

Project Title	New Products for the Control of Downy Mildew (<i>Peronospora destructor</i>) in Bulb and Salad Onions
Project number:	FV189c
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Report:	Final report, February 2007
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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
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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.

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Grower Summary

Headline

- One new fungicide product (Sonata) and two coded materials (KIF 230 and UK958) demonstrated good control of downy mildew.
- Mancozeb based products consistently afford best control of onion downy mildew.
- Downy mildew resistant late variety BGS (Bejo Zaden) showed good promise, however its late maturity means that it is unlikely to be widely grown in the UK.
- Products or programmes containing a strobilurin fungicide or chlorothalonil provided the best control of leaf spot (*Botrytis squamosa*) and leaf blotch (*Cladosporium allii-cepae*).

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. There were four main objectives :

1. To evaluate four new products for efficacy against Downy Mildew.
2. To evaluate three new products identified in FV189b in commercially comparative spray programmes for efficacy against Downy Mildew.
3. To assess a silicone wetter and a wax based adjuvant and determine their affect on Downy Mildew susceptibility.
4. To evaluate the effectiveness of two new resistant bulb onion varieties against Downy Mildew.

Bulb onion treatments

Single treatments

- (i) Control – water
- (ii) Control – 2.6kg/ha Dithane NT
- (iii) Coded UK958
- (iv) Coded EXP11120
- (v) Coded A1379D
- (vi) Coded A4111B

Spray programmes – all treatments at standard label dose rate and not to exceed maximum total dose.

- (vii) Standard grower programme (Control) – 2L/ha Folio Gold + 1L/ha Amistar alternating with 2kg/ha Invader + 2L/ha Bravo 500.
- (viii) Standard programme as (vii) but including 0.1L/ha Silwett L-77.
- (ix) 2L/ha Folio Gold + 1.5L/ha Grevit 200SL alternating with 2kg/ha Invader + 1.5L/ha Grevit 200SL.
- (x) KIF230 @1.6kg/ha + 1L/ha Amistar alternating with 2kg/ha Invader + 2L/ha Bravo 500.
- (xi) 1.5kg/ha Sonata + 1L/ha Amistar alternating with 2kg/ha Invader + 2L/ha Bravo 500.
- (xii) 2.6kg/ha Dithane NT + 2L/ha Bravo 500.
- (xiii) 2.6kg/ha Dithane NT + 2L/ha Bravo 500 until active lesions noted then 2L/ha Folio Gold + 2kg/ha Invader.

Other Treatments

- (xiv) 0.2L/ha Silwett L-77
- (xv) 6L/ha Agrowax PHC
- (xvi) Physically dewaxed control plot
- (xvii) Resistant variety Santaro untreated
- (xviii) Resistant variety Santaro treated with 1L/ha Amistar alternating with 2L/ha Bravo 500.
- (xix) Resistant variety BGS untreated.
- (xx) Resistant variety BGS treated with 1L/ha Amistar alternating with 2L/ha Bravo 500.

Salad onion treatments

Single Treatments

- (i) Control – water
- (ii) Control – 2.6kg/ha Dithane NT
- (iii) Coded UK958
- (iv) Coded EXP11120
- (v) Coded A1379D
- (vi) Coded A4111B

Spray programmes – all treatments at standard label dose rate and not to exceed maximum total dose.

- (vii) Standard grower programme (Control) – 1.5kg/ha Fubol Gold + 1L/ha Amistar + 2L/ha Chlorothalonil.
- (viii) Standard programme as (vii) but including 1.5L/ha Grevit 200SL.
- (ix) Standard programme as (vii) but including 0.1L/ha Silwett L-77
- (x) 1.6kg/ha KIF230 + 1L/ha Amistar alternating with 1.5kg/ha Fubol Gold + 2L/ha Chlorothalonil.
- (xi) 1.5kg/ha Sonata + 1L/ha Amistar alternating with 1.5kg/ha Fubol Gold + 2L/ha Chlorothalonil.
- (xii) 2.6kg/ha Dithane NT + 2L/ha Chlorothalonil alternating with 1.5kg/ha Fubol Gold + 1L/ha Amistar + 2L/ha Chlorothalonil

Other Treatments

- (xiii) 0.2L/ha Silwett L-77
- (xiv) 6L/ha Agrowax PHC
- (xv) Physically dewaxed control plot

All applications to be made in the equivalent water rate of 200L/ha using 110° flat fan nozzles at 2 bar pressure producing a fine/medium spray quality.

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.

Field evaluations involved regular assessment 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.

Whilst levels of downy mildew infection were considerably lower than in previous trials (FV189b) and as a result there were therefore fewer statistical differences between treatments, the main findings of the project concur with 2005 findings. In general mancozeb or mancozeb based products or programmes afforded the best control of onion downy mildew.

The most effective products in 2005 trials 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.

In 2006 as in 2005 at the Sleaford and Evesham sites mancozeb based products gave the poorest control of leaf spot. Products or programmes containing a strobilurin fungicide or chlorothalonil providing the best control.

Financial benefits

In field trials in both 2005 and 2006 it was demonstrated that new products Sonata and KIF 230 were effective in controlling downy mildew in both bulb and salad onions.

In addition in 2006 a new coded product UK958 showed promise at all three trial sites for control of both downy mildew and leaf spot.

If these products could be used on onion crops, growers would have three 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.

The downy mildew resistant variety BGS from Bejo Zaden shows promise for future control of the disease, although being exceptionally late to mature may make it not particularly suitable for use in all areas of the UK. It should be recognized that fungicides will need to still be applied to these varieties for control of leaf spot and leaf blotch.

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 consistently afford best control of onion downy mildew.
- Strobilurin/chlorothalonil based products consistently afford best control of leaf spot and leaf blotch.
- Consideration should be given to the use downy mildew resistant varieties as and when they become commercially available.

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 resistant varieties 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 15 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.

The salad onion variety Green Banner was used in the trial with treatments commencing 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 4-7 times on the bulb onion trials dependent upon disease pressure.

