

Project Title	New Products for the Control of Downy Mildew (<i>Peronospora destructor</i>) in Bulb and Salad Onions
Project number:	FV189b
Project leader:	Andrew Richardson, Allium & Brassica Centre Ltd.
Report:	Final report, January 2006
Previous report	N/A
Key staff:	Andrew Richardson, Allium & Brassica Centre Ltd. Tom Will, Vegetable Consultancy Services Ltd. Phillip Langley, Bomfords Ltd.
Location of project:	Main Site: Allium & Brassica Centre Ltd., Wash Rd., Kirton, Lincs. PE20 1QQ Trial Sites: (bulb onions) E M Key & Son, Old School House, Burton Pedwardine, Sleaford, Lincs. NG34 0BX Bullock Lodge Farm, Risby, Bury St Edmunds, Suffolk Trial Site: (salad onions) Bomfords Ltd., Orchard Farm, School Rd. Salford Priors, Evesham WR11 5UU
Project coordinator:	Stefan Williams, PG Rix (Farms) Ltd.
Date project commenced:	1 st April 2005
Date completion due:	31 st December 2005
Key words:	Bulb onion, salad onion, downy mildew, <i>Peronospora destructor</i> , leaf spot, <i>Botrytis squamosa</i> , leaf blotch, <i>Cladosporium allii-cepae</i> , fungicide.

Whilst reports issued under the auspices of the HDC are prepared from the best available information, neither the authors nor the HDC can accept any responsibility for inaccuracy or liability for loss, damage or injury from the application of any concept or procedure discussed.

The contents of this publication are strictly private to HDC members. No part of this publication may be copied or reproduced in any form or by any means without prior written permission of the Horticultural Development Council.

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Name: A S Richardson
Position: Joint Managing Director
Organisation: Allium & Brassica Centre Limited

Signature Date

Report authorised by:

[Name]
[Position]
[Organisation]

Signature Date

[Name]
[Position]
[Organisation]

Signature Date

CONTENTS

	Page
<u>Grower Summary</u>	1
Headline	1
Background and expected deliverables	1
Summary of the project and main conclusions	1-4
Financial benefits	4
Action points for growers	5
<u>Science section</u>	
Introduction	6
Biology of <i>P.destructor</i> on onions crops	6
Control of downy mildew in onion crops	7
Materials and Methods	8-9
Bulb onion yield, quality and internal defect assessment	10
Application and assessment dates	11-12
Results and Discussion	12
Bulb Onion – Sleaford, Lincolnshire	12-17
Bulb Onion – Bury St. Edmunds, Suffolk	18-21
Salad Onion – Evesham, Worcestershire	22-23
Conclusions	23-24
Further Work	24
Technology transfer	25
References	25
Appendices	26-30
Appendix 1a – Summary of fungicide products applied in bulb onions	26
Appendix 1b – Summary of fungicides applied in salad onion trial	27
Appendix 2a – Trial layout – Sleaford, Lincolnshire	28
Appendix 2b – Trial layout – Bury St Edmunds, Suffolk	29
Appendix 2c – Trial layout – Evesham, Worcestershire	30

Grower Summary

Headline

- Two new products (Sonata and KIF 230), were effective in controlling downy mildew (*Peronospora destructor*) in bulb and salad onions. Neither product is currently approved for use on onions in the UK.
- Mancozeb-based products still offer the best control of downy mildew.
- Strobilurin / chlorothalonil based products were best at controlling leaf spot and leaf blotch.

Background and expected deliverables

Downy mildew (*Peronospora destructor*) is the most serious air-borne disease of bulb and salad onion crops and has caused increasingly severe yield and quality losses in recent years.

Fungicidal control of downy mildew is becoming increasingly difficult with currently approved products providing only limited control of active infections. In many cases fungicides are only effective when used as protectants or if used very soon after initial infection. Commercially recent concerns have been raised in many onion growing areas that downy mildew may be becoming insensitive or even resistant to methanoxam (metalaxyl-m), one of the main eradicant actives used in control.

Over recent years a number of new formulations and actives have emerged primarily for potato blight (*Phytophthora infestans*) control. As blight and downy mildew are both oomycete fungi, fungicides approved for potato blight often show efficacy against downy mildew. All the actives currently approved for downy mildew control are also approved for potato blight control.

Summary of the project and main conclusions

Trials were undertaken at three sites, two bulb onion and one salad onion. The main objective was to compare both existing products and new active ingredients to determine their efficacy with regard to downy mildew. Treatments as below:

1. Bulb onion treatments

- (i) Control – water
- (ii) Control – Folio Gold (chlorothalonil + metalaxyl-m) @ 2l/ha
- (iii) Control – Invader (mancozeb + dimethomorph)@ 2kg/ha
- (iv) Control –SL567a (metalaxyl-m) @ 156ml/ha (metalaxyl-m rate as 2l/ha Folio Gold)
- (v) Signum (boscalid + pyraclostrobin) @ 1kg/ha.
- (vi) Amistar Opti (azoxystrobin + chlorothalonil) @ 2l/ha
- (vii) Ranman Twinpack (cyazofamid) @ 0.2l/ha
- (viii) Electis 75WG (mancozeb + zoxamide) @ 1.8kg/ha
- (ix) Sonata (fenamidone + mancozeb) @ 1.5kg/ha
- (x) Tanos (famoxadone + cymoxanil) @ 0.7kg/ha
- (xi) Consento (fenamidone + propamocarb hydrochloride) @ 2kg/ha
- (xii) Grevit 200SL (grapefruit extract) @ 1.5l/ha
- (xiii) Jet 5 (peroxyacetic acid) @ 2l/ha
- (xiv) KIF 230 (a.i. undisclosed) @ 1.6kg/ha
- (xv) Silwet L-77 (silicone wetter) @ 200ml/ha
- (xvi) LI700 (Penetrant, acidifier) @ 200ml/ha

2. Salad onion treatments

- (i) Control - water
- (ii) Control - Fubol Gold (mancozeb + metalaxyl-m) @ 1.5kg/ha
- (iii) Control - Invader (mancozeb + dimethomorph) @ 2kg/ha
- (iv) Control - Bravo 500 (chlorothalonil) @ 2l/ha + Amistar (azoxystrobin) @ 0.8l/ha
- (v) Signum (boscalid + pyraclostrobin) @ 1kg/ha.
- (vi) Amistar Opti (azoxystrobin + chlorothalonil) @ 2l/ha
- (vii) Electis 75WG (mancozeb + zoxamide) @ 1.8kg/ha
- (viii) Sonata (fenamidone + mancozeb) @ 1.5kg/ha
- (ix) Tanos (famoxadone + cymoxanil) @ 0.7kg/ha
- (x) Consento (fenamidone + propamocarb hydrochloride) @ 2kg/ha
- (xi) Grevit 200SL (grapefruit extract) @ 1.5l/ha
- (xii) Jet 5 (peroxyacetic acid) @ 2l/ha
- (xiii) KIF 230 (a.i. undisclosed) @ 1.6kg/ha
- (xiv) Silwet L-77 (silicone wetter) @ 200ml/ha
- (xv) LI700 (Penetrant, acidifier) @ 200ml/ha

The trials were arranged in a randomized block design and embedded in commercial crops. Assessments were carried out for the duration of the field trial and also after a period of storage of harvested bulbs.

Field evaluations involved regular assessments of occurrence and severity of downy mildew, leaf spot (*Botrytis squamosa*) and leaf blotch (*Cladosporium allii-cepae*.) whilst plots were subjected to different fungicide treatments. Plots from the bulb onion trials were harvested at 80% fallow and dried/cured according to standard commercial practice prior to the following assessments being made.

Size Grades: <40mm diameter	Skin quality: Class 1 (no skinning)
40-60mm diameter	Class 2 (<30% skinning)
60-80mm diameter	Outgrades – shrinkage/skinning
>80mm diameter	

Internal Defects:	Neck-Rot (<i>Botrytis allii</i>)
	Bacterial (<i>Pseudomonas sp.</i> , <i>Erwinia sp.</i> , <i>Lactobacillus sp.</i>)
	Fusarium (<i>Fusarium oxysporum f.sp.cepae</i>)
	Physiological disorders

The main finding of the project was that mancozeb or mancozeb based products afforded the best control of onion downy mildew, particularly where this disease was most severe at the Lincolnshire and Worcestershire sites.

