CP 205 AHDB Horticulture Efficacy Trials 2022
Final Trial Report

Work package:	WP 11
Title:	Identification of new products for control of powdery mildew (*Golovinomyces cichoracearum*) on protected and outdoor lettuce
Crop	Lettuce
Target	Powdery Mildew (*Golovinomyces cichoracearum*)
Lead researcher:	Bruce Napier
Organisation:	NIAB
Period:	2022
Report date:	12/04/2023
Report authors:	Bruce Napier
ORETO Number: (certificate should be attached)	397

I the undersigned, hereby declare that the work was performed according to the procedures herein described and that this report is an accurate and faithful record of the results obtained

Date Author's signature

Trial Summary

Introduction

Lettuce powdery mildew is caused by *Golvinomyces cichoracearum.* Powdery mildew on outdoor and protected lettuce has been seen more frequently in recent seasons.

In dry weather in summer and in hydroponic crops, powdery mildew can rapidly become widespread and cause significant reductions in crop quality. Initial inoculum arises from airborne asexual or sexual spores but other sources may include debris from previously infected crops and some weed species.

Options for control have largely been focused on growing environment hygiene and the use of crop protection products.

As the causal organism is generally favoured by warm conditions, outdoor production under hotter summer conditions means that powdery mildew is very likely to be an increasing threat to production. Since warmer conditions in the UK are usually accompanied by drier weather, the irrigation regimes necessary for good productivity will create conditions that will drive infection and subsequent spread of disease and lead to greater chances of persistence in the environment.

The study looked at a range of commercially available protective and curative fungicides (but not all authorised for lettuce), applied to powdery mildew inoculated protected and field lettuce crop trials.

Methods

Products were tested on both glasshouse and field grown plants of the susceptible variety Napelo transplanted into plots at NIAB Cambridge on 6 September 2022.

Plots were inoculated with *G. cichoraceum* isolated from commercial lettuce crops in the summer of 2022 using spore suspensions and by brushing infected plants across plots. Infector plants were also planted alongside trial plots to maximise the chance of infection and overcome any resilience to disease of the young plants.

The field trial was designed around a ‘3 application’ programme that could be used as a standard commercial disease control programme with minimum residue levels and accepted harvest interval compliance in mind.

The glasshouse trial was designed to assess the efficacy products individually i.e. to assess their duration without interactions with other products in order to help interpret the results of the programmes used in the field trial.

Product residue levels and phytotoxicity (on a 0-9 scale of leaf scorch) were recorded 3 days after each application.

Disease was regularly assessed from the first appearance of symptoms on a leaf layer basis when infection levels were very low and a whole plant basis as disease levels increased.

Results

Glasshouse trial

No phytotoxicity was observed after any of the applications.

Inoculated young spreader plants were slow to develop powdery mildew symptoms (photo 1) with the first disease symptoms not recorded until 11 November 2022; 35 days after the first application.

As all inoculum samples had been found on older plant material and it was concluded that disease develops more easily on older, more stressed material.

Photo 1 – powdery mildew

At the first assessment, the untreated control had significantly higher disease levels than all the treated plots (figure 1).

Plots treated with AHDB9957 had higher disease levels than the other treatments.

Kenja had half the infection levels of AHDB9957.

AHDB9852 and AHDB9712 both had very low levels of infection.

All other treatments had no infection at this stage. AHDB9862, AHDB9696, AHDB9771, AHDB9695, Luna Sensation and Perseus should all be considered as options for a programme to control powdery mildew. Use at earlier application timing is likely to be most effective.

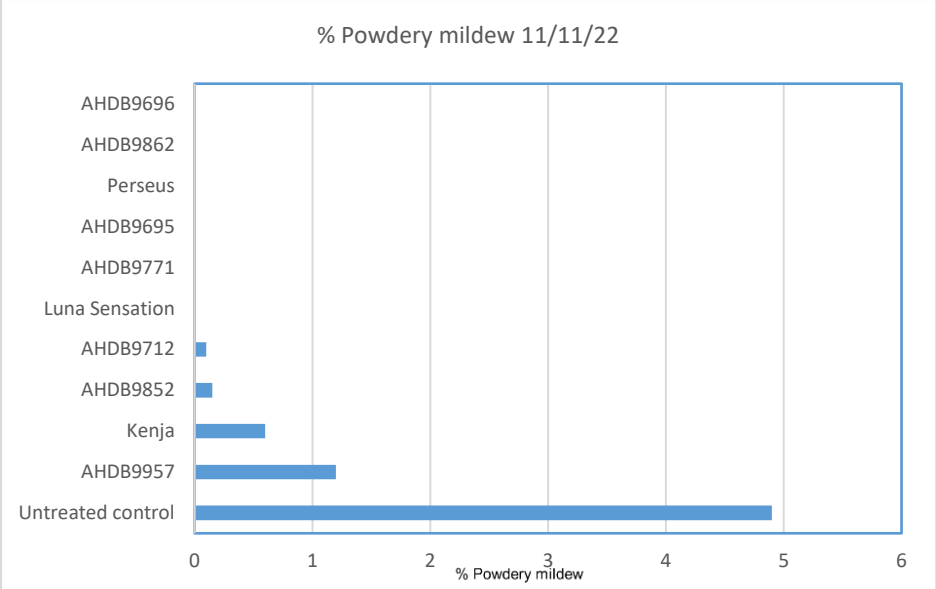


Figure 1. Early disease levels on a single leaf layer

Towards the final assessment (28/11/22) the AHDB9852 treated plots started to have similar levels of disease to those of AHDB9957. Kenja and AHDB9712 plots also started to show symptoms of powdery mildew at the later assessments.

