains metalaxyl as the active

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ingredient for mildew control, gave poor control compared with Apron Elite (cymoxanil + oxadixyl) and Triple Pea (fosetyl aluminium).

Foliar treatments

In 1998 and 1999, spray trials were carried out in 3 commercial pea crops where mildew was developing. Sprays of fungicides or nutrient based products were applied on one or two occasions and a final disease assessment was made at the freezing stage of maturity. In neither year were there any consistent reductions of mildew from any of the treatments.

Specific target for 2000

In the final year, the varietal susceptibility tests were repeated on the eighteen varieties in order to provide information on the robustness of the varietal resistance from site to site and year to year.

The introduction of cymoxanil + oxadixyl as a commercial seed treatment led to its replacement of metalaxyl and the 2000 trials were able to compare this with a new formulation of the fungicides for future introduction as a seed treatment.

There were no new developments in fungicides for foliar treatments and this part of the work was discontinued in the final year.

Summary of results for 2000

Varietal susceptibility

The 18 commercially available varieties of vining peas tested in 1999 were sown in three field trials in Lincolnshire and Norfolk and in a polythene tunnel at Cambridge.

Disease assessments were made at two or three occasions during the growing period and infection recorded.

The data from the field sites were combined to give an average infection level for each variety and the results compared with those from the tunnel test. In all tests, Pinnacle, Sigra and Paso showed the lowest levels of infection compared with Avola, Winner and Cabree, which were the most susceptible.

A comparison of seed treatments to control seedling infection was made in three field trials, but disease levels in 2000 were very low and results variable. However, Apron Elite, Wakil Elite and Triple Pea Treatment gave good control compared to the untreated, and the HyTL treatment.

Summary of results from the project

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1. Vining peas varieties exhibit a range of resistance to downy mildew. There is no apparent difference in susceptibility to disease between leafy or semi-leafless types, nor does there appear to be any difference in susceptibility between different maturity groups.

2. Of the varieties tested in the field, the most susceptible were Avola and Winner followed by Balmoral, Cabree, Ambassador and Jewel. Sigra, Colana, Jaguar were moderately susceptible. Barle, Brule, Oasis and Sancho were less susceptible but Pinnacle, Tyne, Paso, Kermit and Favorit showed consistently good field resistance.

3. Metalaxyl-resistant strains of downy mildew were found to be more generally distributed in the pea growing areas that first thought, but trials showed that both fosetyl aluminium and cymoxanil based seed treatments were very effective in controlling primary seedling infection.

4. There were no consistently effective levels of control of secondary downy mildew with foliar treatments.

Action points for growers

- Choose varieties which are more resistant to downy mildew to avoid the severe affects of secondary infection.

- Use seed treatments which contain either cymoxanil or fosetyl aluminium for all situations where primary seedling infection is a potential risk.

- A combination of good varietal resistance and effective seed treatment will ensure good control of downy mildew throughout the season obviating the need for follow up treatments.

- The currently available foliar sprays are not effective in significantly reducing secondary infection of downy mildew.

Anticipated practical and financial benefits from the project.

A reliable management approach to mildew control will:

- Reduce seedling losses from primary soil-borne infection.

- Reduce secondary disease spread from the primary inoculum source.

- Reduce the rate of build up of resistant fungal populations.

- Maximise yield and product quality of vining peas.

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SCIENCE SECTION

Introduction

Downy mildew caused by *Peronospora viciae* is a common disease of peas in many of the temperate pea growing areas of the world. Seedlings become infected following exposure to soil-borne oospores shortly after germination. Newly emerged plants develop mycelium on the underside of the leaf which later becomes the source of air-borne spores, released during periods of high humidity. Secondary foliar infection develops as a result of infection by the air-borne spores.

Leaves become covered with mildew and pods are poorly developed and contain low seed numbers. The disease affects seedling survival and secondary infection reduces plant vigour and pod development, resulting in low yield and poor quality of vined peas.

Chemical control by foliar applied fungicides has not been effective, partly because of poor leaf uptake and partly because of the lack of active chemicals. Seed treatment containing phenylamide fungicide has been successful in reducing levels of primary infected seedlings from soil-borne inoculum, but there was increasing evidence of resistance to metalaxyl in some areas of the UK and reports of resistance in New Zealand and the USA, where the chemical has been in regular use for a number of years.

Peronospora viciae exists in several races and although some combining pea varieties exhibit very good levels of tolerance, vining peas have generally appeared to be more susceptible. However, screening vining peas for field resistance has been carried out on a very limited scale.

Downy mildew was severe in 1997 and in view of the problems outlined above, there were a number of aspects that needed further investigation in order to formulate a disease management strategy that will be sustainable in the future.

The objectives if the project were as follows:-

a) To evaluate a range of commercially available varieties of vining peas for their relative field resistance to downy mildew.

b) To compare the effectiveness of seed treatments

c) To evaluate foliar applications of fungicides or foliar treatments to control secondary infection of downy mildew.

Material and methods

In 1998, 13 varieties and in 1999 and 2000, 18 varieties of vining peas were selected to represent a range of plant types, seed size and maturity.

In all three years, a core or varieties were trialled although eight were added to the list for the 1999 and 2000 trials. Seed of each variety was planted in disease observation trials sited in three commercial crops of vining peas in each year. The varieties were also planted each year in an inoculated soil in a polythene tunnel at NIAB, Cambridge. The varieties and their characteristics are shown in table 1.

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Table 1. Varieties and characteristics.

Variety	Years trialled	Maturity	Leaf type	Seed size
Avola	98, 99, 2000	first early	leafy	medium/large
Cabree	98, 99, 2000	first early	leafy	medium
Winner	98, 99, 2000	first early	leafy	medium
Jaguar	98, 99, 2000	second early	semi-leafless	medium/large
Barle	98, 99, 2000	early maincrop	semi-leafless	medium/large
Brule	99, 2000	early maincrop	semi-leafless	medium
Colana	98, 99, 2000	early maincrop	leafy	medium
Favorit	99, 2000	early maincrop	leafy	medium/small
Samish	98, 99, 2000	early maincrop	leafy	medium/large
Kermit	99, 2000	early maincrop	semi-leafless	medium/small
Sancho	98, 99, 2000	early maincrop	semi-leafless	medium/small
Oasis	99, 2000	early maincrop	semi-leafless	medium/large
Sigra	98, 99, 2000	early maincrop	semi-leafless	small
Jewel	99, 2000	early maincrop	leafy	petit pois
Paso	99, 2000	early maincrop	semi-leafless	petit pois
Ambassador	98, 99, 2000	maincrop	leafy	medium/large
Balmoral	98, 99, 2000	maincrop	leafy	medium
Purser	98, 99, 2000	maincrop	semi-leafless	medium
Pinnacle	99, 2000	maincrop	semi-leafless	medium/small
Saturn	98, 99, 2000	maincrop	leafy	medium
Tyne	99, 2000	maincrop	leafy	medium

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Field trials

No fungicide seed treatment was applied to any of the varieties in the field trials. Each plot consisted of two rows of 100 seeds, 5m in length and replicated twice. The seed was planted with an Øyjord plot seeder, at a depth of 10 cm. The soil was rolled after drilling and a pre-emergence herbicide applied. The trial site details are shown in Table 2.

Table 2. Site details - Field disease observation trials

1998	Site 1	Holland Farm, Sibsey, Lincs	Sown: 30.3.98
	Site 2	Manor Farm, Fosdyke, Boston Lincs	Sown: 31.3.98
	Site 3	Cadwell Grange, Horncastle, Lincs	Sown: 1.5.98
1999	Site 1	Slate House Farm, Gypsy Bridge, Lincs	Sown: 23.3.99
	Site 2	Birds Drove Farm, Gosborton, Lincs	Sown: 26.4.99
	Site 3	Colony Farm, Chatteris, Cambs	Sown: 27.4.99
2000	Site 1	Hill Marsh Farm, Surfleet, Lincs	Sown: 16.3.00
	Site 2	Leadenhall Farm, Fosdyke, Lincs	Sown: 22.3.00
	Site 3	Wootton Marsh Farm, N: Wootton, Norfolk	Sown: 21.3.00

Disease assessments were made on two occasions during the growing season. The first was made just after emergence at gs 104 -105 and the second, during the flowering and pod development stages gs 205 -206. On each occasion, the plots were examined and an assessment of the percentage of plants showing systemic infection was made. The plots were then further examined to assess the percentage sporulation on the infected plants. The two figures were combined to give an average over the plot area (NIAB Disease Assessment key no 32)

Seed treatment trials

In 1998, seed of the variety Avola, known to be susceptible to downy mildew was treated on 5th February with a range of commercial fungicide treatments using a Hege laboratory seed treater. In 1999, the same treatments were applied on 1st March to Avola and Tristar, both of which are mildew susceptible. The treatments are shown in table 3.