The most effective products against downy mildew were:

1. Dithane 945 (mancozeb) – currently approved under SOLA 3037/05 for use on bulb onions
2. Invader (mancozeb + dimethomorph) – currently approved under SOLA 2334/04 for use on bulb onions.
3. KIF230 (a.i. undisclosed) – no current approval for use on bulb or salad onions.
4. Sonata (mancozeb + fenamidone) – no current approval for use on bulb or salad onions.

5. Fubol Gold (mancozeb + methanoxam) – currently approved under SOLA 2324/03 for use on salad onions.

At the Suffolk site where mildew was less severe but leaf spot and leaf blotch were significant, mancozeb based products gave the poorest control of these foliar diseases. Products containing azoxystrobin, pyraclostrobin, chlorothalonil, peroxyacetic acid or grapefruit extract provided the best control of leaf spot and leaf blotch.

Early downy mildew infection at the Suffolk site strongly predisposed affected plants to later leaf spot and leaf blotch infection.

Of particular note was the relatively poor performance of the commercial standard Folio Gold, which contains the eradicator fungicide methanoxam, against downy mildew. Results from the Sleaford site indicate that Folio Gold is not significantly different to the Water control.

More encouragingly Invader, the commercial standard approved for use in bulb onion and Fubol Gold the commercial standard approved for use in salad onion both showed good efficacy against downy mildew.

The dewaxing penetrant adjuvant LI700 showed no significantly better or worse disease control than the water control at all three sites.

Financial benefits

In field trials it was demonstrated that new products Sonata and KIF 230 were effective in controlling downy mildew in both bulb and salad onions. If these products could be used on onion crops, growers would have two new active ingredients for reliable disease control. In addition to the benefits of protecting both yield/quality the introduction of new actives reduces the potential for resistance to build up in the pathogen population.

Action points for growers

- Downy mildew is not the only foliar disease issue in bulb and salad onion crops, consideration should also be given to leaf spot and leaf blotch control as these diseases can also cause significant losses.
- Alternation of products containing different active ingredients is essential for a disease free crop.
- For optimum disease control tank mix products containing different active ingredients at each application.
- Mancozeb based products afford best control of onion downy mildew.
- Strobilurin/chlorothalonil based products afford best control of leaf spot and leaf blotch.
- Growers should be alert to new product / SOLAs being made available to industry.

Science Section

Introduction

Downy Mildew (*Peronospora destructor*) is the most significant foliar disease affecting bulb and salad onion crops. Most effective control of the disease is achieved by prophylactic and regular application of fungicides. Fungicidal control is currently the only effective means of controlling the disease and avoiding crop loss.

There is some evidence to suggest that the mildew pathogen may be losing sensitivity to methanoxam (metalaxyl-m) one of the main eradicant fungicides used commercially. In order to protect the only other approved eradicant dimethomorph it is essential that new actives are found.

Biology of *P. destructor* on onion crops

The pathogen is an Oomycete with aseptate mycelium and asexual monopodially branched sporangiophores which bear fusiform to pyriform sporangia. It has sexual oogonia and antheridia which fuse to produce numerous thick walled oospores (Mc Kay R, 1959). Sporangia are produced over a temperature range of 3 to 25°C (Viranyi F, 1981) at relative humidities in excess of 95%. The mature sporangia are forcibly released when relative humidity drops below 59%. Sporangia are thin walled and easily transported over large distances by wind/air movement.

Sporangia germinate only in free water in the temperature range 6-27°C (optimum 10-12°C) typically producing germ tubes in 2-4 hours (Viranyi F, 1975). Sporangia viability is affected by ambient temperature and humidity conditions. At 10°C, spore viability is unaffected by relative humidity (r.h.), however at temperatures in excess of 30°C viability declines swiftly below 55% r.h..

Downy mildew can overwinter as mycelium in onion bulbs and sets and as oospores in debris from diseased foliage. Leaves of overwintering bulb and salad onions may also carry the disease which can then spread to nearby spring drilled/planted crops. Downy mildew affects all onion types including the common onion (*Allium cepa*), shallots (*A. cepa* var. *ascalonicum*) as well as *A. fistulosum* used extensively for salad onion production.

Control of downy mildew in onion crops

Present control of downy mildew relies upon fungicide applications made from 4-5 true leaves (TL) onwards in bulb onion or from 2TL in salad onion. Fungicides are typically applied at 7-14 day intervals. Commercial fungicide programmes rely heavily on applications of two eradicant fungicides, methanoxam and dimethomorph as well as protectant fungicides such as mancozeb, chlorothalonil and azoxystrobin.

In recent years despite routine applications and/or timing of fungicides using disease forecasts (DACOM/MORPH) losses due to downy mildew infection are increasing and existing approved chemistry appears to have decreasing efficacy.

Materials and Methods

The effect of fungicides/adjuvants and disinfectants were all investigated in the field. Trials were sited at three locations in Lincolnshire, Suffolk and Worcestershire.

On all sites treatments were arranged in a randomized block design, with bulb onion sites incorporating 16 treatments (including controls) and salad onion sites 14 treatments (including controls). All treatments were replicated four times and trials were embedded within a commercial crop.

Bulb onion sites were drilled with the open pollinated, red variety Red Baron, chosen for its susceptibility to mildew. Treatments commenced when the crop was at the 4-5TL stage.

Two salad onion varieties Baja Verde and Green Banner were used. Treatments commenced at 2TL.

All treatments were applied in 200l/ha water using standard 110° flat fan nozzles at 2 bar (fine/medium spray), using either a gas pressurised AZO plot sprayer with a 2m boom or a modified commercial hydraulic sprayer. Treatments were applied four times on salad onion and 5-8 times on the bulb onion trials dependent upon disease pressure.

Fungicide treatments:

1. Bulb onion treatments

- (i) Control – water
- (ii) Control – Dithane 945 (mancozeb) @ 2.5kg/ha
- (iii) Control – Folio Gold (chlorothalonil + metalaxyl-m) @ 2l/ha
- (iv) Control – Invader (mancozeb + dimethomorph) @ 2kg/ha
- (v) Control – SL567a (metalaxyl-m) @ 156ml/ha (metalaxyl-m rate as 2l/ha Folio Gold)
- (vi) Signum (boscalid + pyraclostrobin) @ 1kg/ha.
- (vii) A4111B (azoxystrobin + chlorothalonil) @ 2l/ha
- (viii) Ranman Twinpack (cyazofamid) @ 0.2l/ha
- (ix) Electis 75WG (mancozeb + zoxamide) @ 1.8kg/ha
- (x) Sonata (fenamidone + mancozeb) @ 1.5kg/ha
- (xi) Tanos (famoxadone + cymoxanil) @ 0.7kg/ha
- (xii) Consento (fenamidone + propamocarb hydrochloride) @ 2kg/ha
- (xiii) Grevit 200SL (grapefruit extract) @ 1.5l/ha
- (xiv) Jet 5 (peroxyacetic acid) @ 2l/ha
- (xv) KIF 230 (a.i. undisclosed) @ 1.6kg/ha
- (xvi) LI700 (Penetrant, acidifier) @ 200ml/ha

2. Salad onion treatments

- (i) Control – water
- (ii) Control - Fubol Gold (mancozeb + metalaxyl-m) @ 1.5kg/ha
- (iii) Control - Invader (mancozeb + dimethomorph) @ 2kg/ha
- (iv) Control - Bravo 500 (chlorothalonil) @ 2l/ha + Amistar (azoxystrobin) @ 0.8l/ha
- (v) Signum (boscalid + pyraclostrobin) @ 1kg/ha.
- (vi) A4111B (azoxystrobin + chlorothalonil) @ 2l/ha
- (vii) Electis 75WG (mancozeb + zoxamide) @ 1.8kg/ha
- (viii) Sonata (fenamidone + mancozeb) @ 1.5kg/ha
- (ix) Tanos (famoxadone + cymoxanil) @ 0.7kg/ha
- (x) Consento (fenamidone + propamocarb hydrochloride) @ 2kg/ha
- (xi) Grevit 200SL (grapefruit extract) @ 1.5l/ha
- (xii) Jet 5 (peroxyacetic acid) @ 2l/ha
- (xiii) KIF 230 (a.i. undisclosed) @ 1.6kg/ha
- (xiv) LI700 (Penetrant, acidifier) @ 200ml/ha

Regular disease assessments were undertaken in each of the trial plots to compare the development of downy mildew, leaf spot and leaf blotch lesions. Disease lesions were identified and counted for each plot up to 500 lesions per plot, after this point an assessment of green leaf area was undertaken for the plot. See reference photographs below:



Bulb onion - yield, quality and internal defect assessments

At the bulb onion sites, an area of 3.66m² was harvested from each plot at 80% fallow and dried/cured according to standard commercial practice prior to the following assessments being made.