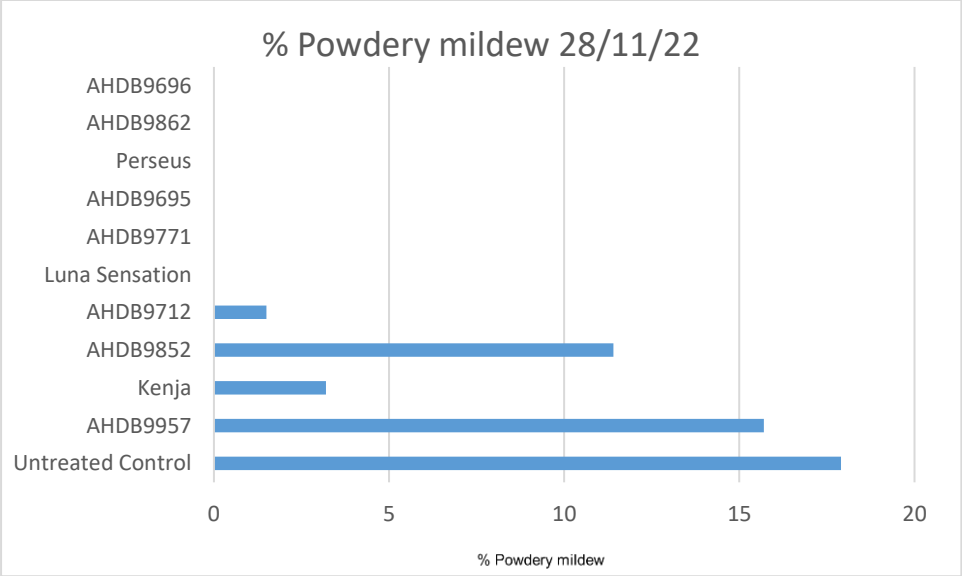


Figure 2. Final disease levels on whole plants

AHDB9852, Kenja and AHDB9712 should only be used as part of a mixed programme for the control of powdery mildew as, on their own, they did not give full control.

Some other mildew like symptoms came in on the untreated plots and the treated plots followed the same pattern of breakdown of control as the season progressed.

At the final assessment plant vigour was assessed. There were slight differences in vigour. The AHDB9957 treated plots had the lowest vigour while the AHDB9696 treated plants were the most vigorous.

Some low levels of leaf surface residues were observed on the AHDB9771 (photo 2) and AHDB9695 (photo 3) treatments.

Photo 2

Photo 3

Field trial

No phytotoxicity was observed and all assessments were recorded as zero.

Disease did not establish on the plots despite “top-up” inoculations on the untreated plots.

As with the glasshouse trial some low levels of leaf surface residues were observed on the AHDB9771 (photo 2) and AHDB9695 (photo 3) treatments.

Take home message:

Good crop hygiene and a healthy crop should be maintained to reduce the risk of plants becoming stressed and susceptible to disease.

Crop protection products play an important part in this and a robust programme of fungicides and bio-pesticides should be considered on high risk crops.

AHDB9862, AHDB9696, AHDB9771, AHDB9695, Luna Sensation and Perseus plots were all free of powdery mildew and thus could be considered in a programme to control or to prevent the establishment of powdery mildew.

There is insufficient data to draw any conclusions regarding the inclusion of Signum, Serenade, Romeo, Karma or Phytosave in a programme as they were only included in the field trial which yielded no infection data.

AHDB9712 gave reasonable control but under high disease pressure for a longer period of time may not have stood up. It could form part of a programme to control Powdery mildew.

AHDB9957, Kenja and AHDB9852 all gave limited control on protected crops and thus should not be used alone to attempt control of powdery mildew.

All the field trial treatments were safe to use and showed no phytotoxicity.

As with the glasshouse trial there were some low levels of leaf surface residues on AHDB9771 and AHDB9695 in field trials but these washed off after a couple of rain events. These products should be considered for use early in a pesticide programme.

SCIENCE SECTION

Objectives

Lettuce powdery mildew is caused by *Golvinomyces cichoracearum* (previously named *Erysiphe cichoracearum*). Powdery mildew on outdoor and protected lettuce has been seen more frequently in recent seasons. In dry weather in summer and in hydroponic crops, powdery mildew can rapidly become widespread and cause significant reductions in crop quality. Initial inoculum arises from airborne asexual spores (conidia) or sexual spores (ascospores) but other sources may include debris from previously infected crops and some weed species. Options for control have largely been focused on growing environment hygiene and the use of crop protection products, which are limited in range and availability with the loss of products.

As the causal organism is generally favoured by warm conditions, outdoor production under hotter summer conditions, potentially driven by climate change, means that powdery mildew is very likely to be an increasing threat to production. Since warmer conditions in the UK are usually accompanied by drier weather, the irrigation regimes necessary for productivity in protected conditions will drive infection and spread and lead to greater chances of persistence in the environment.