Bulb onion treatments

Single treatments

- (i) Control – water
- (ii) Control – 2.6kg/ha Dithane NT
- (iii) Coded UK958
- (iv) Coded EXP11120
- (v) Coded A1379D
- (vi) Coded A4111B

Spray programmes – all treatments at standard label dose rate and not to exceed maximum total dose.

- (vii) Standard grower programme (Control) – 2L/ha Folio Gold + 1L/ha Amistar alternating with 2kg/ha Invader + 2L/ha Bravo 500.
- (viii) Standard programme as (vii) but including 0.1L/ha Silwett L-77.

- (ix) 2L/ha Folio Gold + 1.5L/ha Grevit 200SL alternating with 2kg/ha Invader + 1.5L/ha Grevit 200SL.
- (x) KIF230 @1.6kg/ha + 1L/ha Amistar alternating with 2kg/ha Invader + 2L/ha Bravo 500.
- (xi) 1.5kg/ha Sonata + 1L/ha Amistar alternating with 2kg/ha Invader + 2L/ha Bravo 500.
- (xii) 2.6kg/ha Dithane NT + 2L/ha Bravo 500.
- (xiii) 2.6kg/ha Dithane NT + 2L/ha Bravo 500 until active lesions noted then 2L/ha Folio Gold + 2kg/ha Invader.

Other Treatments

- (xiv) 0.1L/ha Silwett L-77
- (xv) 6L/ha Agrowax PHC
- (xvi) Physically dewaxed control plot
- (xvii) Resistant variety Santoro untreated
- (xviii) Resistant variety Santoro treated with 1L/ha Amistar alternating with 2L/ha Bravo 500.
- (xix) Resistant variety BGS untreated.
- (xx) Resistant variety BGS treated with 1L/ha Amistar alternating with 2L/ha Bravo 500.

Salad onion treatments

Single Treatments

- (i) Control – water
- (ii) Control – 2.6kg/ha Dithane NT
- (iii) Coded UK958
- (iv) Coded EXP11120
- (v) Coded A1379D
- (vi) Coded A4111B

Spray programmes – all treatments at standard label dose rate and not to exceed maximum total dose.

- (vii) Standard grower programme (Control) – 1.5kg/ha Fubol Gold + 1L/ha Amistar + 2L/ha Chlorothalonil.
- (viii) Standard programme as (vii) but including 1.5L/ha Grevit 200SL.
- (ix) Standard programme as (vii) but including 0.1L/ha Silwett L-77

- (x) 1.6kg/ha KIF230 + 1L/ha Amistar alternating with 1.5kg/ha Fubol Gold + 2L/ha Chlorothalonil.
- (xi) 1.5kg/ha Sonata + 1L/ha Amistar alternating with 1.5kg/ha Fubol Gold + 2L/ha Chlorothalonil.
- (xii) 2.6kg/ha Dithane NT + 2L/ha Chlorothalonil alternating with 1.5kg/ha Fubol Gold + 1L/ha Amistar + 2L/ha Chlorothalonil

Other Treatments

- (xiii) 0.2L/ha Silwett L-77
- (xiv) 6L/ha Agrowax PHC
- (xv) Physically dewaxed control plot
- (xvi) Resistant variety Santoro untreated
- (xvii) Resistant variety Santoro treated with 1L/ha Amistar alternating with 2L/ha Bravo 500.

Regular visual 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:



98% green leaf



40% green leaf



15% green leaf

Application and Assessment Dates:

ABC Site (Bulb Onion) – Sleaford, Lincolnshire

Application Date	Assessment Date
19/06/2006	23/08/2006
30/06/2006	28/08/2006
10/07/2006	03/09/2006
21/07/2006	11/09/2006
31/07/2006	
11/08/2006	
21/08/2006	

VCS Site (Bulb Onion) – Bury St. Edmunds, Suffolk

Application Date	Assessment Date
23/06/2006	24/07/2006
07/07/2006	03/08/2006
21/07/2006	11/08/2006
03/08/2006	

Bomfords (Salad Onion) – Evesham, Worcestershire.

Application Date	Assessment Date
13/9/2006	23/10/2006
23/09/2006	
3/10/2006	
13/10/2006	

Trial Layouts – see appendices 2a, 2b, 2c and 2d

Results and Discussion

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

Summary of results (Bulb Onions) Sleaford & Bury St. Edmunds Sites

Levels of downy mildew at the two bulb onion sites were relatively low, a result of the exceptionally hot, dry July of 2006. Few significant differences with regard to downy mildew were therefore found between fungicide treatments at the two sites. At the Bury St. Edmunds site the following treatments all had significantly lower levels of downy mildew than the water or dewaxed controls :

Dithane NT

UK958

EXP11120

A4111B

KIF230 + Amistar alternating with Invader + Bravo 500

Sonata + Amistar alternating with Invader + Bravo 500

Relatively high levels of leaf spot were noted at the Sleaford site and a number of products had significantly ($p=0.05$) lower levels of disease than either the water or dewaxed controls :

UK958

A4111B

Folio Gold + Amistar alternating with Invader + Bravo 500

Folio Gold + Amistar + Silwett L-77 alternating with Invader + Bravo 500 + Silwett L-77

KIF230 + Amistar alternating with Invader + Bravo 500

Dithane NT + Bravo 500

Dithane NT + Bravo 500 until active lesions then Folio Gold + Invader.

Summary of results (Salad Onions) Evesham Site

Although downy mildew infection was more significant at the later established salad onion site encouraged by the exceptionally mild, wet autumn conditions of 2006. Levels were not high enough to produce any significant differences ($p=0.05$) between fungicide products or programmes

The following products or programmes all gave significantly ($p=0.05$) better control of downy mildew than either the water or dewaxed controls and the Agrowax treatment.

Dithane NT

UK958

A13978D

Fubol Gold + Amistar + Bravo 500

Fubol Gold + Amistar + Bravo 500 + Grevit 200SL

KIF230 + Amistar alternating with Fubol Gold + Bravo 500

Dithane NT

High levels of leaf spot at the Evesham site also gave significant ($p=0.05$) differences between treatments. The following treatments having significantly ($p=0.05$) lower levels of downy mildew than either the water or dewaxed controls or Agrowax treatment.