Size Grades: <40mm diameter	Skin quality: Class 1 (no skinning)
40-60mm diameter	Class 2 (>30% skinning)
60-80mm diameter	Outgrades – shrinkage/skinning
>80mm diameter	

A 100 bulb sample retained from the harvested area of each plot was assessed for the following internal defects by dissecting the bulbs longitudinally.

Internal Defects:	Neck-Rot	(<i>Botrytis allii</i>)
	Bacterial	(<i>Pseudomonas sp.</i> , <i>Erwinia sp.</i> , <i>Lactobacillus sp.</i>)
	Fusarium	(<i>Fusarium oxysporum f.sp.cepae</i>)
	Physiological disorders	

Application and Assessment Dates:

Bulb Onion – Sleaford, Lincolnshire

Application:	Date	Temp°C	Assessment:	Date	Temp°C
	21/6/2005	19		21/6/2005	19
	29/6/2005	18		29/6/2005	18
	11/7/2005	22		11/7/2005	22
	21/7/2005	17		21/7/2005	17
	29/7/2005	18		29/7/2005	18
	05/8/2005	19		02/8/2005	22
	12/8/2005	19		05/8/2005	19
	18/8/2005	30		09/8/2005	14
				12/8/2005	19
				18/8/2005	30
				26/8/2005	22
				30/8/2005	25
				03/9/2005	21
				06/9/2005	21

Crop harvested: 9/9/05

Crop assessed ex. store: 4/10/05

Bulb Onion – Bury St. Edmunds, Suffolk

Dates of application:	23/6/2005	Date of assessment:	22/6/2005
	08/7/2005		08/7/2005
	21/7/2005		21/7/2005
	03/8/2005		03/8/2005
	12/8/2005		12/8/2005
			25/8/2005

Crop harvested: 2/9/05

Crop assessed ex. store: 15/11/05

Salad Onion – Evesham, Worcestershire.

Application and assessment undertaken in two trials CH14 and CH13. Treatments were undertaken and assessed on the following days.

CH14	Temp. °C	CH13	Temp. °C
29/07/2005	19	23/08/2005	22
05/08/2005	20	31/08/2005	24
12/08/2005	20	06/09/2005	21
23/08/2005	22	13/09/2005	22

Trial Layout – see appendix 2a, 2b and 2c

Results and Discussion

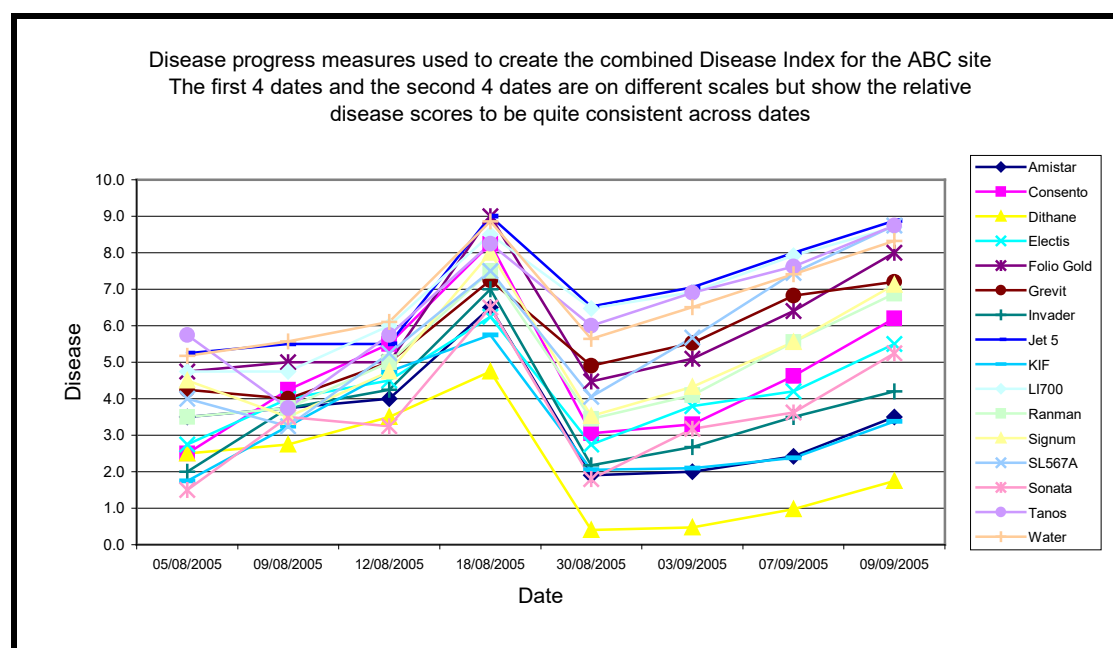
Statistical treatment of the results:

Analysis of variance was carried out on all field assessments and storage results. Comparisons were made between the two bulb onion sites and the salad onion results analysed separately.

Bulb Onion – Sleaford, Lincolnshire

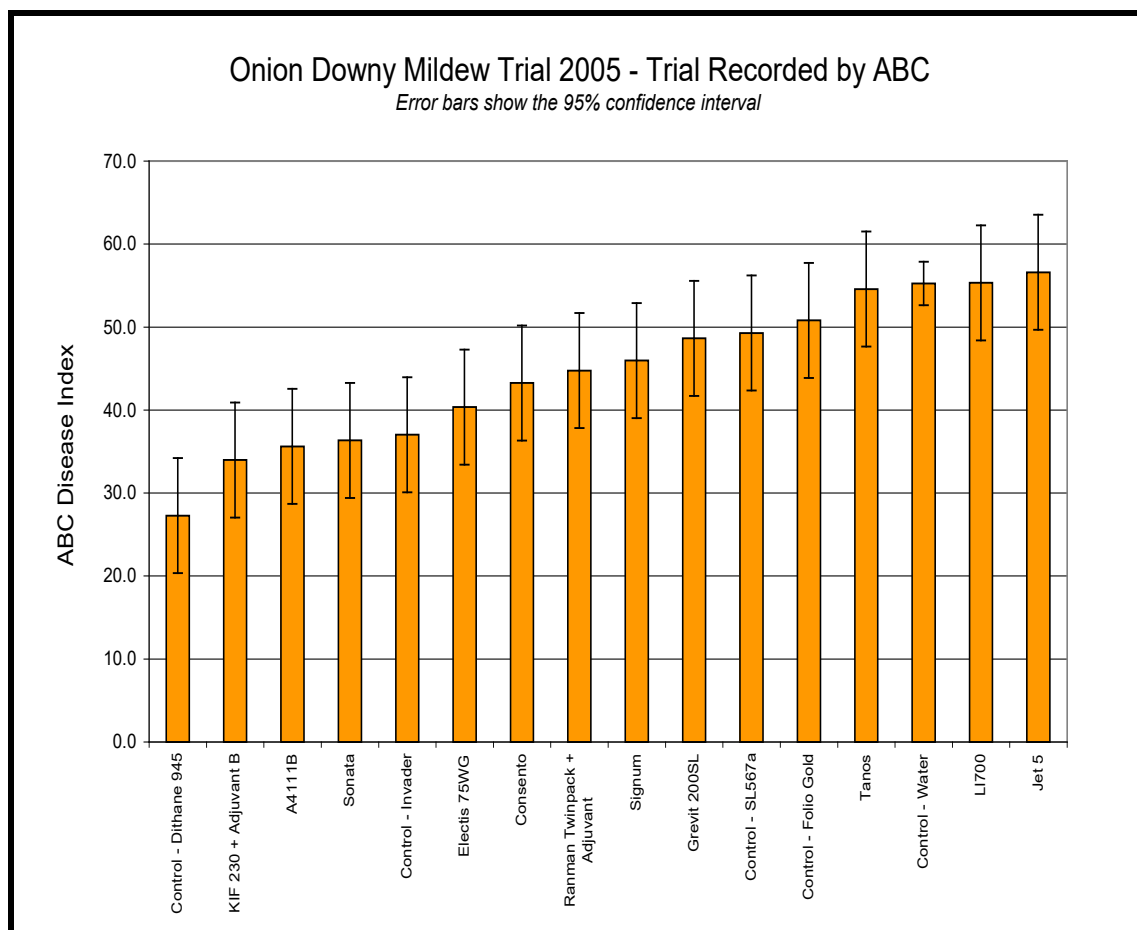
Plot treatments began on the 21 June 2005 with active mildew lesions first being seen a month later on the 21 July.