The study looked at a range of commercially available protective and curative treatments (but not all authorised for lettuce), applied to powdery mildew inoculated protected and field lettuce crop trials.

Methods

Inoculum of *G. cichoraceum* was sourced from natural infection on commercial UK lettuce crops in the summer of 2022.

A glasshouse (protected) trial and a field trial were conducted both using a susceptible cultivar Napelo (powdery mildew had been observed on this cultivar in 2019 and 2020).

Plants were raised in 77 module cell trays under glass until they were big enough for transplanting. The glasshouse trial plots were transplanted into pots and kept outside on a standing bed until ready for treatment and inoculation. The plots were randomized once the first application was applied. The plots were returned to under glass as the peak of summer was over so there were no concerns that plants would be scorched.

The plants for field plots were transplanted out into fine tilth beds. As it was late summer / early autumn, 6 September, there were no high temperature issues during the day and un-seasonally mild nights meant that there were no frost issues until after the assessments had been completed.

Glasshouse and field plots were inoculated by multiple techniques: spores applied as a spore suspension solution; inoculated “transplants”; and brushing infector plants across the plots. All three methods were used to maximise the chance of infection and overcome any resilience of the younger plants.

The objective of the glasshouse trial was to look at the efficacy of each of the products individually i.e. to assess their duration without interactions with other products. The

products were applied as per the authorized product rates or where no authorization exists at the rate advised by the manufacturer.

The field trial was designed, with advice from a commercial agronomist, around a 3 application programme that could be used as a standard commercial disease control programme which might also give powdery mildew control while still complying with minimum residue levels and accepted harvest intervals. The results of the glasshouse trial were planned to help interpret which products within the field trial were effective in giving powdery mildew control.

Standard methods of assessing phytotoxicity were used i.e. 0-9 scale of leaf scorch associated with the application of the treatments.

Disease was assessed on a leaf layer basis when infection levels were very low and a whole plant basis as disease levels increased.

Trial conduct

[*UK regulatory guidelines were followed, but EPPO guidelines took precedence. The following EPPO guidelines were followed:]*

Relevant EPPO guideline(s)		**Variation from EPPO**
PP1/135 (4)	Phytotoxicity assessment	
PP1/152 (4)	Guideline on design and analysis of efficacy evaluation trials	
PP1/181 (5)	Conduct and reporting of efficacy evaluation trials including good experimental practice	
PP 1/214 (4)	Principles of acceptable efficacy	

Test site

Item	**Details**
Location address	NIAB, Cambridge, CB3 0LE
Crop	Lettuce
Cultivar	Napelo (E01E.11136)
Soil or substrate type	Glasshouse trial – Peat Field trial – silty clay loam
Agronomic practice	Transplanted crop
Prior history of site	Winter wheat

Trial design - Glasshouse trial

Item	Details
Trial design:	Randomised complete block
Number of replicates:	6
Row spacing:	n/a
Plot size: (w x l)	12 pots
Plot size: (m^2)	n/a
Number of plants per plot:	12
Leaf Wall Area calculations	

Trial design - Field trial

Item	Details
Trial design:	Randomised complete block
Number of replicates:	6
Row spacing:	n/a
Plot size: (w x l)	5 rows of 8 plants (1.5 x 2.5m)
Plot size: (m^2)	4.25m^2
Number of plants per plot:	40
Leaf Wall Area calculations	

Treatment details – Glasshouse trial and field trial

AHDB Code	Active substance	Product name/ manufacturer code	Formulation batch number	Content of active substance in product	Formulation type	Adjuvant
-	Untreated control	-	-	-	-	-
AHDB 9957	ND	ND	ND	ND	ND	-
-	Isofetamid	Kenja	n/a	400 g/l isofetamid	Soluble concentrate (SL)	-
-	Fluopyram / trifloxystrobin	Luna Sensation	E M4 L-031052	250 g/l fluopyram , 250 g/l trifloxystrobin	Soluble concentrate (SL)	-
AHDB 9771	ND	ND	ND	ND	ND	-
AHDB 9695	ND	ND	ND	ND	ND	-
-	Difenoconazole / fluxapyroxad	Perseus	0018862150	50 g/l difenoconazole, 75 g/l fluxapyroxad	Soluble concentrate (SL)	-
AHDB 9862	ND	ND	ND	ND	ND	-
AHDB 9852	ND	ND	ND	ND	ND	-
AHDB 9712	ND	ND	ND	ND	ND	
AHDB 9696	ND	ND	ND	ND	ND	
-	Boscalid / pyraclostrobin	Signum	12-k00884	26.7% w/w boscalid, 6.7 % w/w pyraclostrobin	Soluble concentrate (SL)	

-	*Bacillus subtilis* QST 713	Serenade	EZU1631901	1015.1 g/l (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	Suspension Concentrate (SC)	
-	*Saccharomyces cerevisiae*	Romeo		941 g/kg Cerevisane	Soluble powder	
-	Potassium hydrogen carbonate	Karma	AG1951002	85.42 % w/w Potassium hydrogen carbonate	Soluble powder	
-	COS-OGA	Fytosave	210225	12.5 g / l COS-OGA	Soluble concentrate (SL)	