Table 3. Seed treatment details 1998-1999

Product	active ingredients	rate/kg seed
1. HyTL	thiabendazole + thiram	2.0 ml
2. Apron Combi 453FS	metalaxyl + thiabendazole thiram	3.0 ml
3. Triple Pea Treatment	fosetyl aluminium +thiabendazole +thiram + Sepiret 2020	2g + 1.7 ml + 0.8g + 3 ml water
4. Apron Elite	cymoxanil + oxadixyl + carbendazim + thiram	3.0g + 3 ml water

In 2000, Avola and Tristar seed was treated on 2nd March with the treatments as shown in table 4.

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Table 4. Seed treatment details 2000

Product	Active ingredients	rate/ kg seed
1. HyTL	thiabendazole + thiram	2.0 ml
2. Apron Elite	cymoxanil + oxadixyl + carbendazim + thiram	3.0 g + 3.0 ml water
3. Wakil Elite	cymoxanil + oxadixyl + fludioxonil	3.0 g + 3.0 ml water
4. Triple Pea Treatment	fosetyl aluminium + thiabendazole + thiram + Sepiret 2020	2 g + 1.7 ml +0.8 g + 3 ml water
5. Untreated		

In each year, seed was drilled at the three sites used for the varietal resistance trials described above. The drilling was done with an Øyjord plot seeder in plots measuring 5m x 1.5m with 15 cm row spacing. Each treatment was replicated five times in a fully randomised block experiment. The plots were rolled immediately after drilling and a pre-emergence or post emergence herbicide applied.

Seedling emergence was recorded by counting seedlings within a $^1/_3m^2$ circular 'quadrat' at six positions in each plot. An assessment of diseased seedlings was made during the early part of the growing season and again at the flowering and pod development time. Disease assessments were recorded as described earlier.

In 2000, the trials at Surfleet and North Wootton were harvested. Plots were cut and the haulm vined in the PGRO plot viner. The weight of the produce was recorded and the maturity of the peas measured by tenderometer.

Foliar Treatments.

A range of foliar applied treatments were evaluated in three spray trials sited in commercial pea crops in 1998 and 1999. Several products were evaluated, but not all included at all sites. The products are shown in table 5.

Table 5. Treatments used in spray trials

Product	Active ingredients
1998	
1. Folio	metalaxyl + chlorothalonil
2. Amistar	azoxystrobin
3. Agrofos	potassium phosphite
4. Resistim	potassium + phosphorus
5. Folpan 80 WDG	folpet
6. Agral	alkylphenol ethylene oxide (wetter)
1999	
1. Aliette WDG	fosetyl aluminium
2. Invader	dimethomorph + mancozeb
3. Bravo 500	chlorothalonil
4. Thiovit	sulphur

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The treatment details, rates of application and timing are shown in Appendix 1.

Sprays were applied to plots measuring 5m x 2m on two occasions (T_1 early vegetative stage gs 107 -110 and T_2,14 days later) with an Azo plot sprayer in 200 l water/ha through 02/F110 fan nozzles at 2.5 bar provided by propane. Each treatment was replicated four times and included an untreated control in a randomised block design.

Disease assessments were made immediately before the T_2 timing and were based on leaf area infection of five positions in each plot as described earlier. In 1998, a second assessment was made at the pod fill growth stage (gs 205), but in 1999, the second assessment was made on 15 plants selected randomly from each plot and the percentage leaf and stem infection was made on the top, middle and bottom thirds of each plant.

Results

Varietal resistance to downy mildew.

The disease assessment figures from the field trials in each of the three year's are shown in figures 1 - 3. The data are the combined scores for each assessment date and trial site. The complete data sets are shown in Appendices 2 - 4.

Figure 1 illustrates the relative resistance of the varieties to downy mildew in the field trials for all 18 varieties tested in 1999 and 2000 period. The graph shows the mean leaf area infection for each variety. The complete data set is shown in Appendices 2 - 4.

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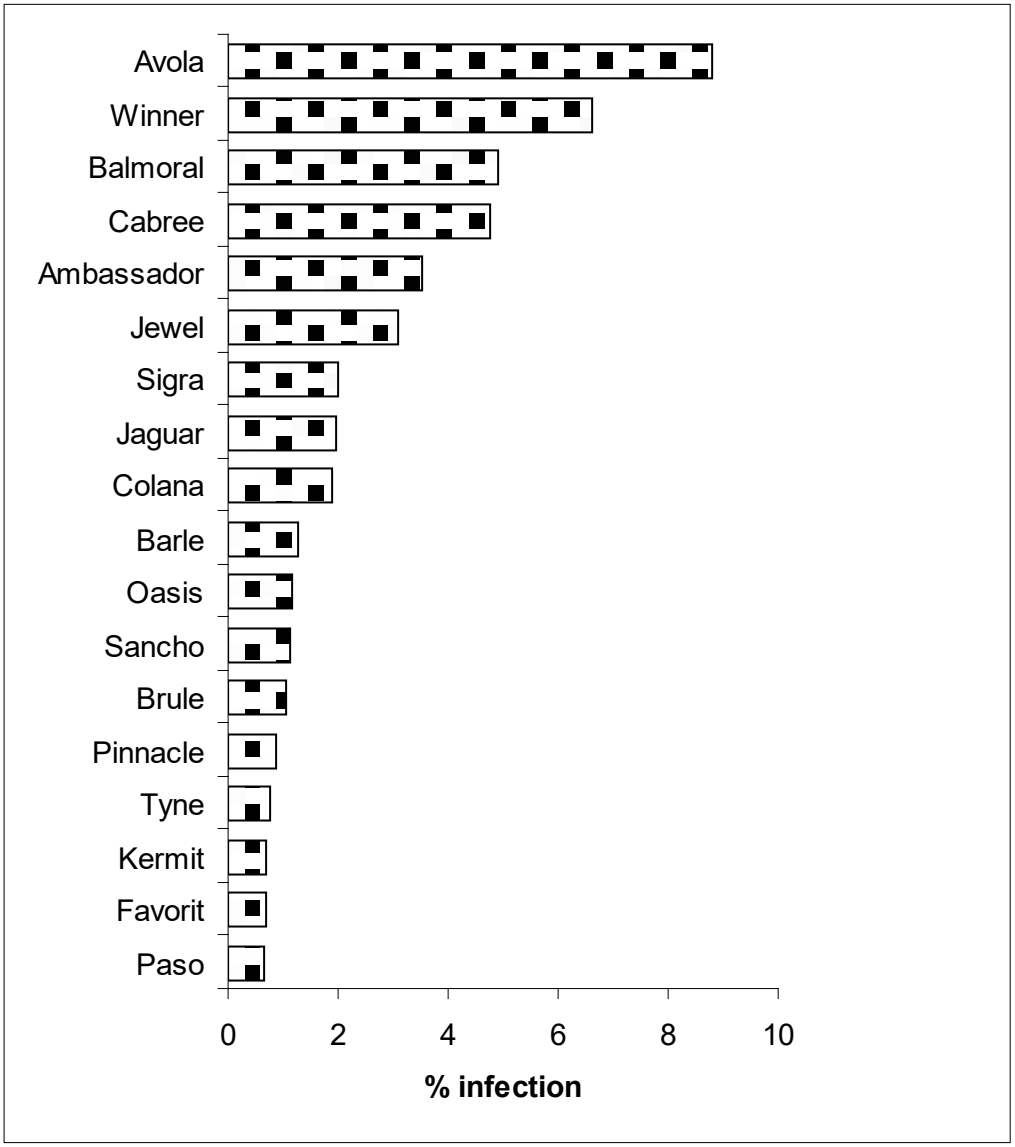
Figure 1. Disease infection levels of varieties in field trials 1999 and 2000



A similar graph is shown in figure 2 for the mean infection of varieties planted in the polythene tunnel over the period. The complete data for all years are shown in Appendices 5 - 7.