UK 958

A13978D

Fubol Gold + Amistar + Bravo 500

Fubol Gold + Amistar + Bravo 500 + Grevit 200SL

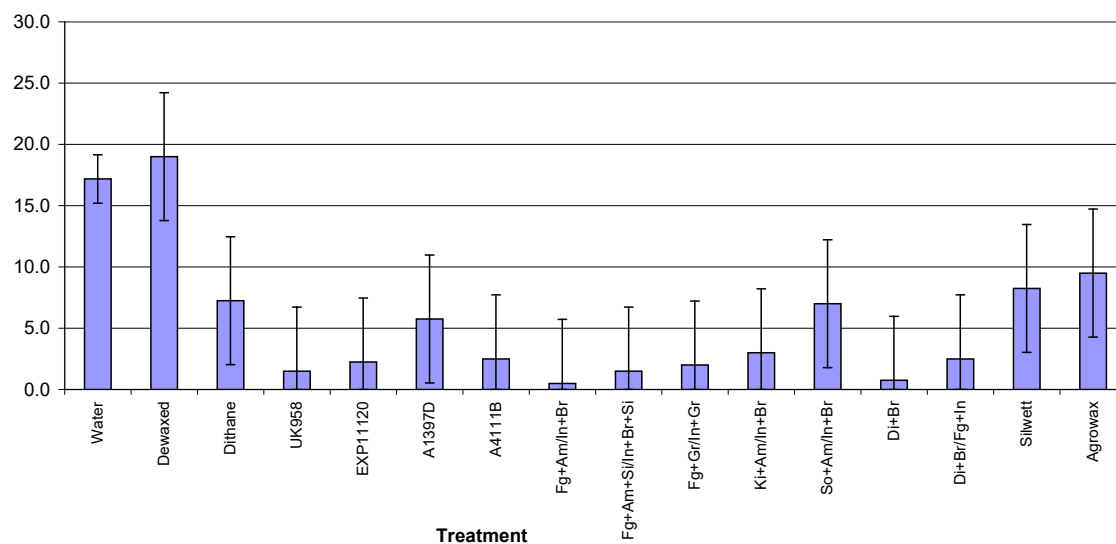
Fubol Gold + Amistar + Silwett L-77

KIF230 + Amistar alternating with Fubol Gold + Bravo 500

Dithane NT + Bravo 500 x 2 then Fubol Gold + Amistar + Bravo 500

**Allium & Brassica Centre (Bulb Onion) Mean Number of Downy Mildew Lesions
- Sleaford site (28/08/2006)**

Fungicide Trial 2006 - ABC Sleaford Trial
Mean number of mildew lesions on August 28 2006
Error bars show 95% confidence intervals



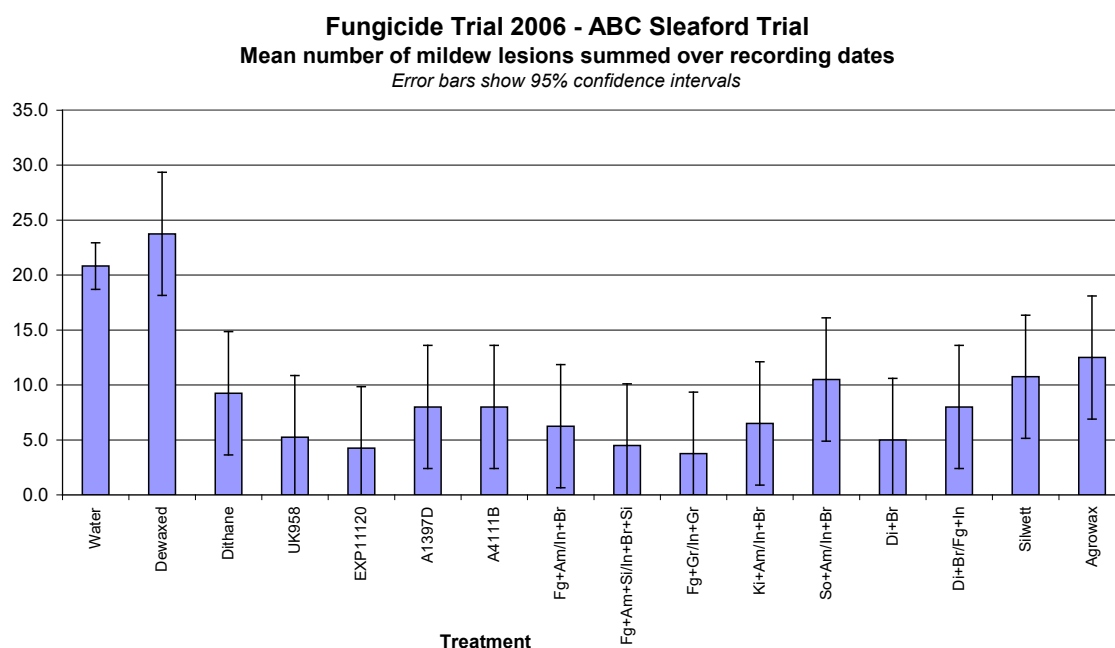
Analysis of variance

Source	df	SS	MS	F	P	Significance
Treatment	15	4214.461	280.9641	10.27129	2.65E-12	***
Rep	3	858.4091	286.1364	10.46037	9.33E-06	***
Treatment.Rep	45	1022.019	22.71154	0.629835	0.910706	ns
Residual	24	865.4286	36.05952			
Total	87	6960.318				

SE for treatment A 0.988403
 SE for treatments B-P 2.615068

All fungicide treatments including Silwett L-77 had significantly ($p=0.05$) lower levels of downy mildew than either the dewaxed or water control. No significant differences ($p=0.05$) were found between fungicide treatments (including Silwett and Agrowax).