Application schedule – Glasshouse trial

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application code
1	Untreated control		-	-
2	AHDB9957	ND	ND	A, B, C, D
3	Kenja	400 g/ha isofetamid	1.0 L/Ha	A
4	Luna Sensation	200 g/ha fluopyram, 200 g/ha trifloxystrobin	0.8 L/Ha	A
5	AHDB9771	ND	ND	A, B, C, D
6	AHDB9695	ND	ND	A, B, C, D
7*	Perseus	60 g/ha difenoconazole, 90 g/ha fluxapyroxad	1.2 L/Ha	B, C
8	AHDB9862	ND	ND	A, B
9	AHDB9852	ND	ND	A, B
10	AHDB9712	ND	ND	A, B, C, D
11	AHDB9696	ND	ND	A, B

Application schedule – Field trial

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application code
1	Untreated control		-	-
2	Signum	400 ml/ha boscalid, 100 ml/ha % w/w pyraclostrobin	1.5 l/ha	A
2	Perseus	60 g/ha difenoconazole, 90 g/ha fluxapyroxad	1.2 l/Ha	B

2	Luna Sensation	200 g/ha Fluopyram, 200 g/ha trifloxystrobin	0.8 l/Ha	C
3	Luna Sensation	200 g/ha Fluopyram, 20 g/ha trifloxystrobin	0.8 l/Ha	A
3	Serenade	10 kg/ha (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	10 l/ha	B
3	AHDB9696	ND	ND	C
3	Karma	2.56 l/ha Potassium hydrogen carbonate	3.0 l/ha	D
4	Kenja	400 g/ha Isofetamid	1.0 l/Ha	A
4	Serenade	10 kg/ha (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	10 l/ha	B
4	Perseus	60 g/ha difenoconazole, 90 g/ha fluxapyroxad	1.2 L/Ha	C
4	AHDB9771	ND	ND	D
5	Romeo	706 g/ha Cerevisane	0.75	A
5	Signum	400 ml/ha boscalid, 100 ml/ha % w/w pyraclostrobin	1.5 l/ha	B
5	Serenade	10 kg/ha (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	10 l/ha	C
5	Karma	2.56 l/ha Potassium hydrogen carbonate	3.0 l/ha	D
6	Fytosave	25 g/ha COS-OGA	2.0 l/ha	A
6	Signum	400 ml/ha boscalid, 100 ml/ha % w/w pyraclostrobin	1.5 l/ha	B
6	Serenade	10 kg/ha (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	10 l/ha	C

6	AHDB9771	ND	ND	D
7	Fytosave	25 g/ha COS-OGA	2.0 l/ha	A
7	Fytosave	25 g/ha COS-OGA	2.0 l/ha	B
7	Serenade	10 kg/ha (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	10 l/ha	C
7	Karma	2.56 l/ha Potassium hydrogen carbonate	3.0 l/ha	D
8	AHDB9957	ND	ND	A
8	AHDB9957	ND	ND	B
8	Serenade	10 kg/ha (1.05 x 1012 CFU/L equivalent) bacillus subtilis (strain QST 713)	10 l/ha	C
8	AHDB9771	ND	ND	D

Application details – Glasshouse trial

	Application A	Application B	Application C	Application D
Application date	07/10/22	11/10/22	18/10/22	25/10/22
Time of day	n/a	n/a	n/a	n/a
Crop growth stage (Max, min average BBCH)	15 (14-16)	15 (14-16)	16 (15-17)	17 (16-18)
Crop height (cm)	n/a	n/a	n/a	n/a
Crop coverage (%)	n/a	n/a	n/a	n/a
Application Method	By hand	By hand	By hand	By hand
Application Placement	Foliar spray	Foliar spray	Foliar spray	Foliar spray
Application equipment	Hand sprayer	Hand sprayer	Hand sprayer	Hand sprayer
Spray pattern				
Spray type	Fine mist	Fine mist	Fine mist	Fine mist
Nozzle pressure				
Nozzle type	Solid cone	Solid cone	Solid cone	Solid cone
Nozzle size				
Application water volume/ha	300 l/ha	300 l/ha	300 l/ha	300 l/ha
Temperature of air - shade (°C)	n/a	n/a	n/a	n/a
Relative humidity (%)	n/a	n/a	n/a	n/a
Wind speed range (m/s)	n/a	n/a	n/a	n/a
Dew presence (Y/N)	n/a	n/a	n/a	n/a
Temperature of soil - 2-5 cm (°C)	n/a	n/a	n/a	n/a
Wetness of soil - 2-5 cm	n/a	n/a	n/a	n/a
Cloud cover (%)	n/a	n/a	n/a	n/a