Figure 1. Progress of downy mildew infection at the Sleaford Site according to treatment - 2005



Note: the disease scale used in the graph above is arbitrary and designed to express differences between treatments.

Figure 2. Average downy mildew incidence according to treatment at Sleaford Site - 2005



Note: the disease index used in the graph above is arbitrary and designed to express differences between treatments.

Table of Means

Code	Treatment	Means
E	Control - Dithane 945	27.28
O	KIF 230 + Adjuvant B	33.98
G	A4111B	35.62
J	Sonata	36.34
C	Control - Invader	37.03
I	Electis 75WG	40.36
L	Consento	43.27
H	Ranman Twinpack + Adjuvant	44.76
F	Signum	45.96
M	Grevit 200SL	48.65
D	Control - SL567a	49.28
B	Control - Folio Gold	50.80
K	Tanos	54.58
A	Control - Water	55.26
P	LI700	55.33
N	Jet 5	56.61

LSD P = 95% 9.80

Analysis of Variance

Source	df	SS	MS	F	P
Treatments	15	6708.24	447.22	9.26	<0.001
Reps	3	1035.16	345.05		
Residual	69	3332.58	48.30		
Total	87	11075.97			

Figure 3. Average plot weight (kg) of bulbs according to treatment at Sleaford Site - 2005

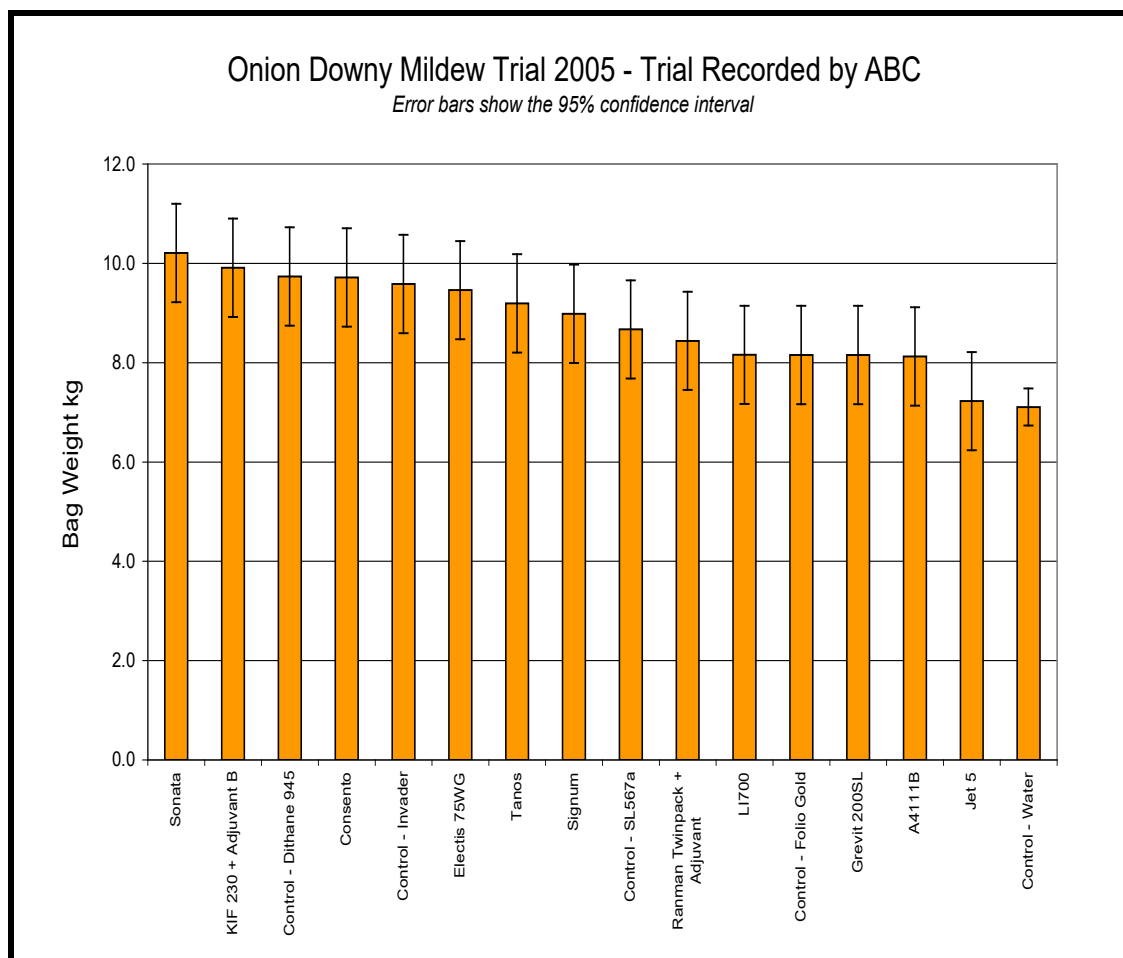


Table of Means

Code	Treatment	Means
J	Sonata	10.21
O	KIF 230 + Adjuvant B	9.91
E	Control - Dithane 945	9.74
L	Consento	9.72
C	Control - Invader	9.59
I	Electis 75WG	9.46
K	Tanos	9.20
F	Signum	8.99
D	Control - SL567a	8.67
H	Ranman Twinpack + Adjuvant	8.44
P	LI700	8.16
B	Control - Folio Gold	8.16
M	Grevit 200SL	8.16
G	A4111B	8.13
N	Jet 5	7.23
A	Control - Water	7.11
LSD P = 95%		1.40

Analysis of Variance

Source	df	SS	MS	F	P
Treatments	15	103.57	6.90	7.01	<0.001
Reps	3	4.54	1.51		
Residual	69	67.93	0.98		
Total	87	176.04			

Figure 4. Average plot weight (kg) of bulbs >60mm according to treatment at Sleaford Site - 2005