Figure 2. Disease infection levels of varieties in polythene tunnel 1999/2000

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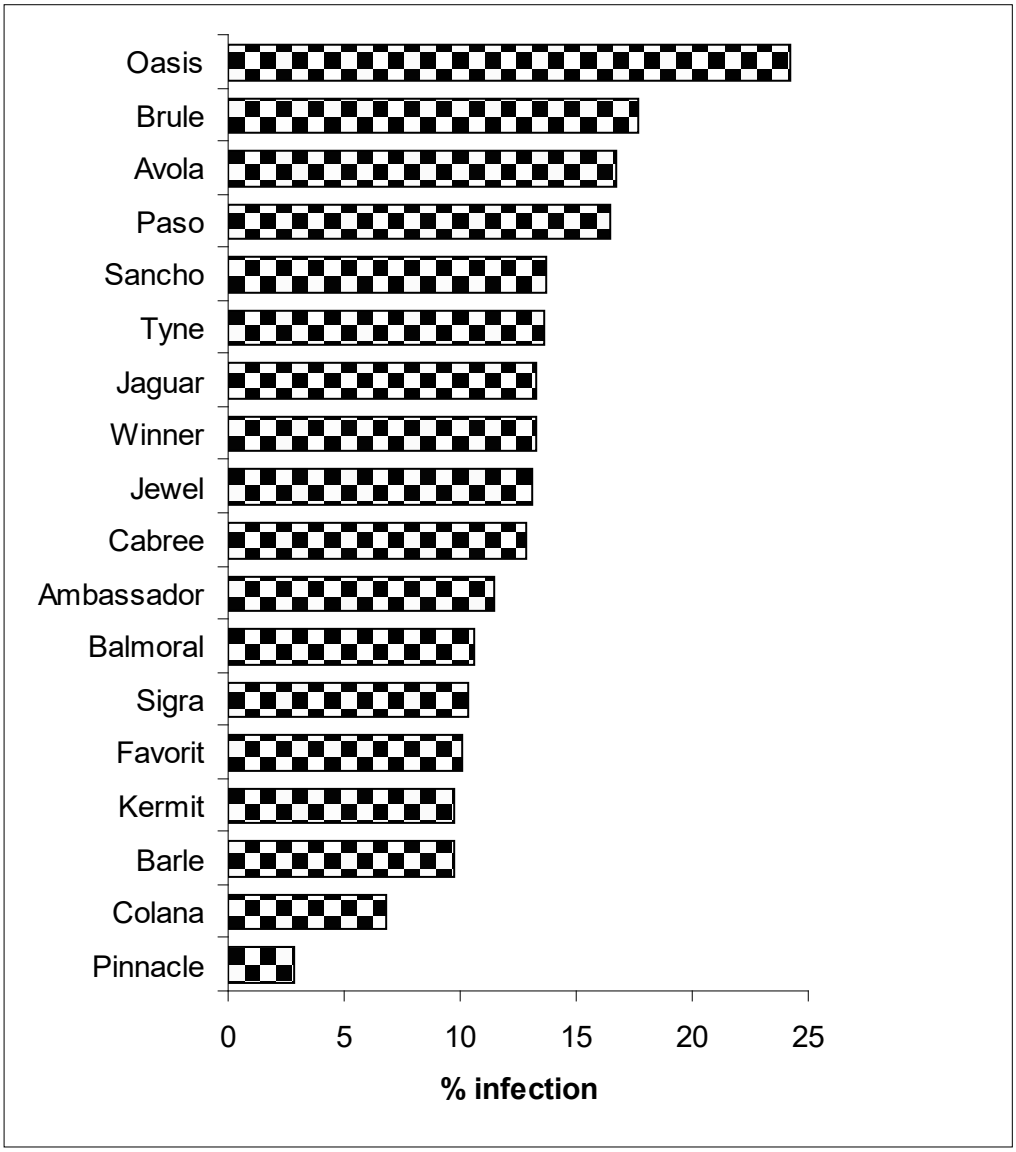

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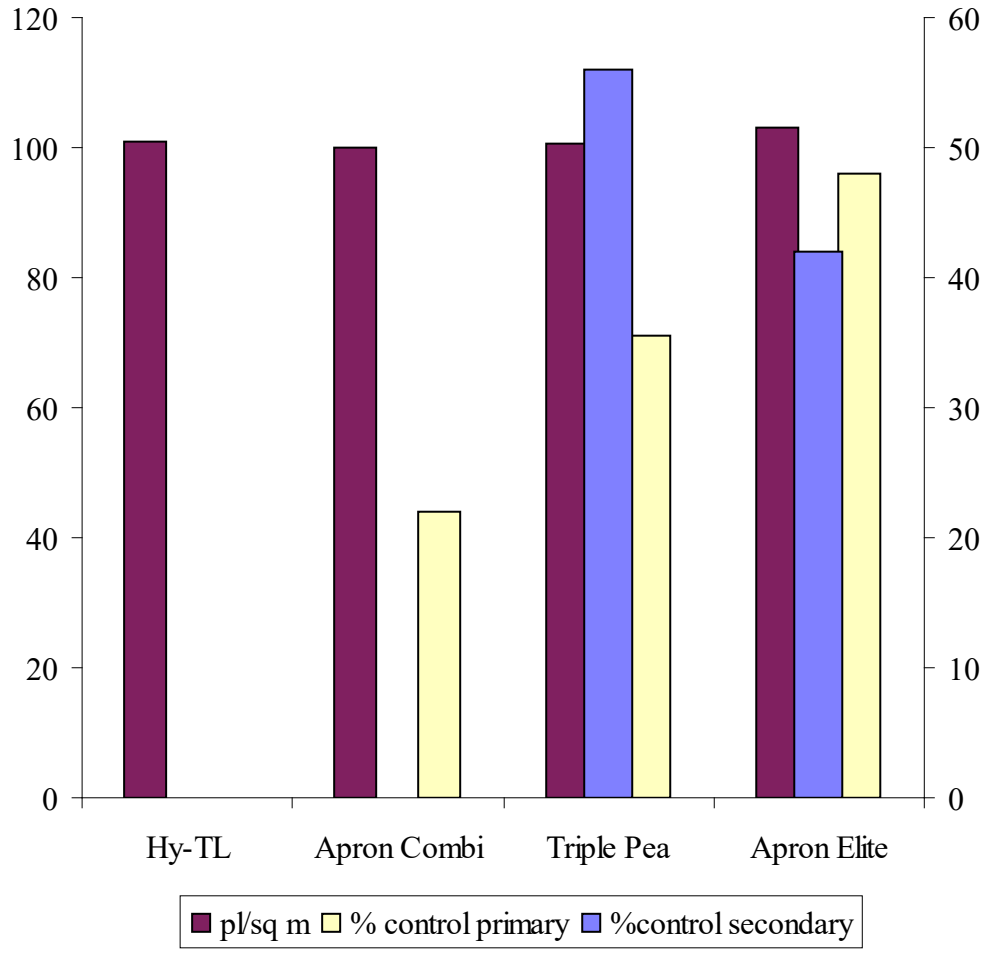
Comparison of seed treatments

Data from the 1998 and 1999 trials are shown as mean plant population, and percentage reductions of primary and secondary downy mildew in figure 3. Control of primary mildew by the Apron Combi was poor in both years and no reduction of secondary mildew was recorded. The full data sets are shown on Appendices 8 -12.

Figure 3. Control of downy mildew by seed treatments 1988-99



In the 2000 field trials, disease levels were very low at all sites, but Triple Pea, Apron Elite and the new compound Wakil Elite all gave very good control of downy mildew with no detrimental effect to the seedling establishment. Yield data also showed no effects of treatment in the absence of significant disease levels.