Application details – Field trial

	Application A	Application B	Application C	Application D
Application date	15/10/22	19/10/22	24/10/22	31/10/22
Time of day	am	am	am	am
Crop growth stage (Max, min average BBCH)	9 leaf	9 leaf	10 leaf	11 leaf
Crop height (cm)	15cm	15cm	15cm	15cm
Crop coverage (%)	n/a	n/a	n/a	n/a
Application Method	By hand	By hand	By hand	By hand
Application Placement	Foliar spray	Foliar spray	Foliar spray	Foliar spray
Application equipment	AZO sprayer	AZO sprayer	AZO sprayer	AZO sprayer
Spray pattern				
Spray type	Fine mist	Fine mist	Fine mist	Fine mist
Nozzle pressure				
Nozzle type	Solid cone	Solid cone	Solid cone	Solid cone
Nozzle size				
Application water volume/ha	300 l/ha	300 l/ha	300 l/ha	300 l/ha
Temperature of air - shade (°C)	n/a	n/a	n/a	n/a
Relative humidity (%)	n/a	n/a	n/a	n/a
Wind speed range (m/s)	n/a	n/a	n/a	n/a
Dew presence (Y/N)	n/a	n/a	n/a	n/a
Temperature of soil - 2-5 cm (°C)	n/a	n/a	n/a	n/a
Wetness of soil - 2-5 cm	n/a	n/a	n/a	n/a
Cloud cover (%)	n/a	n/a	n/a	n/a

Untreated levels of pests/pathogens at application and through the assessment period – Glasshouse trial

Common name	Scientific Name	EPPO Code	Infestation level pre-application	Infestation level at start of assessment period	Infestation level at end of assessment period
Powdery mildew	*Golvinomyces cichoracearum*		nil	nil	45%

Untreated levels of pests/pathogens at application and through the assessment period – field trial

Common name	Scientific Name	EPPO Code	Infestation level pre-application	Infestation level at start of assessment period	Infestation level at end of assessment period
Powdery mildew	*Golvinomyces cichoracearum*		nil	nil	nil

Assessment details – Glasshouse trial

	Evaluation Timing (DA)*				
Evaluation date	**After first conventional pesticide**	**After first bio-pesticides**	**Crop Growth Stage (BBCH)**	**Evaluation type**	**Assessment**
10/10/22	3	3	9 TL	phytotoxicity	Phytotoxicity + product residue
17/10/22	10	10	9 TL	phytotoxicity	Phytotoxicity + product residue
24/10/22	17	17	10 TL	phytotoxicity	Phytotoxicity + product residue
31/10/22	24	24	11 TL	phytotoxicity	Phytotoxicity + product residue
11/11/22	35	35	12 TL	phytotoxicity, efficacy	Phytotoxicity + product residue + disease levels
15/11/22	39	39	12 TL	efficacy	disease levels
18/11/22	42	42	13 TL	efficacy	disease levels
28/11/22	52	52	14 TL	efficacy	disease levels

Assessment details – field trial

	Evaluation Timing (DA)*				
Evaluation date	**After first conventional pesticides**	**After first bio-pesticides**	**Crop Growth Stage (BBCH)**	**Evaluation type**	**Assessment**
15/10/22	0		9 TL	disease	Disease levels (natural infection)
17/10/22	2		9 TL	inoculation	
19/10/22	4		9 TL	phytotoxicity	Phytotoxicity + product residue
24/10/22	9		9 TL	phytotoxicity	Phytotoxicity + product residue
31/10/22	16		10 TL	phytotoxicity, efficacy	Phytotoxicity + product residue + disease levels
07/11/22	23		10 TL	efficacy	disease levels
14/11/22	30		11 TL	efficacy	disease levels

* DA – days after application

Statistical analysis

Analysis of variance. Mean treatment values, standard deviations and CV are appended.

Results

Glasshouse trial

No phytotoxicity was observed after any of the applications and all phytotoxicity assessments were recorded as zero.

Inoculated young spreader plants were slow to develop symptoms. Inoculum didn't take very well on juvenile plants and symptoms were weak and not representative of those normally seen for lettuce powdery mildew. All inoculum samples had been found on older plant material and thus it was concluded that disease develops more easily on older, more stressed material. While this is common it is unusual for younger plants to be so resilient.

Powdery mildew (photo 1) was slow to establish on the inoculated plot plants and levels of disease symptoms were not recorded before the 11th November, 35 days after the first application.

Photo 1 – powdery mildew

At the 11th November assessment, figure 1, the untreated control had significantly higher disease levels than all the treated plots.

Plots treated with AHDB9957 had higher disease levels than the other treatments. Kenja had half the infection levels of AHDB9957.

AHDB9852 and AHDB9712 both had very low levels of infection.

All other treatments had no infection at this stage.

AHDB9862, AHDB9696, AHDB9771, AHDB9695, Luna Sensation and Perseus should all be considered as options for a programme to control powdery mildew. Use at earlier application timing is likely to be most effective.