Allium & Brassica Centre (Bulb Onion) Mean Number of Downy Mildew Lesions Summed Over Recording Dates – Sleaford site (28/08/2006)



Analysis of variance

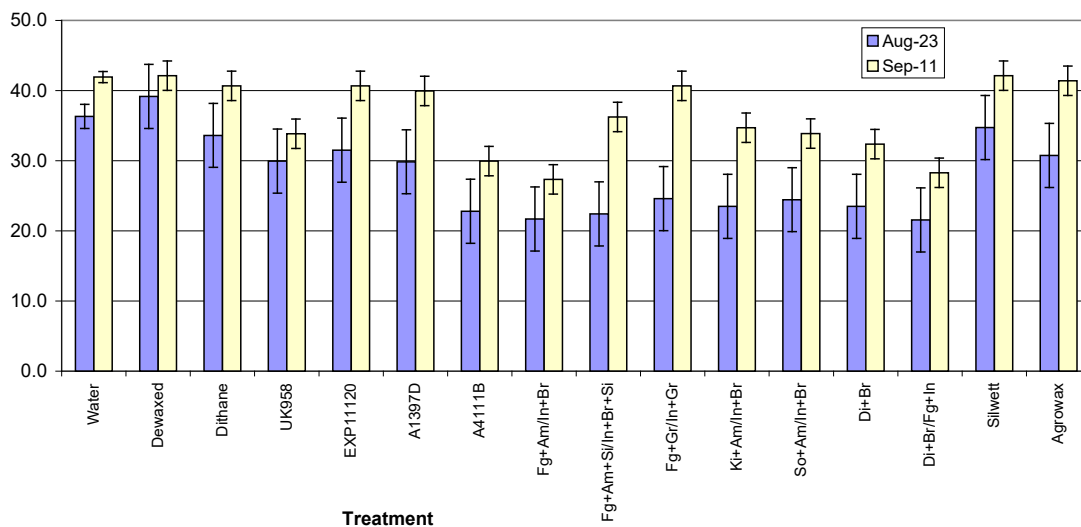
Source	df	SS	MS	F	P	Significance
Treatment	15	4327.006	288.4671	9.136123	3.24E-11	***
Rep	3	880.7273	293.5758	9.29792	3.04E-05	***
Treatment.Rep	45	1263.773	28.08384	0.73674	0.814986	ns
Residual	24	914.8571	38.11905			
Total	87	7386.364				

SE for treatment A 1.061911
 SE for treatments B-P 2.809553

All fungicide treatments including Silwett L-77 and Agrowax had significantly ($p=0.05$) lower levels of downy mildew than either the dewaxed or water control. No significant differences ($p=0.05$) were found between fungicide treatments (including Silwett and Agrowax).

Allium & Brassica Centre (Bulb Onion) % Leaf Area Affected by *B. squamosa* - Sleaford site 23/08/2006 and 11/09/2006.

Fungicide Trial 2006 - ABC Sleaford Site
Angle transformed % leaf area infected with Botrytis on 2 recording dates
Error bars show 95% confidence intervals



Analysis of variance (23/08/2006)

Source	df	SS	MS	F	P	Significance
Treatment	15	3172.638	211.5092	10.08927	3.91E-12	***
Rep	3	50.49595	16.83198	0.802908	0.496501	ns
Treatment.Rep	45	1139.979	25.33286	1.983506	0.036963	*
Residual	24	306.5222	12.77176			
Total	87	4669.635				

SE for treatment A 0.865278
SE for treatments B-P 2.289311

Analysis of variance 11/09/2006

Source	df	SS	MS	F	P	Significance
Treatment	15	2126.248	141.7498	32.14625	3.24E-25	***
Rep	3	45.79568	15.26523	3.461872	0.020878	*
Treatment.Rep	45	289.8514	6.441141	10.73065	2.15E-08	***
Residual	24	14.40615	0.600256			
Total	87	2476.301				

SE for treatment A 0.396842
SE for treatments B-P 1.049944

The following treatments had significantly ($p=0.05$) lower levels of leaf spot than either the water or dewaxed controls at both assessment dates (23/08/2006 & 11/09/2006):

UK958

A4111B

Folio Gold + Amistar alternating with Invader + Bravo

Folio Gold + Amistar + Silwett L-77 alternating with Invader + Bravo + Silwett L-77

KIF230 + Amistar alternating with Invader + Bravo 500

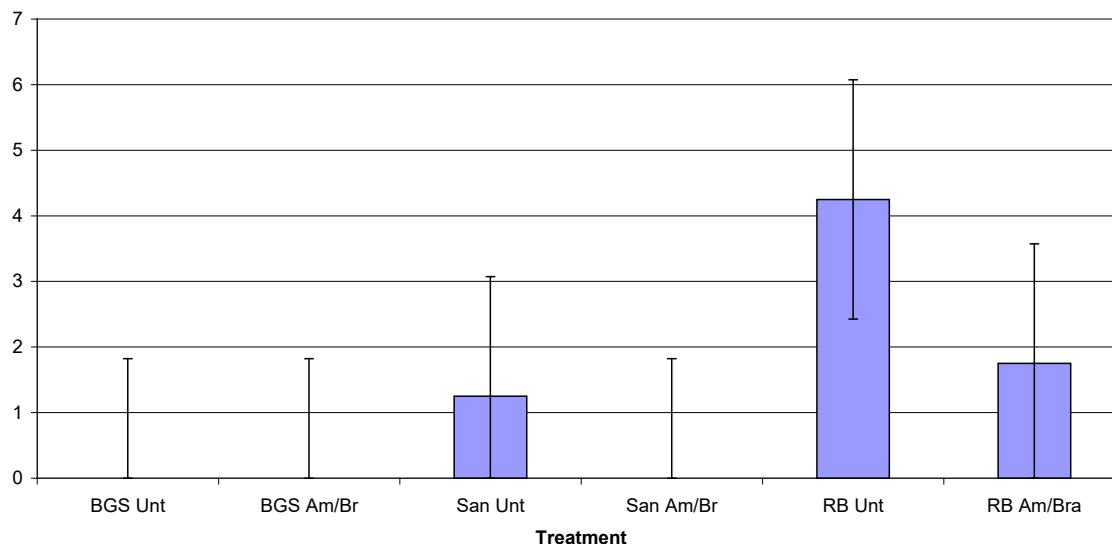
Dithane NT + Bravo 500

Dithane NT + Bravo 500 until active lesions then Folio Gold + Invader.