Data are shown in figure 4 and the full set is shown in Appendices 13-15.

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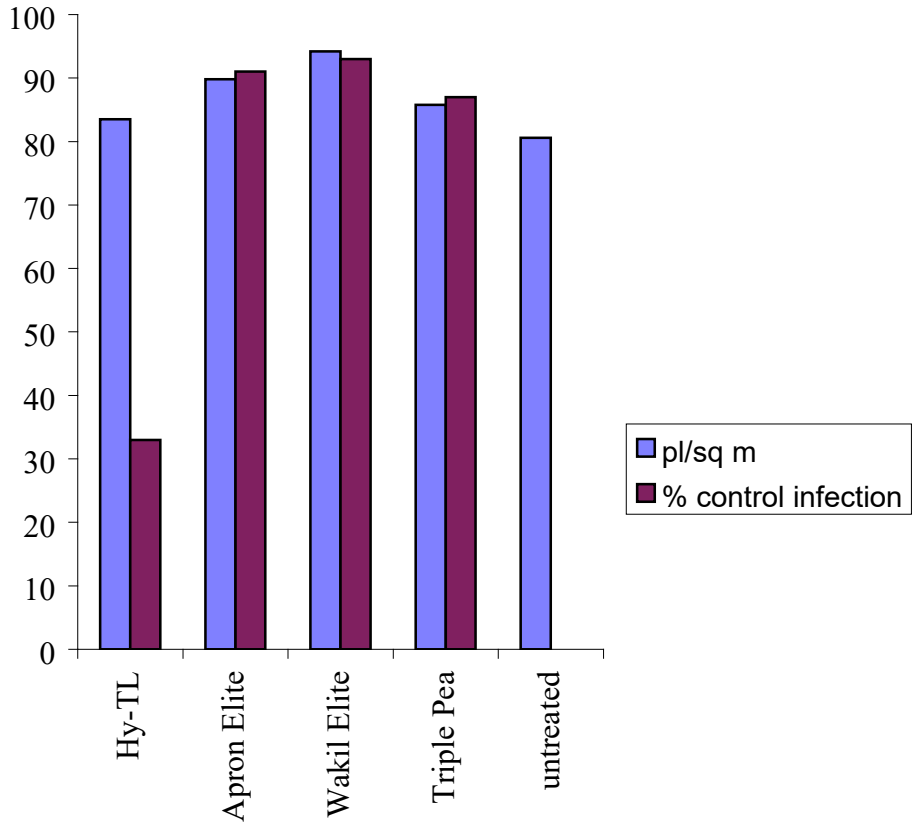
Figure 4. Control of downy mildew by seed treatments 2000



Foliar treatments.

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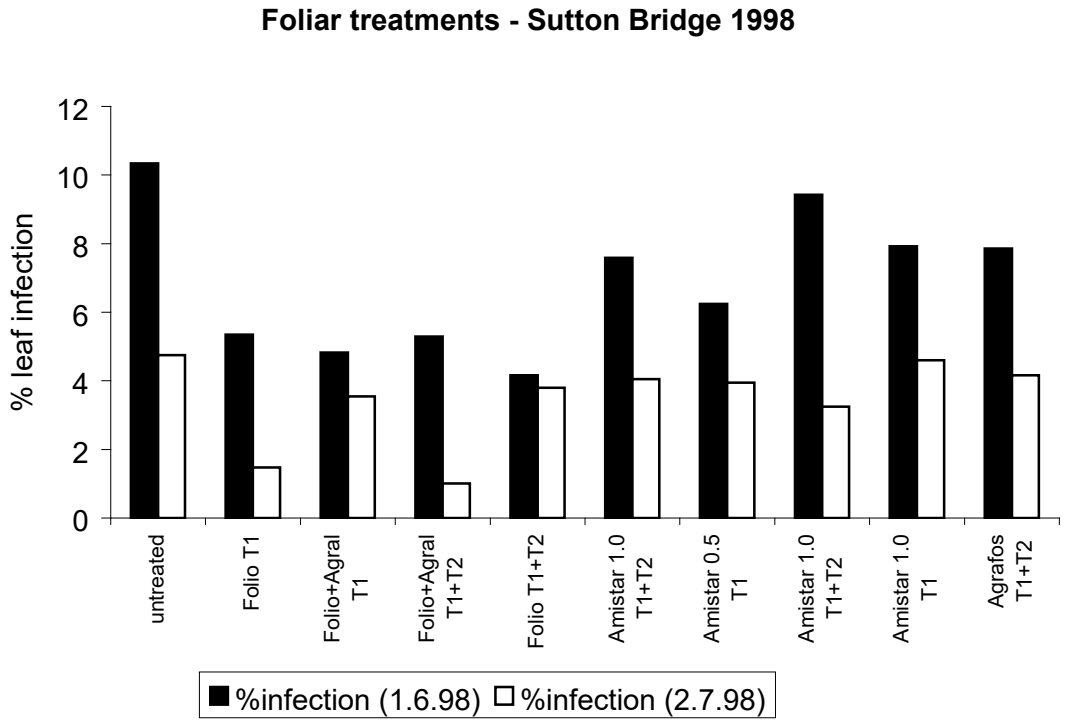
In 1998, at the Sutton Bridge site, mildew had caused a high level of primary infection and sprays were applied to evaluate their effectiveness in reducing secondary development. The results are shown in figure 5.

Figure 5. Foliar treatment



At the Fosdyke and Stenigot sites, all treatments were applied twice and additional products were evaluated see figure 6.

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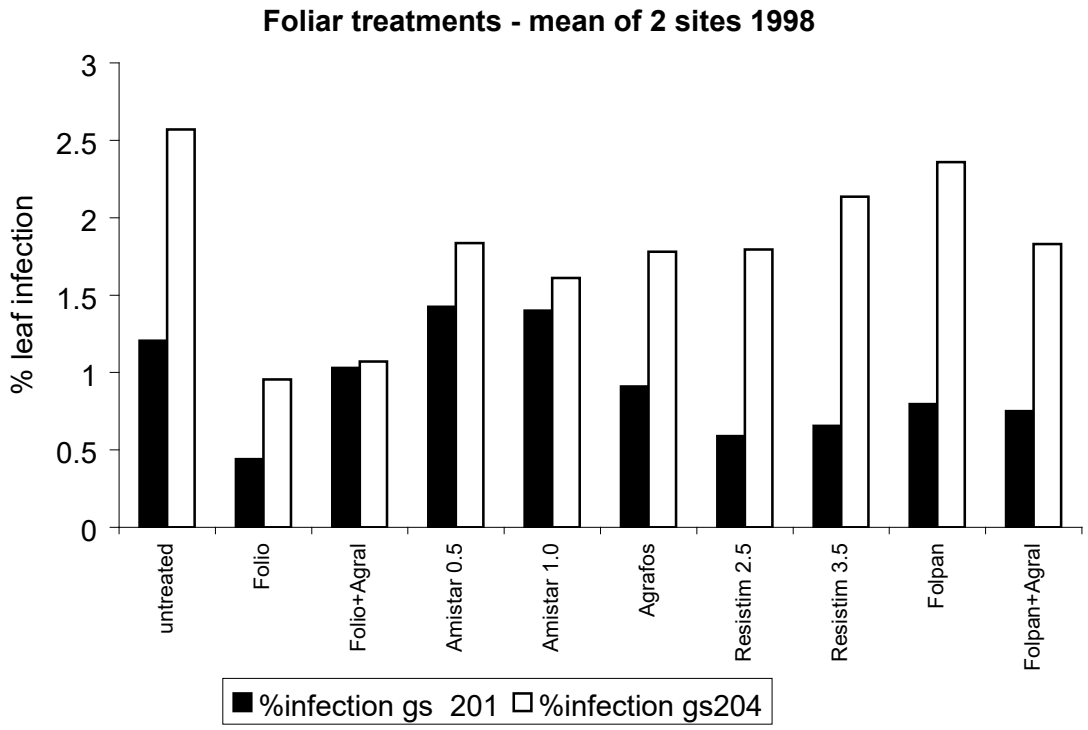
Figure 6. Foliar treatments



In 1999, disease had developed early in the season at all sites, but North Wootton was affected by the warm dry weather during July which severely restricted. secondary mildew development. All treatments were applied on two occasions see figures 7 - 9.