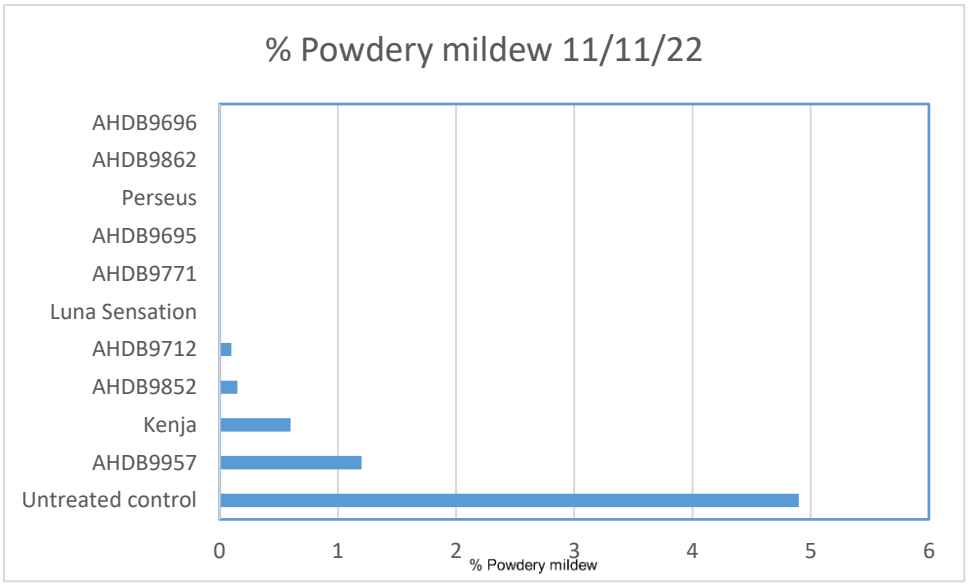


Figure 1. Early disease levels on a single leaf layer

Towards the final assessment powdery mildew levels (Figure 2) had converged with the AHDB9852 (11.4% powdery mildew) treated plots started to have similar levels of disease to those of AHDB9957 (15.7% powdery mildew). Kenja (3.2% powdery mildew) and AHDB9712 (1.6% powdery mildew) plots also started to show symptoms of powdery mildew at the later assessments.

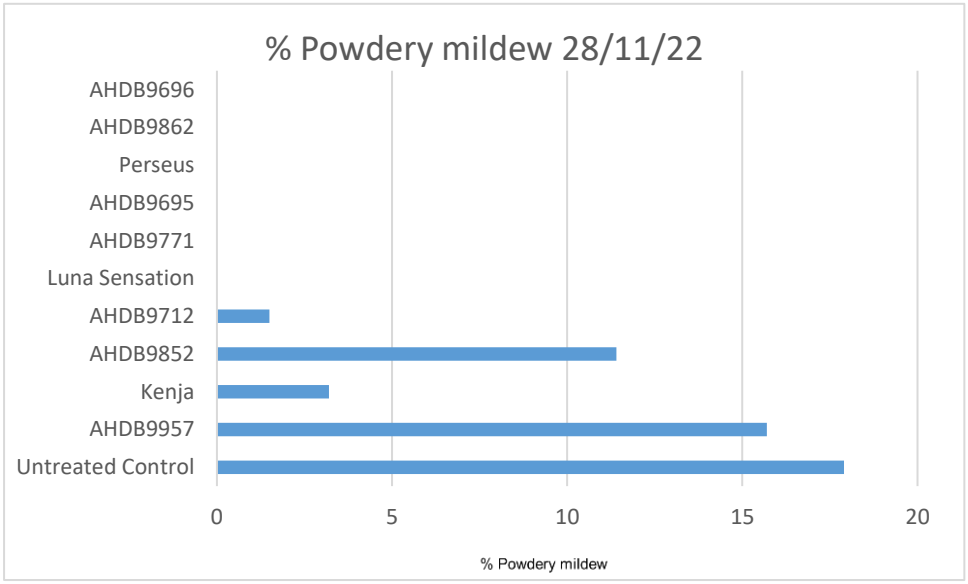


Figure 2. Final disease levels on whole plants

Some other mildew like symptoms came in on the untreated plots and the treated plots followed the same pattern of breakdown of control as the season progressed.

At the final assessment plant vigour was assessed. There were slight differences in vigour. The AHDB9957 treated plots had the lowest vigour while the AHDB9696 treated plants were the most vigorous.

Some low levels of leaf surface residues were observed on the AHDB9771 (photo 2) and AHDB9695 (photo 3) treatments. The trials were conducted in a hard water area and there is some chance that the residues were from the water rather than the products.

Photo 2

Photo 3

Field trial

No phytotoxicity was observed and all assessments were recorded as zero.

Disease did not establish on the plots despite “top-up” inoculations on the untreated plots.

As with the glasshouse trial some low levels of leaf surface residues were observed on the AHDB9771 (photo 2) and AHDB9695 (photo 3) treatments.

Discussion

Fresh UK isolates of lettuce powdery mildew were sought to inoculate the trial. Based on this the two trials were sown late in the season to allow time to bulk up any inoculum. Infection was late to appear on commercial crops and thus the trials were treated and inoculated later than planned.

Glasshouse (protected) trial

The protected trial had been planned for a polythene tunnel but due to the hot summer this was deemed too risky as the plants were likely to overheat at that time of year. The plants were sown under glass but on emergence they were transferred to a

standing bed outside and then moved back later into a glasshouse for treatment and inoculation.

Inoculated plants were slow to develop symptoms and it became evident that powdery mildew is more likely to establish if the leaves/plants are starting to age or are becoming stressed.

High levels of infection eventually established and significant differences were seen between the untreated and treated plots.

No phytotoxicity was observed but this was no surprise as all treatments are already approved for use on outdoor lettuce or other vegetable crops and were applied at standard rates.

AHDB9771and AHDB9695 both had leaf surface residues which would make them unsuitable products for late applications.