Allium & Brassica Centre – Resistant Variety Downy Mildew Results for Sleaford site.

ABC Resistant Variety Trial - Sleaford Site 2006
Mean number of mildew lesions

Error bars show 95% confidence interval calculated omitting the treatments with no lesions



Analysis of variance

Source	df	SS	MS	F	<i>P</i> (<i>F</i> test)	Significance
Variety	2	40.08333	20.04167	13.60566	0.000296	***
Fungicide	1	9.375	9.375	6.364393	0.021901	*
Var.Fung	2	6.25	3.125	2.494457	0.116082	ns
Rep	3	5.458333	1.819444	1.452328	0.267308	ns
Residual	15	18.79167	1.252778			
Total	23	79.95833				

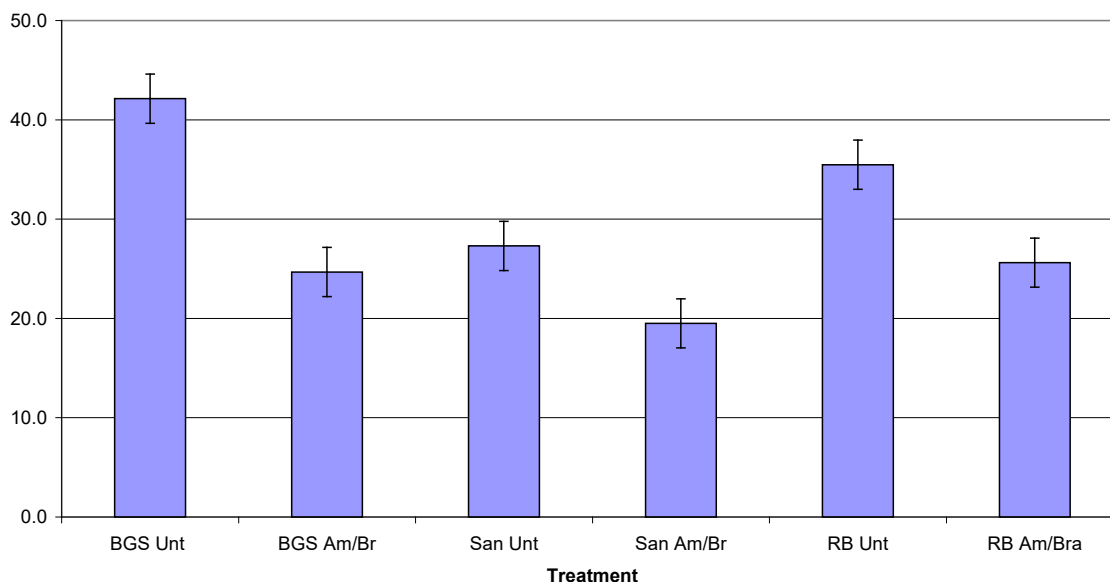
Whilst no downy mildew lesions were seen in any treatment of the BGS variety, occasional lesions were noted in the untreated Santaro. However because of the low level of disease in the trial few statistical differences ($p=0.05$) are apparent.

The untreated Red Baron (RB) did however have a significantly ($p=0.05$) higher level of downy mildew than either the treated or untreated (Unt) plots of BGS.

No significant difference ($p=0.05$) was found with regard to downy mildew control between the untreated Red Baron and Red Baron treated with alternate applications of Amistar and Bravo 500.

Allium & Brassica Centre (Bulb Onion) Resistant Variety Trial % Leaf Area Affected by *B. squamosa* - Sleaford site 28/08/2006.

ABC Resistant Variety Trial - Sleaford Site 2006
Angle transformed % leaf area infected with Botrytis
Error bars show 95% confidence intervals



Analysis of variance

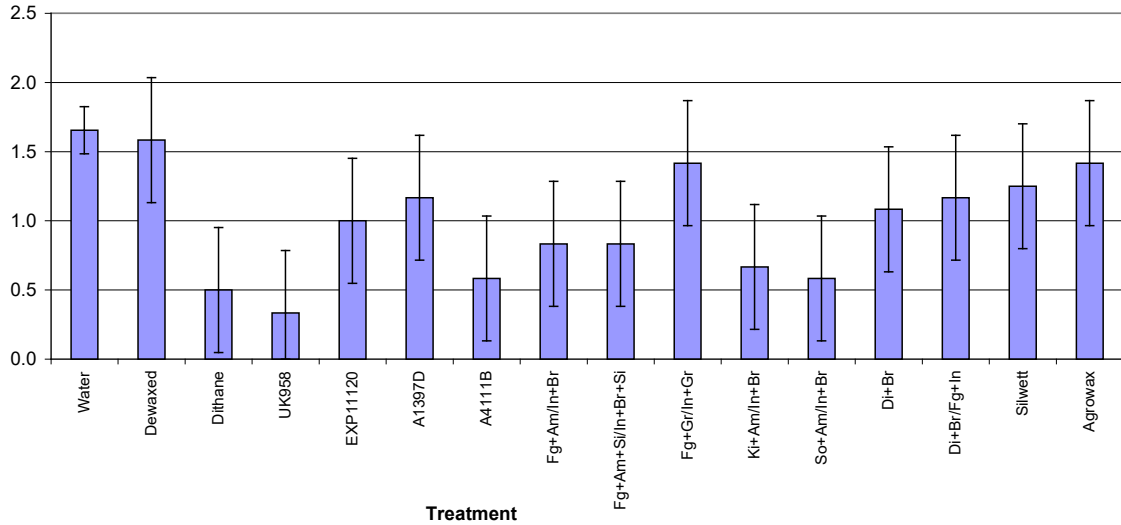
Source	df	SS	MS	F	P	Significance
Variety	2	422.1104	211.0552	0.627731	0.614352	ns
Fungicide	1	253.5081	253.5081	0.753996	0.476758	ns
V.F	2	672.4386	336.2193	62.47271	5.32E-08	***
Rep	3	18.9432	6.314401	1.173275	0.352883	ns
Residual	15	80.72788	5.381859			
Total	23	1447.728				

All varieties had significantly ($p=0.05$) lower levels of leaf spot in the plots treated with Amistar alternating with Bravo 500, than in the untreated plots.