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Figure 7. Foliar treatment N. Wootton 1999

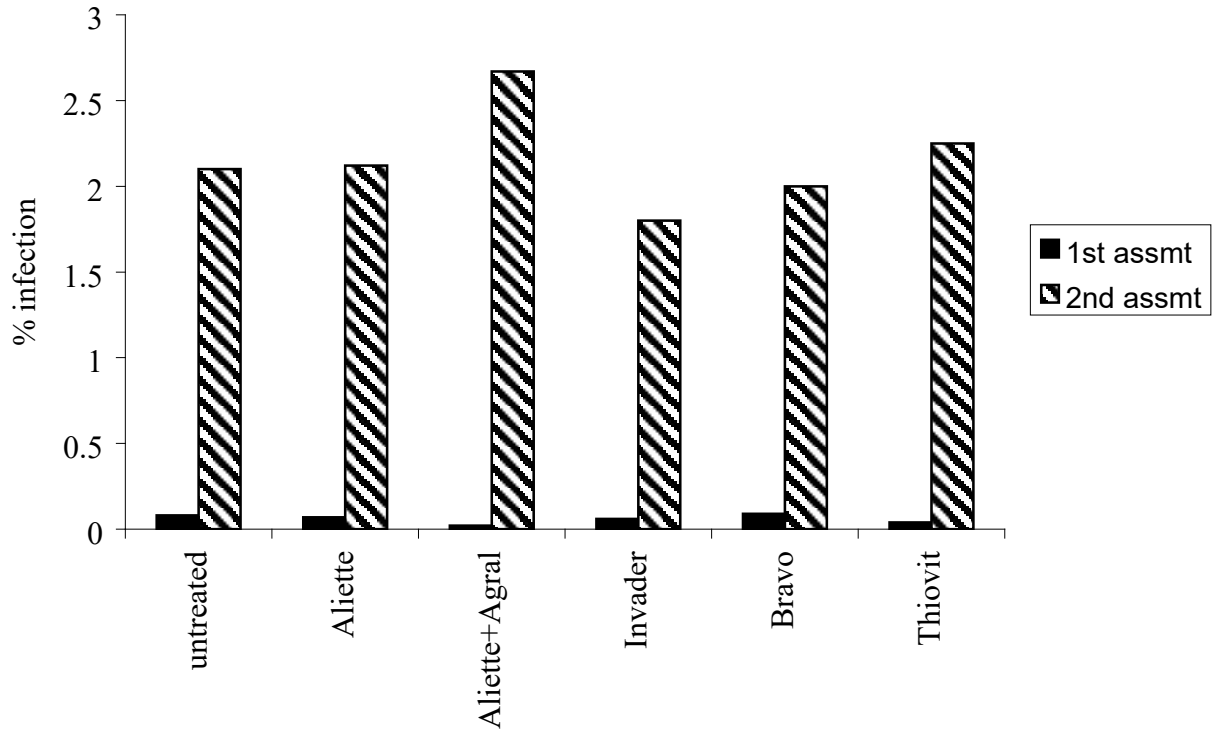

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Figure 8. Foliar treatments Spilsby 1999