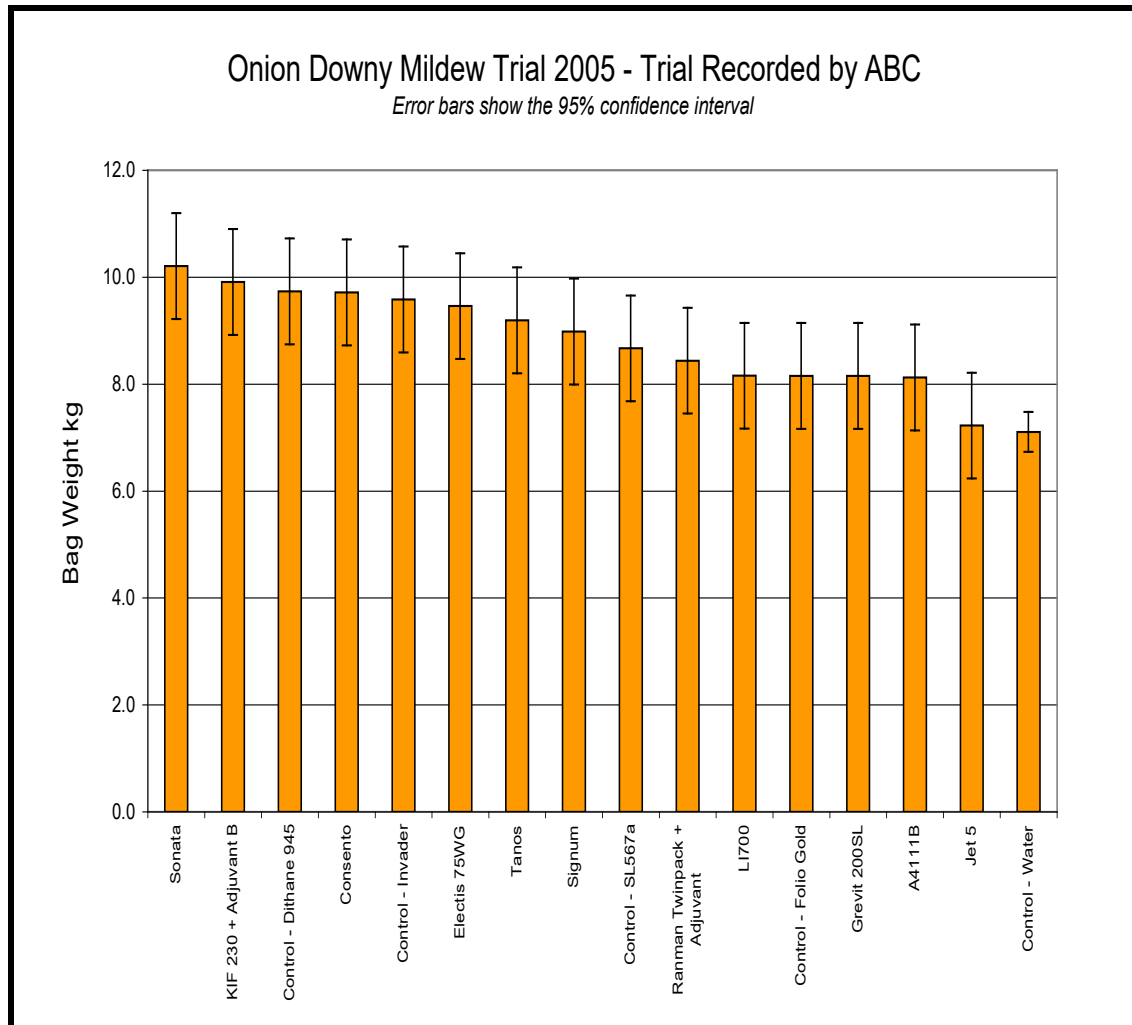


Table of Means

Code	Treatment	Means
E	Control - Dithane 945	5.9
O	KIF 230 + Adjuvant B	5.5
I	Electis 75WG	4.8
L	Consento	4.7
C	Control - Invader	4.4
K	Tanos	4.4
J	Sonata	4.3
F	Signum	4.2
H	Ranman Twinpack + Adjuvant	4.0
M	Grevit 200SL	3.5
D	Control - SL567a	3.5
B	Control - Folio Gold	3.1
G	A4111B	2.6
P	LI700	2.6
N	Jet 5	2.5
A	Control - Water	2.4

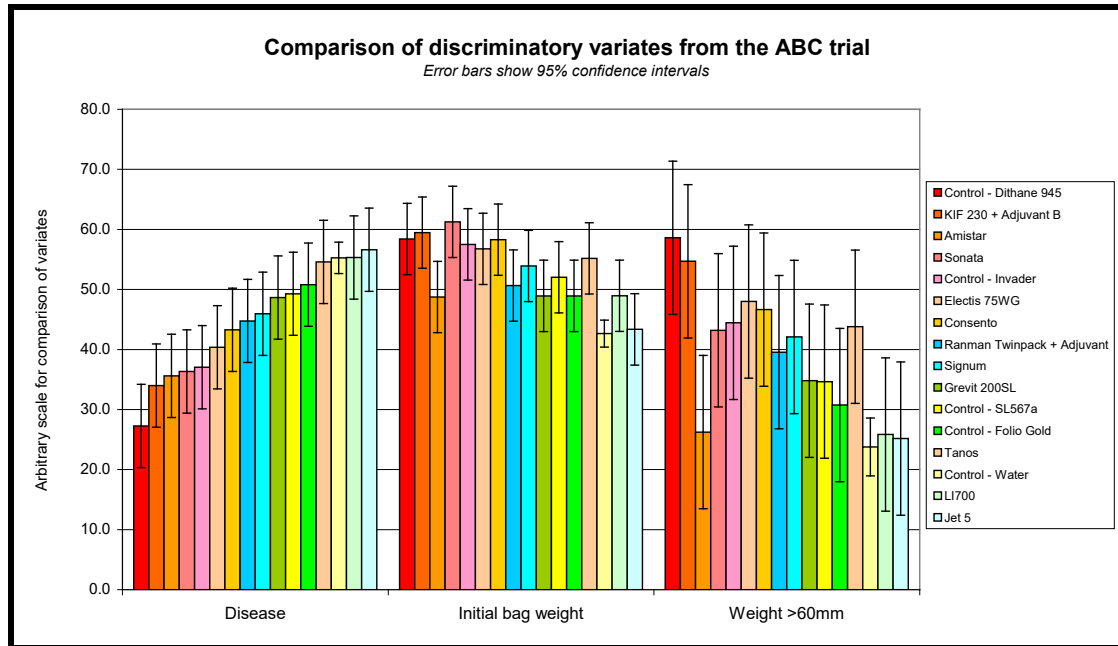
LSD P = 95%

1.81

Analysis of Variance

Source	df	SS	MS	F	P
Treatments	15	108.50	7.23	4.42	<0.001
Reps	3	13.23	4.41		
Residual	69	113.01	1.64		
Total	87	234.73			

Figure 5. Comparison of discriminatory variates for Sleaford Site - 2005



Summary of results – Sleaford Site

1. Dithane 945, KIF230, A4111B, Sonata and Invader gave significantly better control of downy mildew than the Folio Gold, Tanos, Water, LI700 and Jet 5 treatments.
2. Dithane 945 and KIF230 gave significantly higher plot yields of bulbs >60mm than A4111B, LI700, Jet 5 or Water treatments.

Bulb Onion – Bury St. Edmunds, Suffolk

Plot treatments began on the 23 June 2005 with active mildew lesions first being seen a month later on the 21 July.

Figure 6. Average downy mildew incidence according to treatment at Bury St. Edmunds site - 2005