Field trial

The field trial was inoculated only a few days after the glasshouse trial as we had to wait for 9 true leaf stage to be able to apply Perseus.

It was a mild autumn with relatively warm evening and no frosts. The plants were healthy and un-stressed.

Even in the glasshouse trial disease was slow to establish and it may be that the plants need to be older and under some stress to allow disease to become established. Assessments continued beyond the scheduled assessments until the first night frosts arrived.

Conclusions

AHDB9957, Kenja and AHDB9852 all gave limited control on protected crops and thus should not be used alone to attempt control of powdery mildew.

AHDB9712 gave reasonable control but under high disease pressure for a longer period of time may not have stood up. It could form part of a programme to control Powdery mildew.

AHDB9862, AHDB9696, AHDB9771, AHDB9695, Luna Sensation and Perseus plots were all free of powdery mildew and thus could be considered in a programme to control or to prevent the establishment of powdery mildew.

The field trial yielded no infection data but all the treatments were safe to use and showed no phytotoxicity. As with the protected trial there were some leaf surface residues on AHDB9771and AHDB9695 but these washed off after a couple of rain events.

While it is not possible to give a definitive programme to control powdery mildew a standard programme containing one of AHDB9862, AHDB9696, AHDB9771, AHDB9695, Luna Sensation and Perseus is likely to give some protection.

There is insufficient data to draw any conclusions regarding the inclusion of Signum, Serenade, Romeo, Karma or Phytosave.

Acknowledgements

AHDB for funding the work, Enza Zaden for providing seed for the trial and the crop protection companies for their in-kind contributions of providing samples for the trials.

Appendix

a. Trial diary

Date	Notes
12/07/2022 + Various	Plants sown for bulking inoculum / producing spreader plants
19/07/2022	Protect trial sown
05/08/2022	Field trial plants sown in glasshouse
06/09/2022	Field trial planted
09/09/2022 – 11/09/2022	Gapping up of field trial
07/10/2022 – 25/10/2022	Glasshouse trial fungicide applications
10/10/2022 – 28/11/2022	Glasshouse trial assessments
15/10/2022 – 31/10/2022	Field trial fungicide applications
15/10/2022 – 14/11/2022	Feild trial assessments