When directly comparing fungicide treated and untreated plots Santaro appears to be significantly ($p=0.05$) less susceptible to leaf spot than either BGS or Red Baron. Variety maturity could possibly be a factor here, as Santaro is significantly earlier maturing than either BGS or Red Baron.

Vegetable Consultancy Services (Bulb Onion) Mean Downy Mildew Infection Score 1-9 (1=no infection, 9 = severe infection) Meaned Over Recording Dates - Suffolk site.

Fungicide Trial 2006 - VCS Suffolk Site
Mildew score meaned over recording dates
Error bars show 95% confidence intervals



Analysis of variance

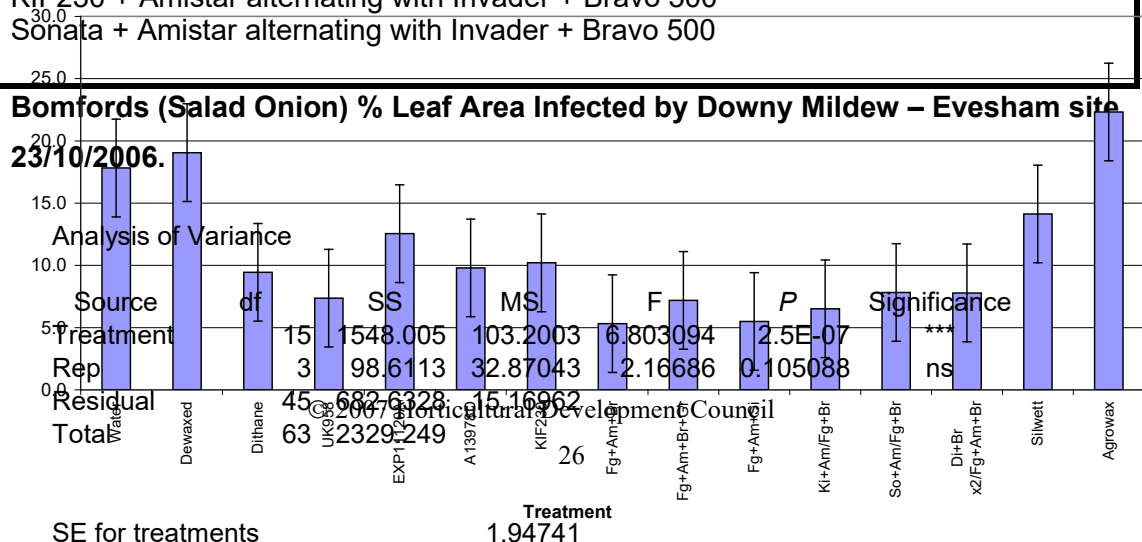
Source	df	SS	MS	F	P	Significance
Treatment	15	17.17821	1.145214	5.586401	2.97E-07	***
Rep	3	5.10101	1.700337	8.294313	8.71E-05	***
Treatment.Rep	45	7.160895	0.159131	0.546832	0.960151	ns
Residual	24	6.984127	0.291005			
Total	87	36.42424				

SE for treatment A 0.085565
 SE for treatments B-P 0.226385

The following treatments all had significantly ($p=0.05$) lower levels of downy mildew infection than either the water or dewaxed controls:

- Dithane NT
- UK958
- A4111B
- KIF230 + Amistar alternating with Invader + Bravo 500
- Sonata + Amistar alternating with Invader + Bravo 500

Fungicide Trial 2006 - Bomfords, Tiddington Site
Angle transformed % leaf area infected with mildew
Error bars show 95% confidence intervals

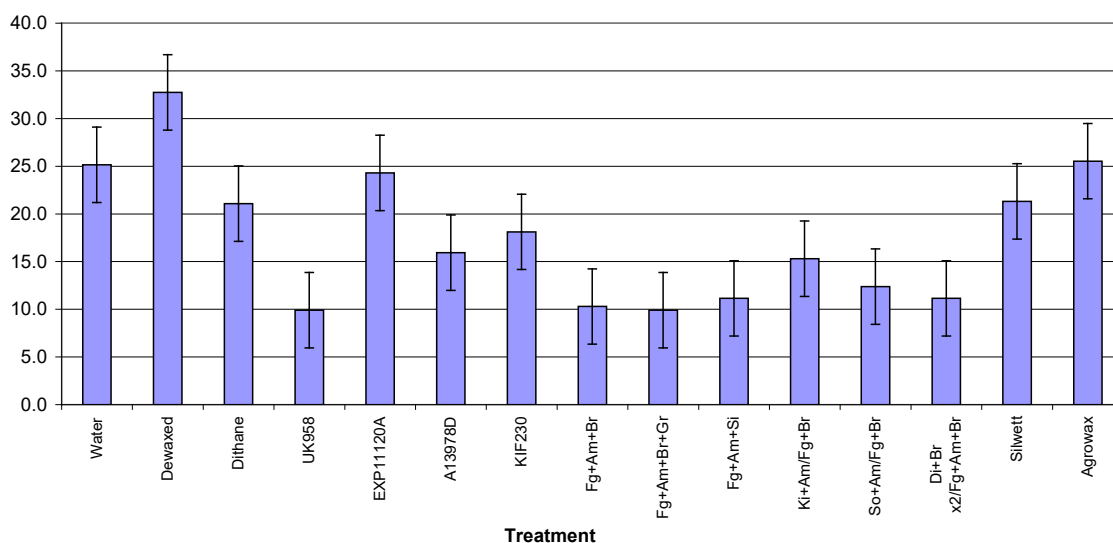


The following treatments all had significantly ($p=0.05$) lower levels of downy mildew infection than either the water or dewaxed controls and Agrowax treatment:

Dithane NT
 UK958
 A13978D
 Fubol Gold + Amistar + Chlorothalonil
 Fubol Gold + Amistar + Chlorothalonil + Grevit 200SL
 Fubol Gold + Amistar + Chlorothalonil + Silwett L-77
 KIF230 + Amistar alternating with Fubol Gold + Chlorothalonil
 Sonata + Amistar alternating with Fubol Gold + Chlorothalonil
 Dithane NT + Chlorothalonil x 2 then Fubol Gold + Amistar + Chlorothalonil.