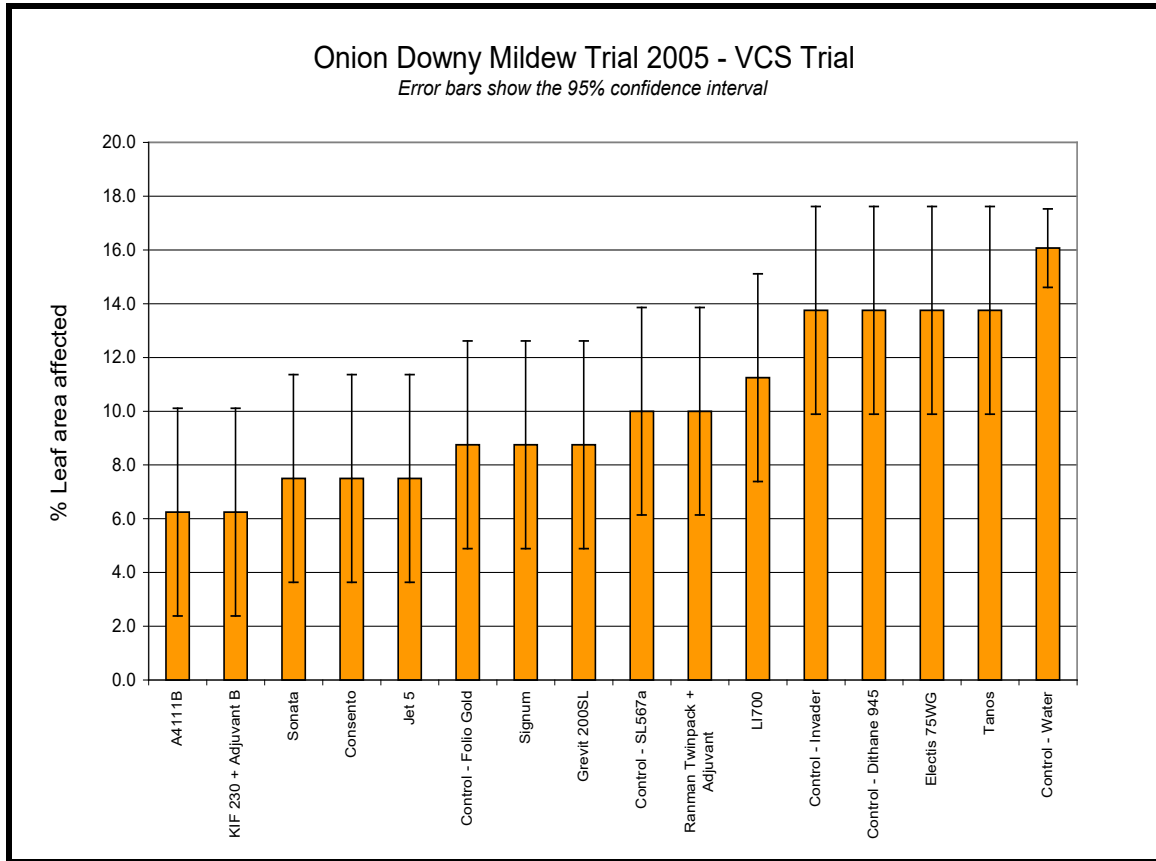


Table of Means

Code	Treatment	Means
G	A4111B	6.25
O	KIF 230 + Adjuvant B	6.25
J	Sonata	7.50
L	Consento	7.50
N	Jet 5	7.50
B	Control - Folio Gold	8.75
F	Signum	8.75
M	Grevit 200SL	8.75
D	Control - SL567a	10.00
H	Ranman Twinpack + Adjuvant	10.00
P	LI700	11.25
C	Control - Invader	13.75
E	Control - Dithane 945	13.75
I	Electis 75WG	13.75
K	Tanos	13.75
A	Control - Water	16.07

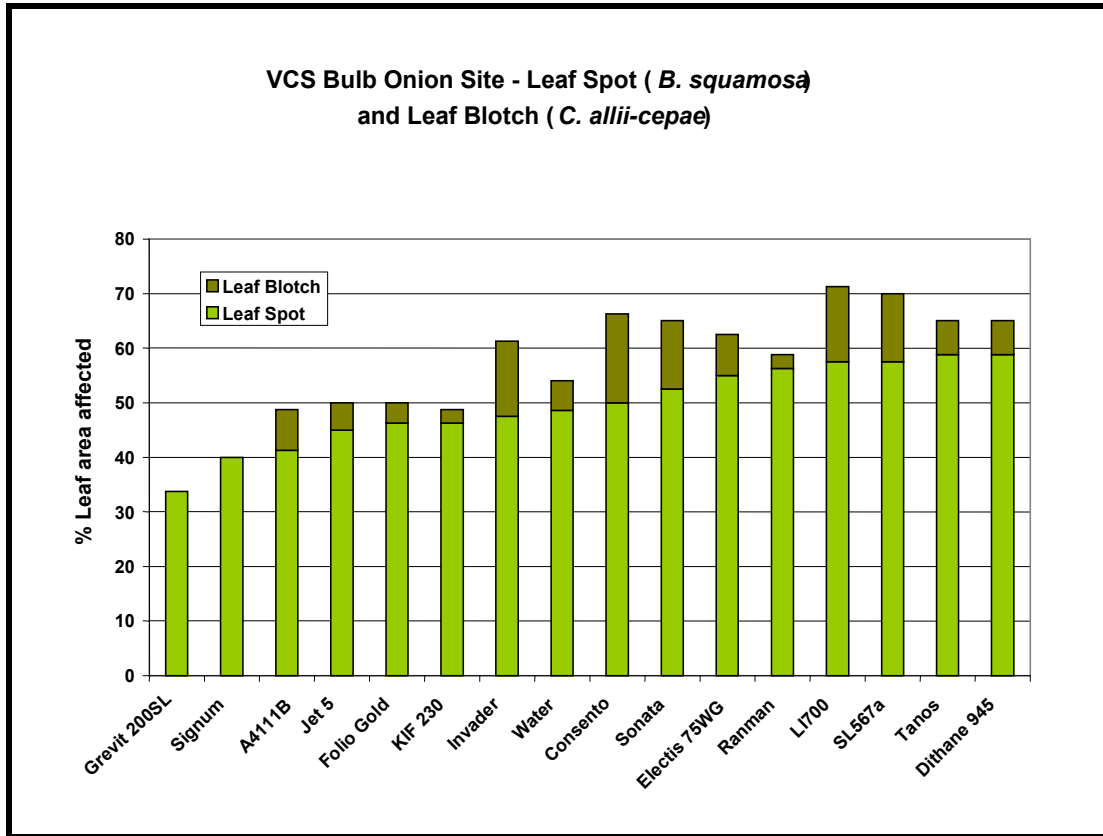
Analysis of Variance

Source	df	SS	MS	F	P
Treatments	15	1178.7	78.58	5.24	<0.001
Reps	3	45.5	15.15		
Residual	69	1034.9	15.00		
Total	87	2259.1			

LSD P = 95%

5.46

Figure 7. Average incidence of Leaf Spot and Leaf Blotch according to treatment, Bury St. Edmunds - 2005



Note: No statistical differences were noted between treatments.

Figure 8. Average total unmarketable bulbs according to treatment – Bury St. Edmunds - 2005

Total unmarketable or 'discards' calculated by summing all internal defect scores together and outgrades from the skin quality assessment.

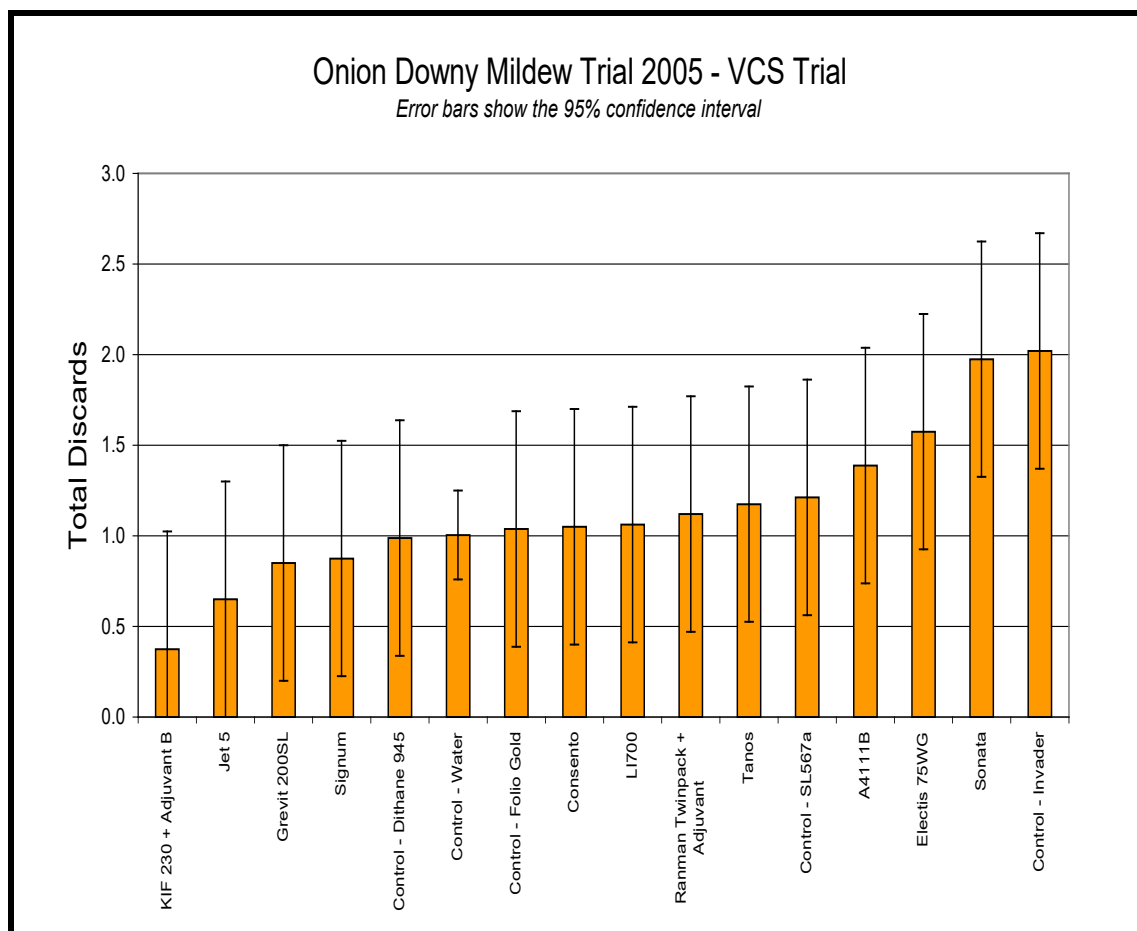


Table of Means

Code	Treatment	Means
O	KIF 230 + Adjuvant B	0.38
N	Jet 5	0.65
M	Grevit 200SL	0.85
F	Signum	0.88
E	Control - Dithane 945	0.99
A	Control - Water	1.00
B	Control - Folio Gold	1.04
L	Consento	1.05
P	LI700	1.06
H	Ranman Twinpack + Adjuvant	1.12
K	Tanos	1.18
D	Control - SL567a	1.21
G	A4111B	1.39
I	Electis 75WG	1.58
J	Sonata	1.98
C	Control - Invader	2.02