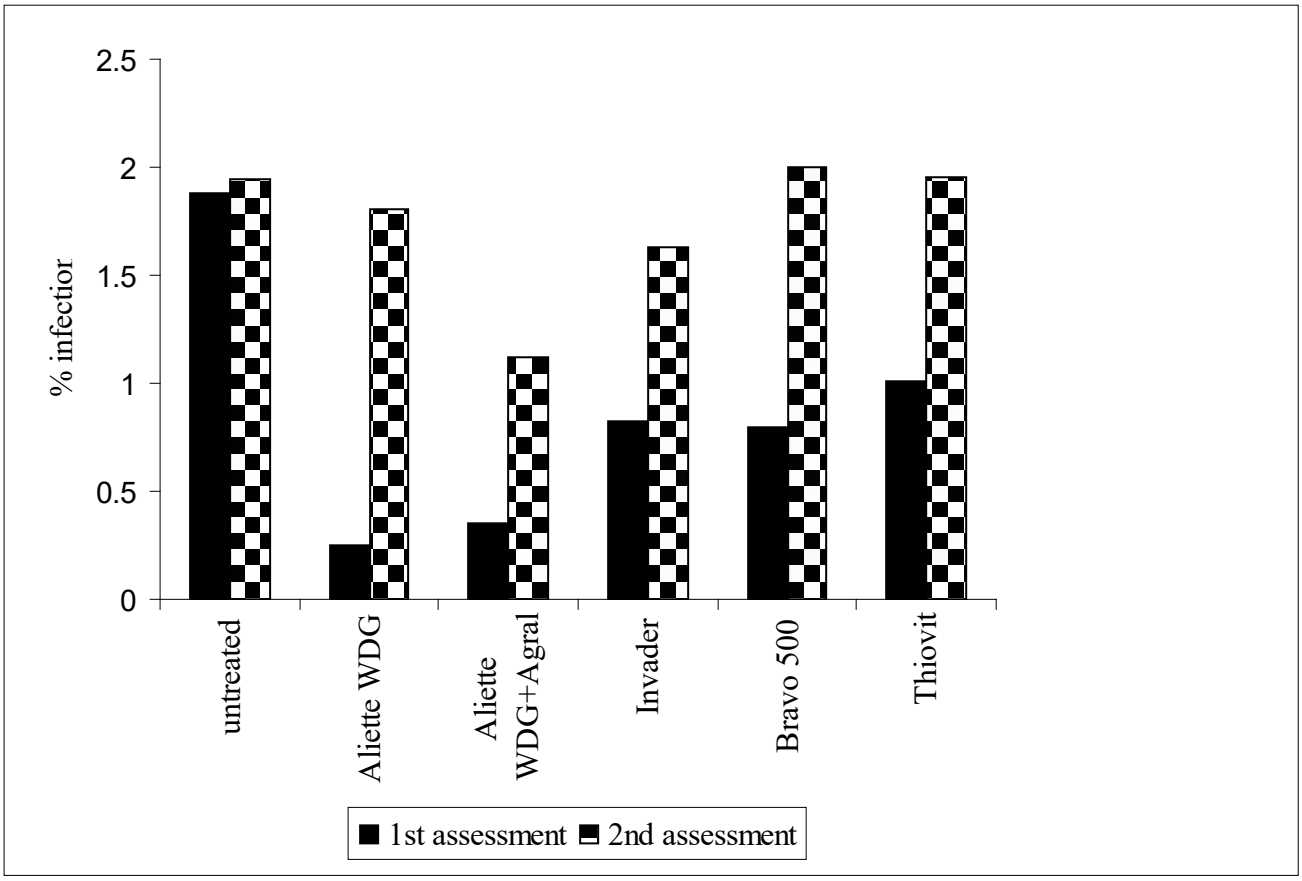

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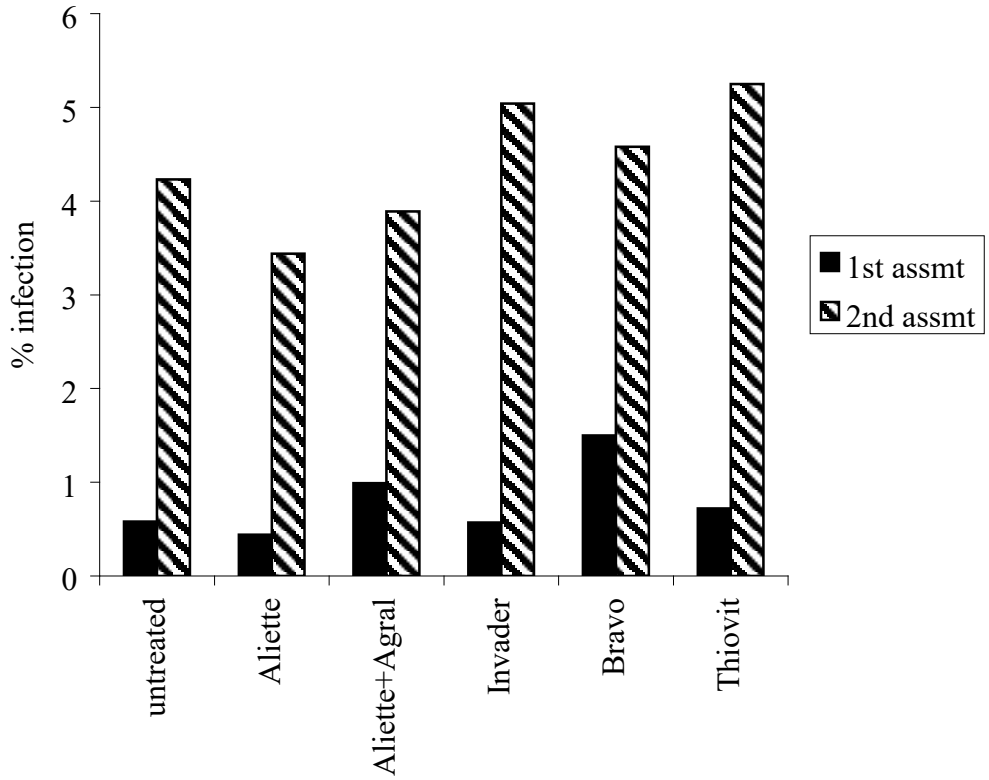
Figure 9. Foliar treatments Market Weighton 1999

Figure 13. Foliar treatments Market Weighton 1999



The full data sets for the spray trials are shown in Appendices 16 - 21.

CONCLUSIONS

Commercially available varieties of vining peas exhibit a range of resistance to infection by downy mildew. However, the performance can vary from year to year and between sites, possibly because of the presence of a diverse population of mildew races.

There appears to be no difference in susceptibility between leafy and semi-leafless types and not all the early maturing varieties were found to be susceptible. Overall, there were a small number of varieties that consistently tolerated mildew infection and these should be considered as being especially useful in areas where downy mildew has been a severe problem in the past and where variable levels of control of mildew by seed treatments has been noted. They should also be considered by organic producers and as part of an IPM programme.

The work with seed treatments indicated that metalaxyl resistant *Peronospora viciae* populations were more generally distributed than previously thought. However, the introduction of alternative products have proved to be timely and the effects on disease control have been consistently good.

The foliar treatment trials produced very variable results, but in general, unsatisfactory levels of control of secondary infection were obtained in the trials on 1998 and 1999. Foliar treatments of nutrients in the form of phosphates or sulphur had little or no effect and fungicides which normally provide good control of mildew when applied as seed treatments, also were disappointing. However, as new compounds are developed for related pathogens in other crops, there remains a need for a continuing programme of screening for pea downy mildew control.

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A combination of tolerant varieties, and effective seed treatment will provide a more robust means of disease management in vining peas and should reduce the rate of development of fungicide resistant strains of *Peronospora viciae.*

Technology Transfer

Information on varietal resistance will be incorporated in the PGRO Advisory Leaflet Vining Pea Varieties which is available to vining pea growers.

The research has been regularly reported in the PGRO Journal Pea and Bean Progress.

Progress reports have been given at the Vegetable Agronomists Association meeting in 1999 and 2000.

Information has been incorporated in the PGRO Pea and Bean Pest and Disease Course.

APPENDICES

Appendix 1. Details of foliar treatment application for downy mildew control.

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Site 1. Lighthouse Farm, Sutton Bridge

Variety: Espace

T_1 applied 22.5.98 gs 201 enclosed bud

T_2 applied 4.6.98 gs 203 first open flower

1998	treatment	rate	timing
	1. untreated		
	2. Folio	2.0	$T_1 + T_2$
	3. Folio + Agral	2.0 +0.1	T_1
	4. Folio + Agral	2.0 +0.1	$T_1 + T_2$
	5. Folio	2.0	T_1
	6. Amistar	0.5	$T_1 + T_2$
	7. Amistar	1.0	$T_1 + T_2$
	8. Amistar	0.5	T_1
	9 Amistar	1.0	T_1
	10 Agrofos	2.0	T_1
	11.Agrofos	2.0	$T_1 + T_2$

Site 2. Majors Farm, Fosdyke, Lincs

Variety: Bikini

T_2 applied 6.6.98 gs 201 enclosed bud

T_2 applied 19.6.98 gs 204 first pod

1998	treatment	rate	timing
	1. untreated		
	2. Folio	2.0	$T_1 + T_2$
	3. Folio + Agral	2.0 +0.1	$T_1 + T_2$
	4. Amistar	0.5	$T_1 + T_2$
	5. Amistar	1.0	$T_1 + T_2$
	6. Agrofos	2.0	$T_1 + T_2$
	7. Resistim	2.5	$T_1 + T_2$
	8. Resistim	3.5	$T_1 + T_2$
	9. Folpan	2.0	$T_1 + T_2$
	10. Folpan + Agral	2.0 +0.1	$T_1 + T_2$

Site 3. Cadwell Highfield Farm, Stenigot, Lincs

Variety: Samish

T_1 applied 22.6.98 gs 201 enclosed bud

T_2 applied 6.7.98 gs 203 open flower

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1999	treatments	rate/ha	timing
	1. untreated		
	2. Aliette WDG	1.68 kg	T_1+ T_2
	3. Aliette WDG + Agral	1. 68 kg + 0.1 l	T_1+ T_2
	4. Invader	2.0 kg	T_1+ T_2
	5. Bravo 500	2.0 l	T_1+ T_2
	6. Thiovit	10 kg	T_1+ T_2

Site 1. Wootton Marsh Farms, N. Wootton, Norfolk
Variety: Tristar
T_2 applied 24.6.99 gs 107 pre bud
T_2 applied 8.7.99 gs 206 pod swell

Site 2. Moat House Farm, Monkesthorpe, Spilby, Lincs
Variety: Walsingham
T_1 applied 25.6.99 gs 201 enclosed bud
T_2 applied 8.7.99 gs 206 pod swell

Site 3. Hesleskew Farm, Market Weighton, Yorks
Variety: Puget
T_1 applied 22.6.99 gs 201 enclosed bud
T_2 applied 6.7.99 gs 204 first pod

Appendix 2. Varietal resistance to downy mildew - field trials 1998.

Site	Fosdyke		Holland Fen		Cadwell		Mean
	% leaf area infection						
	assmt 1	assmt 2	assmt 1	assmt 2	assmt 1	assmt 2	

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	29.5.98	30.6.98	22.5.98	30.6.98	06.5.98	21.7.98	
Sancho	0	0.75	0.13	0	0.25	0.13	0.21
Sigra	0	0.25	1.50	0	0.40	2.5	0.51
Saturn	1.50	1.25	0	0.15	0.50	0	0.56
Colana	0.13	3.0	0.13	0.4	0.25	0.13	0.59
Ambassador	5.5	0.38	0	0.13	1.5	0	1.07
Jaguar	3.0	2.0	4.25	0.25	0.03	4.25	1.26
Barle	1.5	3.0	0.50	1.0	0.70	0.5	1.34
Balmoral	3.0	0.13	2.0	0	2.25	2.0	1.37
Purser	0.25	0.25	7.5	0	1.1	7.5	1.78
Winner	0.38	4.50	2.5	0.05	2.1	2.5	2.10
Samish	3.13	3.0	4.0	0.5	1.3	4.0	2.18
Cabree	0.38	5.5	2.0	0.5	0.14	2.0	2.36
Avola	1.01	4.0	6.5	2.25	1.40	6.5	3.40
LSD							2.13 nsd
CV%							68.0

Appendix 3. Varietal resistance to downy mildew - field trials 1999

	% leaf area infection						
Variety	Gypsy Bridge		Gosberton		Manea		Mean
Assmt date:	assmt 1 (26.5.99)	assmt 2 (16.6.99)	assmt 1 (16.6.99)	assmt 2 (16.7.99)	assmt 1 (30.6.99)	assmt 2 (19.7.99)	
Ambassador	20.3	11.2	0.5	0.25	2.15	0.25	5.75
Avola	21.0	5.0	0.75	0.38	2.0	3.13	5.58
Balmoral	34.0	10.5	1.0	1.5	1.63	1.12	8.29