**Bomfords (Salad Onion) % Leaf Area Infected with *B. squamosa* - Evesham site
 23/10/2006.**

Fungicide Trial 2006 - Bomfords, Tiddington Site
Angle transformed % leaf area infected with Botrytis
Error bars show 95% confidence intervals



Analysis of Variance

Source	df	SS	MS	F	P	Significance
Treatment	15	2842.891	189.5261	12.32384	2.66E-11	***
Rep	3	302.3361	100.7787	6.553086	0.000902	***
Residual	45	692.0466	15.37881			
Total	63	3837.274				

SE for treatments 1.960792

The following treatments all had significantly ($p=0.05$) lower levels of leaf spot infection than either the water or dewaxed controls and Agrowax treatment:

UK958

A13978D

Fubol Gold + Amistar + Chlorothalonil

Fubol Gold + Amistar + Chlorothalonil + Grevit 200SL

Fubol Gold + Amistar + Silwett L-77

KIF230 + Amistar alternating with Fubol Gold + Chlorothalonil

Sonata + Amistar alternating with Fubol Gold + Chlorothalonil.

Dithane NT + Chlorothalonil x 2 then Fubol Gold + Amistar + Chlorothalonil

Conclusions

Relatively low levels of downy mildew at all three sites meant that there were no significant differences ($p=0.05$) between either individually applied fungicide products or fungicide programmes with regard to mildew control.

The physically dewaxed treatments at all three sites were not statistically different ($p=0.05$) from the water control with regard to leaf spot and downy mildew control. This result is similar to that noted in FV189b where wax was removed from leaves using the adjuvant LI700. However it should be noted that this result might differ in a high disease pressure year.

The use of the plant wax Agrowax PHC and the silicon wetter Silwett L-77 gave some ambiguous results. At the Evesham and Bury St. Edmunds sites both Agrowax and Silwett L-77 treatments were not statistically different ($p=0.05$) when compared to the water treatment with regard to downy mildew and leaf spot control. At the Sleaford site both Agrowax and Silwett L-77 had significantly ($p=0.05$) lower levels of downy mildew than the water control. It is hypothesized that both Agrowax and Silwett L-77 may have an effect on downy mildew at very low disease levels however this effect appears to be lost as disease pressure increases.

No significant differences ($p=0.05$) in either leaf spot or downy mildew control were seen by the addition of Silwett L-77 or Grevit 200SL into a fungicide programme.

With regard to leaf spot control the best performing products or programmes at the Sleaford and Evesham sites all either contained or included, a strobilurin fungicide, chlorothalonil or both. This result is similar to that seen in individual product trials in 2005 (FV189b).

The claimed downy mildew resistant variety BGS from Bejo Zaden had significantly ($p=0.05$) lower levels of downy mildew infection than the commercial standard Red Baron, when directly comparing plots with no fungicide treatment. Santaro from Nickersons Zwaan by comparison was not statistically different to Red Baron and mildew lesions were noted in the untreated plots. A subsequent investigation by Nickersons indicates that non-resistant off-types within Santaro were most likely the cause of the low levels of downy mildew seen in untreated plots.

Further Work

FV189b identified two new fungicide products Sonata and KIF230 as showing good efficacy against downy mildew. Trials in 2006 confirmed that both products also performed well in fungicide programmes and it is recommended that either full or SOLA approval is sought for both fungicides.

In addition in 2006 a new coded product UK958 showed promise at all three trial sites for control of both downy mildew and leaf spot. The manufacturer has indicated that it is likely to seek approval for this product on bulb onions in the future, approval on salad onions is unlikely.

The downy mildew resistant variety BGS from Bejo Zaden shows great promise for future non-fungicidal control of the disease, however the late maturity of the variety means it is unlikely to be widely grown in the UK. It is recommended that further testing of downy mildew resistant varieties is undertaken to test disease resistance in a year with higher disease pressure.

Technology transfer

Presentation of results to be made at the bi-annual Onion and Carrot Conference 21st and 22nd November 2007.

References

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

Fungicide Product	Active Ingredient	Application Rate	Approval Status (2006)
A1379D	a.i. undisclosed	2.5L/ha	Experimental
A4111B	azoxystrobin + chlorothalonil	2L/ha	Experimental
Agrowax PHC	Plant wax	6L/ha	Non pesticidal product
Amistar	azoxystrobin	1L/ha	Full approval
Bravo 500	chlorothalonil	2L/ha	Full approval
Dithane NT	mancozeb	2.6kg/ha	SOLA 3039/05
EXP11120	a.i. undisclosed	1.6L/ha	Experimental
Folio Gold	chlorothalonil + methanoxam	2L/ha	Full Approval
Grevit 200SL	grapefruit extract	1.5l/ha	Foliar Feed
Invader	mancozeb + dimetamorph	2kg/ha	SOLA 2334/04
KIF230	a.i. undisclosed	1.6kg/ha	Experimental
Silwett L-77	silicone wetter	0.2l/ha	Adjuvant
Sonata	fenamidone + mancozeb	1.5kg/ha	No approval
UK958	a.i. undisclosed	1.5L/ha	Experimental