Analysis of Variance

Source	df	SS	MS	F	P
Treatments	15	11.5	0.76	1.80	0.0524
Reps	3	0.4	0.12		
Residual	69	29.3	0.42		
Total	87	41.1			

LSD P = 95% 0.92

Summary of results – Bury St. Edmunds, Site.

1. A4111B, KIF230, Sonata, Consento, Jet 5, Folio Gold, Signum, Grevit 200SL, SL567a and Ranman gave significantly better control of downy mildew than the Water control.
2. Although no significant differences were obtained with regard to leaf spot and leaf blotch infection it is interesting to note that levels of these diseases were generally higher in plots that had been treated with a mancozeb based product.

Salad Onions – Evesham, Worcestershire.

Trials were undertaken at two neighboring sites CH14 and CH13. Treatments commenced in CH14 (Trial 1) on the 29th July 2005 with downy mildew first noted on the 13 September. Treatments commenced in CH13 (Trial 2) on the 23 August 2005 with downy mildew first noted on the 7th October.

Figure 9. Average downy mildew incidence according to treatment, Evesham - 2005

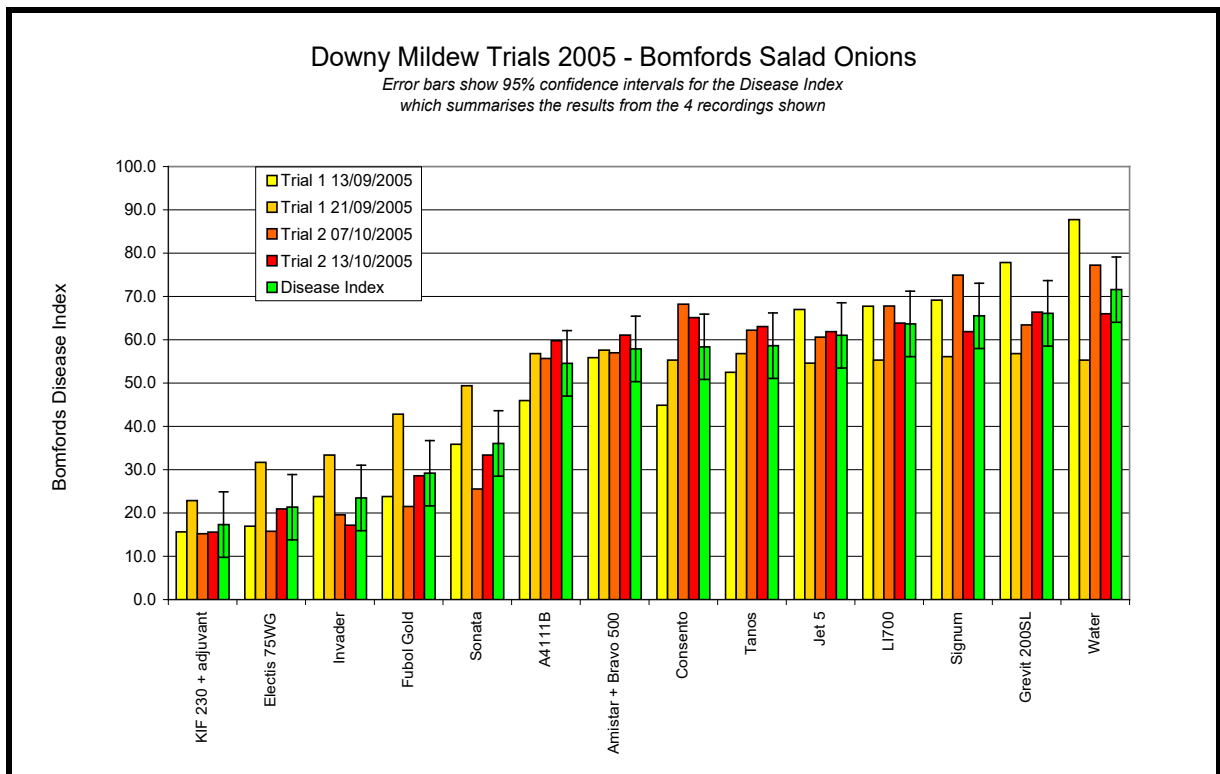


Table of Means

<u>Treatment</u>	<u>Means</u>
KIF 230 + adjuvant	17.3
Electis 75WG	21.3
Invader	23.5
Fubol Gold	29.2
Sonata	36.1
A4111B	54.6
Amistar + Bravo 500	57.9
Consento	58.4
Tanos	58.6
Jet 5	61.0
LI700	63.7
Signum	65.5
Grevit 200SL	66.1
Water	71.6

LSD P = 95% 10.67314

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>	<u>P</u>
Treatments	13	18821.2	1447.8	26.0	<0.001
Reps	3	1509.1	503.0		
Residual	39	2171.8	55.7		
Total	55	22502.1			

Summary of results – Evesham Site.

1. Data for both trials CH14 and CH13 shows that KIF230, Electis 75WG, Invader, Fubol Gold and Sonata gave significantly better control of downy mildew infection than the remaining 9 treatments.

Conclusions

High levels of downy mildew infection at the Sleaford and Evesham sites gave some useful significant differences between treatments. Whilst lower levels of mildew infection at the Bury St. Edmunds site gave little statistical differences between treatments, useful trend data was collected for leaf spot and leaf blotch.

The most effective treatments in both bulb and salad onions against downy mildew, with the exception of A4111B, all contained the active ingredient mancozeb.

Bulb Onion - The most promising 5 products for control of downy mildew infection on bulb onion were; Dithane 945, KIF230, A4111B, Sonata and Invader. Yields from plots treated with Dithane 945 and KIF230 gave significantly higher yields of bulbs >60mm in diameter than A4111B, LI700, Jet 5 or Water treatments. This yield increase is most likely due to retention of green leaf area, allowing more photosynthates to be translocated to the bulb prior to harvest thus increasing bulb size.

Salad Onion – The most promising 5 products for control of downy mildew infection were; KIF230, Electis 75WG, Invader, Fubol Gold and Sonata. These products gave significantly better control at the two sites than all other treatments.

With regard to leaf spot and leaf blotch, results from the Bury St. Edmunds site indicate that products containing strobilurins, chlorothalonil, grapefruit extract or the disinfectant Jet 5 may provide useful control of these diseases. Observations and assessments made at this site indicate that active downy mildew infections in onion crops appear to predispose plants to leaf spot and leaf blotch infection.

Of particular note was the relatively poor performance of the commercial standard Folio Gold, which contains the eradicant fungicide methanoxam, against downy mildew. Results from the Sleaford site indicate that Folio Gold is not significantly different to the Water control.

More encouragingly Invader, the commercial standard approved for use in bulb onion and Fubol Gold the commercial standard approved for use in salad onion both showed good efficacy against downy mildew.

The dewaxing penetrant adjuvant LI700 showed no significantly better or worse disease control than the water control at all three sites.

Further Work

Treatments undertaken in these trials were based on programmes of multiple applications of individual products without regard for maximum permissible total dose, minimum intervals between applications, harvest interval or resistance management. However it is only in this manner that effective control of foliar disease by an individual treatment can be judged.