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Barle	2.5	3.0	0.12	0.62	0.75	2.15	1.52
Brule	6.0	0.5	0.62	0.62	0.12	0.62	1.41
Cabree	9.0	21.5	1.0	0.38	3.5	4.5	6.64
Colana	12.0	2.5	1.5	4.12	0	0.5	3.44
Favorit	3.75	1.0	0.12	0.62	0.25	0.25	1.00
Jaguar	12.0	4.5	1.0	0.12	2.0	1.63	3.54
Jewel	11.0	12.5	0.12	0.5	4.12	0.12	4.73
Kermit	3.12	1.0	0	2.12	0.38	0.5	1.19
Oasis	5.5	2.25	0.75	0.38	1.50	1.0	1.89
Paso	0.62	1.0	0.25	3.0	2.0	0	1.15
Pinnacle	2.0	7.0	0.25	0.75	0.12	0	1.68
Sancho	2.5	1.12	1.0	0.25	0	0.75	0.94
Sigra	5.5	9.0	0.38	8.0	0	1.12	3.91
Tyne	1.12	0.12	0.12	0.62	0.5	5.0	1.25
Winner	27.75	16.63	0.62	3.25	2.38	2.75	7.77
LSD @ p=0.05							5.16(sig)
Coefficient of variation %							66.0

Appendix 4 Varietal resistance to Downy mildew field trials 2000

Variety	% leaf infection				
	Surfleet		Fosdyke	N. Wootton	Mean
	4.5.00	21.6.00	21.6.00	21.6.00	
Ambassador	0	5.0	0.02	0.25	1.32
Avola	2.0	40.0	4.0	2.13	12.03
Balmoral	0	5.0	0.13	1.0	1.53
Barle	4.0	0	0	0.25	1.06
Brule	2.0	0	0.25	0.5	0.69
Cabree	0	0.5	2.13	9.0	2.91

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Colana	0	0	0	1.25	0.31
Favorit	0.5	0.13	0.03	0.75	0.35
Jaguar	1.0	0	0	0.6	0.41
Jewel	0	5.0	0.6	0.25	1.47
Kermit	0.25	5.0	0.5	0	0.19
Oasis	1.5	0	0.25	0.13	0.47
Paso	0.25	0	0	0.25	0.13
Pinnacle	0	0.13	0.13	0	0.06
Sancho	5.0	0	0.13	0	1.28
Sigra	0	0.13	0	0.13	0.06
Tyne	1.0	0.13	0	0.13	0.31
Winner	3.0	11.5	5.13	3.25	5.47
LSD @ p=0.01					2.47
Coefficient of Variation					70.3

Appendix 5 Varietal resistance to mildew - inoculated polythene tunnel 1998

	% leaf infection 30.4.89 (gs 107)	% leaf infection 7.5.98 (gs 110)	mean
Colana	16.2	8.3	12.25
Sigra	6.1	4.7	5.4
Balmoral	26.1	17.3	21.7
Sancho	17.5	15.0	16.25
Samish	30.0	16.7	23.35
Ambassador	19.3	11.7	15.5
Purser	14.8	13.7	14.25
Barle	10.0	8.3	9.15

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Saturn	6.5	5.0	5.75
Cabree	12.5	6.7	9.6
Jaguar	21.5	10.0	10.75
Winner	12.0	5.3	8.65
Avola	30.0	12.7	21.35
LSD @ p = 0.05	11.69 (sig)	9.11(sig)	
Coefficient of variation %	52.5	56.9	

Appendix 6. Varietal resistance to mildew - inoculated polythene tunnel 1999

	9.4.99 (gs 103)	16.4.99 (gs 108)	21.4.99 (gs 110)	mean
Ambassador	3.5	8.1	16.1	9.2
Avola	9.8	11.8	39.5	20.4
Balmoral	5.5	7.2	22.0	11.6
Barle	1.2	0.9	12.1	4.7
Brule	3.4	13.2	31.8	16.1
Cabree	3.1	5.9	26.8	11.9
Colana	2.2	5.9	24.3	10.8
Favorit	4.5	11.5	18.3	11.5
Jaguar	6.5	8.1	21.1	11.9
Jewel	5.5	6.1	18.8	10.1
Kermit	3.0	5.4	11.5	6.6
Oasis	17.5	13.8	36.3	22.5
Paso	8.2	13.0	24.3	15.2
Pinnacle	0.5	1.8	5.5	2.6
Sancho	1.2	8.4	41.8	17.1
Sigra	1.8	2.3	13.8	5.9
Tyne	5.8	4.4	27.1	12.4
Winner	3.0	7.5	23.0	11.2
LSD @ p=0.05	5.61(sig)	6.81(sig)	17.53(sig)	
CV %	82.4	63.1	53.2	

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Appendix 7. Varietal resistance to mildew - inoculated polythene tunnel 2000

	% leaf are infected				
	29.3.00 (gs 103)	10.4.00 (104/5)	15.4.00 (105)	25.4.00 (107)	mean
Ambassador	22.5	19.25	9.75	3.7	13.8
Avola	26.25	15.5	8.0	2.25	13.0
Balmoral	10.0	15.75	8.5	1.4	9.66
Barle	35.0	12.25	9.0	3.0	14.81
Brule	40.0	20.5	12.75	4.0	19.31
Cabree	27.5	14.25	9.75	3.5	13.75
Colana	5.75	4.25	1.1	0.4	2.88
Favorit	18.75	10.25	4.0	1.8	8.7
Jaguar	26.75	20.0	9.75	2.2	14.68
Jewel	20.0	18.0	18.25	8.5	16.19
Kermit	26.25	17.5	6.75	1.25	12.94
Oasis	47.5	28.75	19.5	8.0	25.94
Paso	48.75	15.5	6.0	1.0	17.81
Pinnacle	7.0	4.25	0.75	6.25	3.06
Sancho	20.0	16.25	4.5	0.8	10.39
Sigra	28.75	18.75	9.2	2.7	14.85
Tyne	28.75	15.75	9.2	2.7	14.85
Winner	26.25	22.5	10.25	2.2	15.3
	35.0	13.0	16.75	7.75	18.13
LSD @ P= 0.05	10.42	6.93	3.69	2.62	

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Appendix 8. Seed treatment trial - Holland Fen 1998

Treatment	Seedling emergence m/^{2} (28.4.98)	% Secondary infection (22.5.98)	% Secondary infection (28.4.98)
HyTL	92.7	1.42	1.06
Apron Combi 453 FS	93.1	0.52	1.56
Triple Pea Treatment	89.7	0.09	0.83
Apron Elite	94.5	0.01	0.80
LSD @ p = 0.05	nsd	0.75(sig)	nsd
Coefficient of variation %	10.9	119.8	118.2

Appendix 9. Seed treatment trial - Cadwell 1998

Treatment	Seedling emergence/m^2 (29.5.98)	% leaf area infection (5.6.98)	% leaf area infection (6.7.98)
HyTl	96.0	9.48	2.82
Apron Combi 453 FS	94.8	5.40	2.51
Triple Pea Treatment	94.7	1.62	1.03
Apron Elite	99.1	0.17	1.23
LSD @ p = 0.05	nsd	3.23 (sig)	1.50 (sig)
Coefficient of variation %	12.1	62.9	64.2

Appendix 10. Seed treatment trial - Gypsy Bridge 1999

Treatment	Seedling emergence/m^2 (30.4.99)	% leaf infection (26.5.99)	% leaf infection (16.6.99)
Hy-TL	83.8	3.10	0.72
Apron Combi 453FS	83.1	1.70	0.75
Apron Elite	93.0	0.24	0.39
Triple Pea Treatment	80.4	2.44	0.65
LSD @ p=0.05	18.6(nsd)	2.41(nsd)	1.09(nsd)
coefficient of variation %	16.4	81.3	116.0