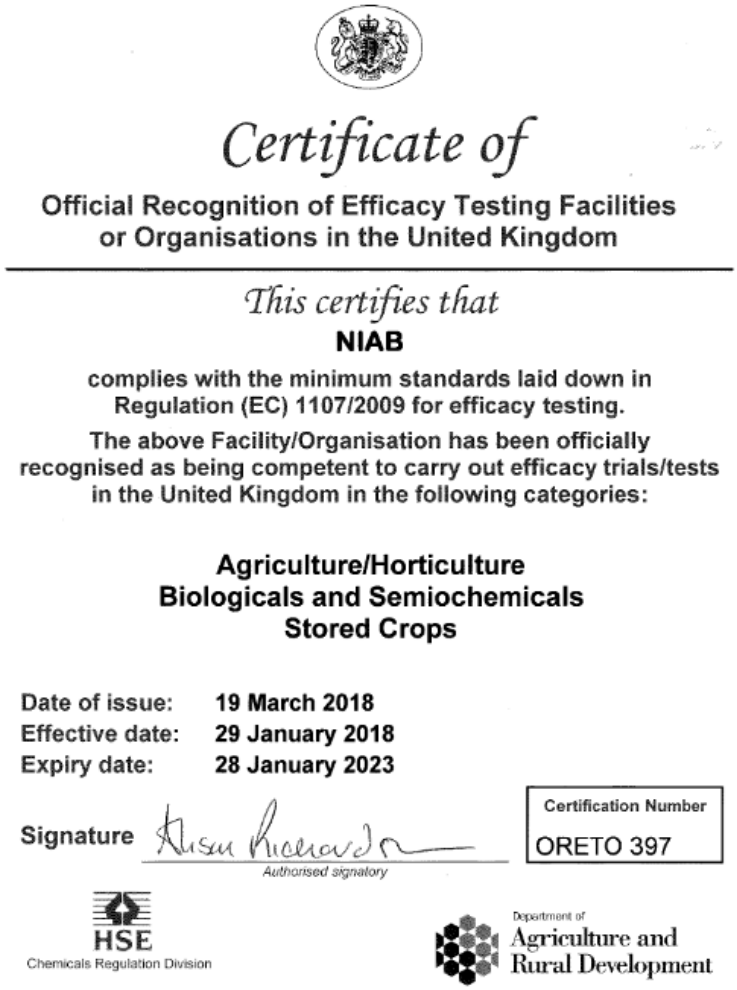
b. Raw data

Protected crop – lettuce downy mildew means and analysis of variance

Rating Date				11/11/2022		15/11/2022		18/11/2022		18/11/2022		18/11/2022		28/11/2022		28/11/2022		28/11/2022		28/11/2022	
SE Description				% Disease on leaf		% Overall Disease		% Overall Disease		% Disease on leaf		Phytotoxicity		% vigour		% Disease		% Disease on leaf		Phytotoxicity	
Part Rated				LEAF2		PLOT		PLOT		PLANT		PLOT		PLOT		PLANT		LEAF7		PLOT	
Rating Unit/Min/Max				%AREA		%AREA		%AREA		%AREA		%AREA		%		%AREA		%AREA		%AREA	
Trt No.	Treatment Name	Rate	Rate Unit	1* dAA		2* dAA		3* dAA		4* d&AA		19*		20*		21* d&AA		35* d&AA		36*	
1	UT			38.7	a	41.4	a	16.7	a	8.5	a	0.0	-	100.0	ab	17.90	a	3.4	a	0.0	-
2	AHDB 9957	0.75	l/ha	13.6	b	20.3	b	3.1	b	1.9	b	0.0	-	97.5	b	15.69	a	3.7	a	0.0	-
3	Kenja	1	l/ha	3.4	c	3.0	d	2.0	b	1.1	b	0.0	-	101.7	ab	3.23	b	1.5	ab	0.0	-
4	Luna sensation	0.8	l/ha	0.0	c	0.2	d	0.0	b	0.0	b	0.0	-	98.3	ab	0.00	c	0.0	b	0.0	-
5	AHDB 9771	5	kg/ha	0.0	c	0.3	d	0.0	b	0.0	b	0.0	-	99.2	ab	0.00	c	0.0	b	0.0	-
6	AHDB 9695	2	l/ha	0.0	c	0.2	d	0.0	b	0.0	b	0.0	-	100.0	ab	0.00	c	0.0	b	0.0	-
7	Perseus	1.2	l/ha	0.0	c	0.0	d	0.0	b	0.0	b	0.0	-	100.0	ab	0.01	c	0.0	b	0.0	-
8	AHDB 9862	1.5	l/ha	0.0	c	0.0	d	0.0	b	0.0	b	0.0	-	100.0	ab	0.00	c	0.0	b	0.0	-
9	AHDB 9852	3.2	l/ha	1.5	c	12.1	c	1.6	b	0.8	b	0.0	-	98.3	ab	11.43	a	3.3	a	0.0	-
10	AHDB 9712	250	g/ha	0.4	c	0.6	d	0.3	b	0.1	b	0.0	-	101.7	ab	1.55	bc	0.0	b	0.0	-
11	AHDB 9696	0.15	l/ha	0.0	c	0.0	d	0.0	b	0.0	b	0.0	-	102.5	a	0.00	c	0.0	b	0.0	-
LSD P=.05				5.63 - 16.95		1.60 - 10.67		3.45 - 9.06		2.22 - 5.33		.		2.71		1.006 - 6.896		0.79 - 2.45		.	

Standard Deviation	9.20t	5.50t	6.97t	5.76t	0.00	2.34	4.877t	4.02t	0.00	
CV	124.27t	54.9t	144.66t	165.86t	0.0	2.34	62.28t	107.72t	0.0	
Grand Mean	7.40t	10.03t	4.82t	3.47t	0.00	99.92	7.831t	3.73t	0.00	
Levene's F^	4.051*	1.702	1.727	1.499	.	1.297	2.454*	2.002	.	
Levene's Prob(F)	0.00*	0.104	0.098	0.165	.	0.255	0.017*	0.051	.	
Rank X2	.	.	.	.	.	.	.	.	.	
P(Rank X2)	.	.	.	.	.	.	.	.	.	
Shapiro-Wilk^	0.8777*	0.9707	0.9369*	0.8951*	.	0.9438*	0.9296*	0.9697	.	
P(Shapiro-Wilk)^	0.0*	0.1207	0.0023*	0.0*	.	0.0048*	0.0011*	0.1064	.	
Skewness^	-0.9892*	-0.2079	-0.2542	0.7904*	.	0.7825*	-0.2577	-0.1796	.	
P(Skewness)^	0.0017*	0.4931	0.4025	0.0109*	.	0.0117*	0.3961	0.5537	.	
Kurtosis^	5.7537*	2.1533*	2.4642*	3.7142*	.	2.1201*	2.4101*	1.2839*	.	
P(Kurtosis)^	0.0*	0.0006*	0.0001*	0.0*	.	0.0007*	0.0001*	0.0347*	.	
Replicate F	1.224	4.394	1.962	1.431	0.000	0.236	1.469	2.566	0.000	
Replicate Prob(F)	0.3120	0.0022	0.1007	0.2294	1.0000	0.9447	0.2165	0.0383	1.0000	
Treatment F	10.792	35.026	6.936	5.158	0.000	2.667	26.368	9.151	0.000	
Treatment Prob(F)	0.0001	0.0001	0.0001	0.0001	1.0000	0.0108	0.0001	0.0001	1.0000	

c. ORETO certificate



Certificate of

Official Recognition of Efficacy Testing Facilities or Organisations in the United Kingdom

This certifies that

NIAB

complies with the minimum standards laid down in Regulation (EC) 1107/2009 for efficacy testing.

The above Facility/Organisation has been officially recognised as being competent to carry out efficacy trials/tests in the United Kingdom in the following categories:

Agriculture/Horticulture
Biologicals and Semiochemicals
Stored Crops

Date of issue: **19 March 2018**
Effective date: **29 January 2018**
Expiry date: **28 January 2023**

Signature *Authorised signatory*

Certification Number
ORETO 397

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development