This project has identified two new fungicide products Sonata and KIF230 as showing good efficacy against downy mildew. Future work should concentrate on determining if these products can be made to work successfully when incorporated into a commercial fungicide programme before SOLA approval is sought.

Further assessment of the grapefruit extract Grevit 200SL as part of a commercial programme should also be made as results indicate that it may provide useful control of leaf spot and leaf blotch.

Technology transfer

Presentation made at the bi-annual Onion and Carrot Conference 23rd-24th November 2005.

References

Kennedy, R., (2000). *Bulb Onions : evaluation of fungicides for control of downy mildew (Peronospora destructor)*. Horticultural Development Council. Final Report FV189.

McKay, R., (1959). *Onion diseases*. The Agricultural Institute, Dublin.

Viranyi, F., (1981). Downy mildew of onions, in the *Downy Mildews*, Spencer, D. M., Ed, Academic Press, London.

Viranyi, F., (1975). *Studies on the biology and ecology of onion downy mildew (Peronospora destructor) in Hungary II. Factors influencing sporulation and conidium germination*. Acta Phytopathology Acad. Sci. Hung., 10, 321.

Appendix 1a – Summary Table of Fungicide Products applied in Bulb Onion trials

Fungicide Product	Active Ingredient	Application Rate	Approval Status (2005)
Folio Gold	chlorothalonil + metalaxyl - m	2l/ha	Full Approval
Invader	mancozeb + dimetamorph	2kg/ha	SOLA 2334/04
SL567a	metalaxyl-m	2l/ha	No approval
Signum	boscalid + pyraclostrobin	1kg/ha	No approval
A4111B	azoxystrobin + chlorothalonil	2l/ha	No approval
Ranman Twinpack	cyazofamid	0.2l/ha	No approval
Electis 75WG	mancozeb + zoxamide	1.8kg/ha	No approval
Sonata	fenamidone + mancozeb	1.5kg/ha	No approval
Tanos	famoxadone + cymoxanil	0.7kg/ha	No approval
Consento	fenamidone + propamocarb hydrochloride	2kg/ha	No approval
Grevit 200SL	grapefruit extract	1.5l/ha	Foliar Feed
Jet 5	peroxyacetic acid	2l/ha	No Approval
Silwett L-77	silicone wetter	0.2l/ha	Adjuvant
LI700	penetrant,acidifier	0.2l/ha	Adjuvant
KIF230	a.i. undisclosed	1.6kg/ha	Experimental

Appendix 1b – Summary Table of Fungicide Products applied in Salad Onion trial

Fungicide Product	Active Ingredient	Application Rate	Approval Status (2005)
Fubol Gold	mancozeb + metalaxyl - m	1.5kg/ha	SOLA 2324/03
Invader	mancozeb + dimetamorph	2kg/ha	No Approval
Bravo 500	chlorothalonil	2l/ha	No Approval
Signum	boscalid + pyraclostrobin	1kg/ha	No Approval
A4111B	azoxystrobin + chlorothalonil	2l/ha	No Approval
Electis 75WG	mancozeb + zoxamide	1.8kg/ha	No Approval
Sonata	fenamidone + mancozeb	1.5kg/ha	No Approval
Tanos	famoxadone + cymoxanil	0.7kg/ha	No Approval
Consento	fenamidone + propamocarb hydrochloride	2kg/ha	No Approval
Grevit 200SL	grapefruit extract	1.5l/ha	No Approval
Jet 5	peroxyacetic acid	2l/ha	No Approval
Silwett L-77	silicone wetter	0.2l/ha	Adjuvant
LI700	penetrant, acidifier	0.2l/ha	Adjuvant
KIF230	a.i. undisclosed	1.6kg/ha	Experimental

Appendix 2a – Trial Layout, Sleaford, Lincolnshire

Rep 4	DISCARD	D ₇₈	P ₇₉	A ₈₀	C ₈₁	L ₈₂	A ₈₃	G ₈₄	N ₈₅	A ₈₆	H ₈₇	F ₈₈	DISCARD
		J ₆₇	M ₆₈	A ₆₉	B ₇₀	K ₇₁	A ₇₂	I ₇₃	E ₇₄	A ₇₅	O ₇₆	A ₇₇	

Rep 3	DISCARD	D ₅₆	L ₅₇	A ₅₈	O ₅₉	C ₆₀	A ₆₁	B ₆₂	E ₆₃	A ₆₄	P ₆₅	A ₆₆	DISCARD
		F ₄₅	H ₄₆	A ₄₇	I ₄₈	K ₄₉	A ₅₀	J ₅₁	N ₅₂	A ₅₃	G ₅₄	M ₅₅	

Rep 2	DISCARD	A ₃₄	D ₃₅	A ₃₆	G ₃₇	F ₃₈	A ₃₉	M ₄₀	H ₄₁	A ₄₂	O ₄₃	N ₄₄	DISCARD
		E ₂₃	C ₂₄	A ₂₅	J ₂₆	K ₂₇	A ₂₈	B ₂₉	I ₃₀	A ₃₁	P ₃₂	L ₃₃	

Rep 1	DISCARD	L ₁₂	M ₁₃	A ₁₄	G ₁₅	J ₁₆	A ₁₇	P ₁₈	I ₁₉	A ₂₀	N ₂₁	A ₂₂	DISCARD
		E ₁	O ₂	A ₃	C ₄	H ₅	A ₆	F ₇	B ₈	A ₉	K ₁₀	D ₁₁	

Bed 2 4 6 8 10 12 14 16 18 20 22 24 26

Treatment List

- A Control - Water
- B Control - Folio Gold
- C Control - Invader
- D Control - SL567a
- E Control - Dithane 945
- F Signum
- G Amistar
- H Ranman Twinpack + Adjuvant
- I Electis 75WG
- J Sonata
- K Tanos
- L Consento
- M Grevit 200SL
- N Jet 5
- O KIF 230 + Adjuvant B
- P LI700

Appendix 2b – Trial Layout, bury St. Edmunds, Suffolk

Rep 4	CAR D	L	H	A	J	A	A	M	I	A	P	D	CAR D

	N	E	A	O	F	A	B	G	A	K	C	
--	---	---	---	---	---	---	---	---	---	---	---	--

Rep 3	DISCARD	L	A	A	K	J	A	O	G	A	H	C	DISCARD
		D	P	A	B	F	A	N	I	A	M	E	

Rep 2	DISCARD	C	L	A	M	D	A	E	P	A	K	I	DISCARD
		G	J	A	N	F	A	O	B	A	H	A	

Rep 1	DISCARD	A	E	A	M	N	A	H	B	A	I	C	DISCARD
		G	K	A	J	P	A	D	O	A	F	L	

Bed 2 4 6 8 10 12 14 16 18 20 22 24 26

Treatment List

- A Control - Water
- B Control - Folio Gold
- C Control - Invader
- D Control - SL567a
- E Control - Dithane 945
- F Signum
- G Amistar
- H Ranman Twinpack + Adjuvant
- I Electis 75WG
- J Sonata
- K Tanos
- L Consento
- M Grevit 200SL
- N Jet 5
- O KIF 230 + Adjuvant B
- P LI700

Appendix 2c – Trial Layout, Evesham, Worcestershire

Rep 4	DISCARD	H	D	A	B	F	A	K	O	A	A	J	DISCARD
		I	M	A	C	E	A	N	L	A	P	G	

Rep 3	DISCARD	H	F	A	P	B	A	C	L	A	D	G	DISCARD
		J	A	A	N	E	A	I	O	A	K	M	

Rep 2	DISCARD	G	H	A	K	J	A	M	A	A	P	O	DISCARD
		L	B	A	I	E	A	C	N	A	D	F	

Rep 1	DISCARD	F	M	A	K	I	A	D	N	A	O	G	DISCARD
		L	P	A	B	A	A	J	C	A	E	H	

Bed 2 4 6 8 10 12 14 16 18 20 22 24 26

Treatment List

- A Control - Water
- B Control - Folio Gold
- C Control - Invader
- D Control - Bravo 500 + Amistar
- E Dithane 945
- F Signum
- G Amistar
- H Electis 75WG
- I Sonata
- J Tanos
- K Consento
- L Grevit 200SL
- M Jet 4
- N KIF 230 + Adjuvant B
- O LI699
- P Fubol Gold