Appendix 11. Seed treatment trial - Gosberton 1999

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Treatment	Seedling emergence/m^2 (18.5.99)	% leaf infection (16.6.99)	% leaf infection (16.7.99)
Hy- TL	133.2	2.18	0.12
Apron Combi 453FS	130.8	1.28	0.13
Apron Elite	131.1	0.29	0.30
Triple Pea Treatment	137.0	0.26	0.07
LSD @ p=0.05	13.25(nsd)	0.91(sig)	0.25(nsd)
coefficient of variation %	7.4	71.6	112.1

Appendix 12. Seed Treatment - Manea 1999

Treatment	Seedling emergence/m^2 (12.5.99)	% leaf infection (30.6.99)
Hy-TL	98.9	0.18
Apron Combi 453FS	97.5	0.17
Apron Elite	97.2	0.27
Triple Pea Treatment	101.1	0.26
LSD @ p=0.05	19.16(nsd)	0.18(nsd)
coefficient of variation %	14.3	65.8

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Appendix 13. Seed treatment trial Surfleet 2000

Treatment	Seedling emergence/m^2 (4.5.00)	% leaf infection (21.6.00)
HyTL	103.6	3.76
Apron Elite	114.4	0.23
Wakil Elite	118.2	0
Triple Pea	110.0	0.11
untreated	101.2	6.93
LSD@ p=0.05	15.3 (nsd)	2.22 sig
Coefficient variation %	9.1	65.5

Appendix 14. Seed Treatment trial Fosdyke 2000

	Seedling emergence /m^2 (3.5.00)	% leaf infection (21.6.00)	Yield t/ha (19.7.00)	TR
HyTL	84.5	1.12	86.0	86.0
Apron Elite	88.2	0.40	85.0	85.0
Wakil Elite	96.6	0.47	83.75	83.75
Triple Pea	87.7	0.80	85.5	85.5
untreated	79.7	0.30	86.25	86.25
LSD @ p = 0.05	13.68 nsd	1.53 nsd	23 nsd	2.33 nsd
Coefficient variation %	10.2	160.8	18.0	1.8

Appendix 15. Seed treatment trial North Wootton 2000

	Seedlings/m^2 (5.5.00)	Yield t/ha (20.7.00)	TR
HyTL	62.4	6.78	115.3
Apron Elite	66.9	6.60	116.3
Wakil Elite	67.9	6.79	116.0
Triple Pea	59.6	6.50	113.5
untreated	61.0	5.99	118.3
LSD @ p = 0.05	13.3 nsd	0.63 nsd	3.79 nsd
Coefficient variation %	13.6	6.3	3.79

Appendix 16. Foliar treatments - Sutton Bridge 1998

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Treatment	Application timing	%leaf area infection (1.6.98)	% leaf infection (2.7.98)
1. Untreated		10.34	4.75
2. Folio	$T^1 + T^2$	5.35	1.47
3. Folio + Agral	T^1	4.82	3.55
4. Folio + Agral	$T^1 + T^2$	5.29	1.01
5. Folio	T^1	4.16	3.80
6. Amistar 0.5	$T^1 + T^2$	7.59	4.05
7. Amistar 1.0	T^1	6.24	3.95
8. Amistar 0.5	T^1	9.42	3.25
9. Amistar 1.0	T^1	8.64	4.55
10. Agrafos	$T^1 + T^2$	7.92	4.60
11. Agrafos	$T^1 + T_2$	7.86	
LSD @ p=0.05		4.95(sig)	1.71(sig)
Coefficient of variation %		45.2	32.9

Variety: Espace
Treatment T_1 applied 22.5.98 gs 201
Treatment T_2 applied 4.6.98 gs 203

Appendix 17. Foliar treatments - Fosdyke 1998

Treatment	% leaf area infection (19.6.98)	% leaf area infection (2.7.98)
1. Untreated	0.37	2.27
2. Folio	0.13	0.47
3. Folio + Agral	0.09	0.90
4. Amistar 0.5	0.21	1.65
5. Amistar 1.0	0.26	2.07
6. Agrafos	0.26	2.49
7. Resistim 2.5	0.26	2.30
8. Resistim 3.5	0.26	3.47
9. Folpan	0.25	2.67
10. Folpan + Agral	0.25	1.82
LSD @ p = 0.05	0.17 (nsd)	1.24 (sig)
Coefficient of variation %	49.3	42.6

Variety: Bikini
Treatment T_1 applied 6.6.98 gs 201
Treatment T_2 applied 19.6.98 gs 204

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Appendix 18. Foliar treatments - Stenigot 1998

Treatment	% leaf area infection (6.7.98)	% leaf area infection (21.7.98)
1. Untreated	2.04	2.87
2. Folio	0.75	1.44
3. Folio + Agral	1.97	1.24
4. Amistar 0.5	2.64	2.02
5. Amistar 1.0	2.54	1.15
6. Agrafos	1.56	1.07
7. Resistim	0.92	1.29
8. Resistim 3.5	1.05	0.80
9. Folpan	1.34	2.05
10. Folpan + Agral	1.25	1.84
11.		
LSD @ p = 0.05	1.40 (nsd)	3.09 (nsd)
Coefficient of variation %	59.9	53.7

Variety:	Samish	
Treatment T_1	applied 22.6.98	gs 201
Treatment T_2	applied 6.7.98	gs 203

Appendix 19. Foliar treatments - North Wootton. 1999

Treatment	% leaf area infected 26.7.99				
	whole plant (13.7.99)	top of plant	middle	bottom	mean infection
1. untreated	0.08	0.60	0.88	4.80	2.10
2. Aliette WDG	0.07	0.44	0.83	5.08	2.12
3. Aliette WDG + Agral	0.02	0.40	1.61	6.00	2.67
4. Invader	0.06	0.53	0.58	4.28	1.80
5. Bravo 500	0.09	0.51	0.92	4.57	2.00
6. Thiovit	0.04	0.37	0.83	5.55	2.25
LSD @ p=0.05	0.09(nsd)	0.54(nsd)	0.77(nsd)	1.34 (nsd)	0.70 (nsd)
coefficient of variation %	97.7	75.6	53.7	17.6	21.5

Variety:	Tristar		
Treatment T_1	applied	24.6.99	gs 107
Treatment T_2	applied	8.7.99	gs 206

Appendix 20. Foliar treatments - Spilsby 1999

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Treatment	% leaf area infected 27.7.99				
	whole plant (13.7.99)	top of plant	middle	bottom	mean infection
1. untreated	1.88	1.79	2.17	1.87	1.94
2. Aliette WDG	0.25	1.28	1.38	2.77	1.81
3. Aliette WDG + Agral	0.35	0.65	1.73	0.97	1.12
4. Invader	0.82	1.15	1.50	2.25	1.63
5. Bravo 500	0.85	1.53	1.80	2.88	2.07
1. Thiovit	1.01	2.33	1.48	2.04	1.95
LSD @ p=0.05	1.01(sig)	1.58(nsd)	0.99(nsd)	1.91(nsd)	1.09(nsd)
coefficient of variation %	78.0	72.0	39.0	59.6	41.3

Variety: Walsingham
Treatment T_1 applied 25.6.99 gs 201
Treatment T_2 applied 8.7.99 gs 206

Appendix 21. Foliar treatments - Market Weighton 1999

Treatment	% leaf area infected 27.7.99				
	whole plant (6.7.99)	top of plant	middle	bottom	mean infection
1. untreated	0.58	6.20	4.23	5.30	4.23
2. Aliette WDG	0.44	3.60	3.43	6.05	3.44
3. Aliette WDG + Agral	0.99	6.08	3.72	5.63	3.89
4. Invader	0.57	3.67	3.20	4.82	5.04
5. Bravo 500	1.50	2.44	3.58	5.23	4.58
1. Thiovit	0.72	3.32	3.38	5.45	5.25
LSD @ p=0.05	0.90(nsd)	4.17(nsd)	2.30(nsd)	2.57(nsd)	2.61(nsd)
coefficient of variation %	74.4	65.5	42.5	31.5	39.2

Variety: Puget
Treatment T_1 applied 22.6.99 gs 201
Treatment T_2 applied 6.7.99 gs 203-4

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