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

Fungicide Product	Active Ingredient	Application Rate	Approval Status (2006)
A1379D	a.i. undisclosed	2.5L/ha	Experimental
A4111B	azoxystrobin + chlorothalonil	2L/ha	Experimental
Agrowax PHC	Plant wax	6L/ha	Non pesticidal product
Amistar	azoxystrobin	1L/ha	SOLA 1687/02
Chlorothalonil	chlorothalonil	2L/ha	Full approval
Dithane NT	mancozeb	2.6kg/ha	No approval
EXP11120	a.i. undisclosed	1.6L/ha	Experimental
Fubol Gold WG	mancozeb + methanoxam	1.5kg/ha	SOLA 2324/03
Grevit 200SL	grapefruit extract	1.5l/ha	Foliar Feed
Invader	mancozeb + dimetamorph	2kg/ha	SOLA 2953/06
KIF230	a.i. undisclosed	1.6kg/ha	Experimental
Silwett L-77	silicone wetter	0.2L/ha	Adjuvant
Sonata	Fenamidone + mancozeb	1.5kg/ha	No approval
UK958	a.i. undisclosed	1.5L/ha	Experimental

Appendix 2a – Efficacy 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 Dewaxed Control
- C Control - Dithane NT @ 2.7 kg/ha
- D Fandango - awaiting application rate
- E Infinito - awaiting application rate
- F A13978D @ 2.5 L/ha
- G A4111B @ 2.5 l/ha
- H Folio Gold @ 2L/ha + Amistar @ 1L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha
- I Folio Gold @ 2L/ha + Amistar @ 1L/ha + Silwett L-77 @ 0.2L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha + Silwett L-77 @ 0.2L/ha
- J Folio Gold @ 2L/ha + Grevit @ 1.5 L/ha alternating with Invader @ 2L/ha + Grevit @ 1.5 L/ha
- K KIF 230 @ 1.6kg/ha + CERF025 @ 0.15L/ha + Amistar @ 1L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha
- L Sonata @ 1.5 kg/ha + Amistar @ 1L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha
- M Dithane NT @ 2.7 kg/ha + Bravo 500 @ 2L/ha
- N Dithane NT @ 2.7 kg/ha + Bravo 500 @ 2L/ha followed by Folio Gold @ 2L/ha + Invader @ 2kg/ha at first sign of active lesions.
- O Silwett L-77 @ 0.2L/ha
- P Agrowax @ 6L/ha

Appendix 2b – Downy Mildew Resistant Variety Trial Layout, Sleaford, Lincolnshire

Rep 4

DISCARD	A	C	DISCARD
	B	D	

Rep 3

DISCARD	B	D	DISCARD
	A	C	

Rep 2

DISCARD	A	C	DISCARD
	B	D	

Rep 1

DISCARD	B	D	DISCARD
	A	C	

Beds 2 4 6 8

Treatment List

- A** **BGS 237 - Untreated**
- B** **BGS 237 - Amistar @ 1L/ha alternating with Bravo 500 @ 2L/ha.**
- C** **Santaro - Untreated**
- D** **Santaro - Amistar @ 1L/ha alternating with Bravo 500 @ 2L/ha.**

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

Rep 4	DISCARD	L	H	A	J	A	A	M	I	A	P	D	DISCARD
		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 Dewaxed Control
- C Control - Dithane NT @ 2.7 kg/ha
- D Fandango - awaiting application rate
- E Infinito - awaiting application rate
- F A13978D @ 2.5 L/ha
- G A4111B @ 2.5 l/ha
- H Folio Gold @ 2L/ha + Amistar @ 1L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha
- I Folio Gold @ 2L/ha + Amistar @ 1L/ha + Silwett L-77 @ 0.2L/ha alternating with Invader @ 2kg/ha + Bravo 500 @2L/ha + Silwett L-77 @ 0.2L/ha
- J Folio Gold @ 2L/ha + Grevit @ 1.5 L/ha alternating with Invader @ 2L/ha + Grevit @ 1.5 L/ha
- K KIF 230 @ 1.6kg/ha + CERF025 @ 0.15L/ha + Amistar @ 1L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha
- L Sonata @ 1.5 kg/ha + Amistar @ 1L/ha alternating with Invader @ 2kg/ha + Bravo 500 @ 2L/ha
- M Dithane NT @ 2.7 kg/ha + Bravo 500 @ 2L/ha
- N Dithane NT @ 2.7 kg/ha + Bravo 500 @ 2L/ha followed by Folio Gold @ 2L/ha + Invader @ 2kg/ha at first sign of active lesions.
- O Silwett L-77 @ 0.2L/ha
- P Agrowax @ 6L/ha

Appendix 2d – 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 Dewaxed Control
- C Control - Dithane NT @ 2.7 kg/ha
- D Fandango - awaiting application rate
- E Infinito - awaiting application rate
- F A13978D @ 2.5 L/ha
- G KIF 230 @ 1.6kg/ha + CERF025 @ 0.15L/ha
- H Fubol Gold @ 1.5kg/ha + Amistar @ 1L/ha + Bravo 500 @ 2L/ha
- I Fubol Gold @ 1.5kg/ha + Amistar @ 1L/ha + Bravo 500 @ 2L/ha + Grevit 200SL @ 1.5L/ha
- J Fubol Gold @ 1.5kg/ha + Amistar @ 1L/ha + Bravo 500 @ 2L/ha + Silwett L-77 @ 0.2L/ha
- K KIF 230 @ 1.6kg/ha + CERF025 @ 0.15L/ha + Amistar @ 1L/ha alternating with Fubol Gold @ 1.5kg/ha + Bravo 500 @ 2L/ha
- L Sonata @ 1.5 kg/ha + Amistar @ 1L/ha alternating with Fubol Gold @ 1.5kg/ha + Bravo 500 @ 2L/ha
- M Dithane NT @ 2.7 kg/ha + Bravo 500 @ 2L/ha x 2 followed by Fubol Gold @ 1.5kg/ha + Amistar @ 1L/ha + Bravo 500 @ 2L/ha
- N Silwett L-77 @ 0.2L/ha
- O Agrowax @ 6L/ha
- P Control - Water